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Northeast Corridor Improvement Project Draft Environmental Impact Statement/Report for Electrification of Northwest Corridor, New Haven, CT to Boston, MA
Volume 3. Technical Appendices

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Cambridge, MA

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Volume III: Technical Studies

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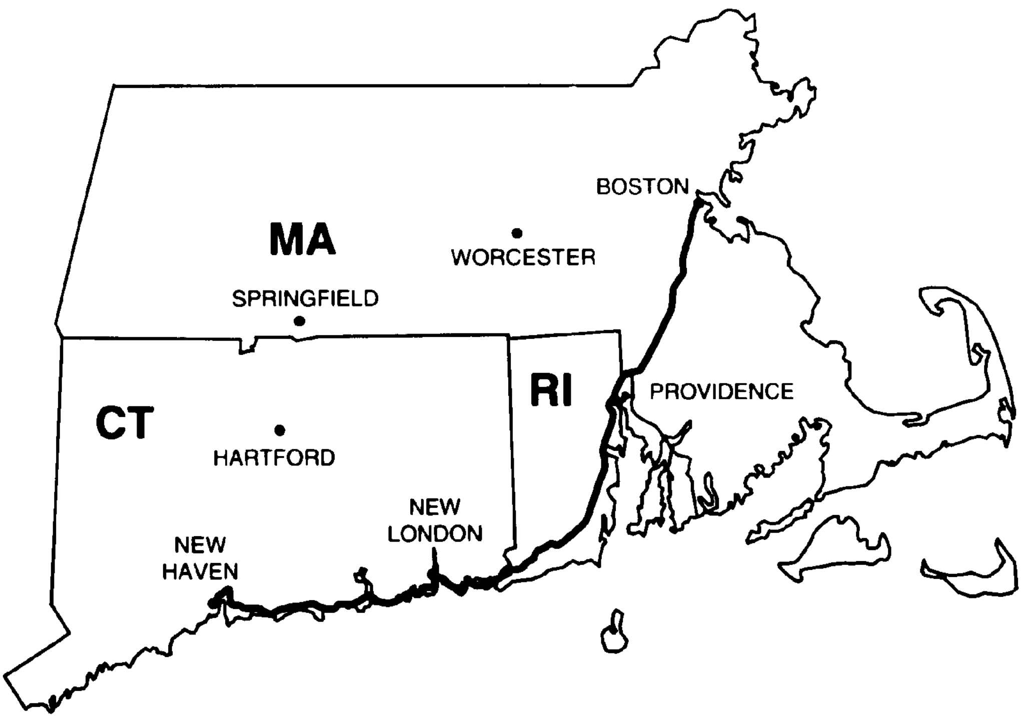

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13\. ABSTRACT (Maximum 200 words)

The impacts of extending electrification on the National Railroad Passenger Corporation's (Amtrak) Northeast Corridor (NEC) from New Haven, Connecticut to Boston, Massachusetts are of direct concern to the Federal Railroad Administration (FRA). To improve rail service and increase ridership between New York and Boston, Amtrak proposes the electrification of the NEC main line between New Haven, CT and Boston, MA using an overhead 2 X 25,000 volt - 60 hertz power system. Congress has appropriated funds to the FRA for transfer to Amtrak for the purpose of undertaking this project. FRA has determined the transfer of these funds would constitute "a major federal action" within the meaning of the National Environmental Policy Act (NEPA) of 1969. Pursuant to the regulations of the President's Council of Environmental Quality implementing the procedural provisions of NEPA (40 CFR Parts 1500-1508), and FRA's "Procedures for Considering Environmental Impacts," (FR Vol. 45 Page 40854), and Massachusetts Environmental Policy Act (MEPA) regulations (301 CMR 11:00), FRA is preparing an Environmental Impact Statement/Report (EIS/R) for Amtrak's proposed electrification of the NEC main line.

This volume contains the detailed technical studies that were performed in order to identify and evaluate the environmental impacts of the proposed project. Some of these studies have been included entirely in the DEIS/R (Volume 1). The technical evaluations performed were based upon regulatory requirements as well as substantive issues raised by individuals and public agencies as part of the public participation program. Technical studies were performed for each of the following disciplines:

- Land Use and Recreation
- Transportation and Traffic
- Socioeconomic
- Historic Resources
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- Air Quality
- Public Health
- Public Safety
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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in.) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd) = 0.9 meter (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in²) = 6.5 square centimeters (cm²)
1 square foot (sq ft, ft²) = 0.09 square meter (m²)
1 square yard (sq yd, yd²) = 0.8 square meter (m²)
1 square mile (sq mi, mi²) = 2.6 square kilometers (km²)
1 acre = 0.4 hectares (he) = 4,000 square meters (m²)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gr)
1 pound (lb) = .45 kilogram (kg)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp) = 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup (c) = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft³) = 0.03 cubic meter (m³)
1 cubic yard (cu yd, yd³) = 0.76 cubic meter (m³)

TEMPERATURE (EXACT)

[(x - 32) (5/9)] °F = y°C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm²) = 0.16 square inch (sq in, in²)
1 square meter (m²) = 1.2 square yards (sq yd, yd²)
1 square kilometer (kn²) = 0.4 square mile (sq mi, mi²)
1 hectare (he) = 10,000 square meters (m²) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gr) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 liter (l) = 2.1 pints (pt)
1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m³) = 36 cubic feet (cu ft, ft³)
1 cubic meter (m³) = 1.3 cubic yards (cu yd, yd³)

TEMPERATURE (EXACT)

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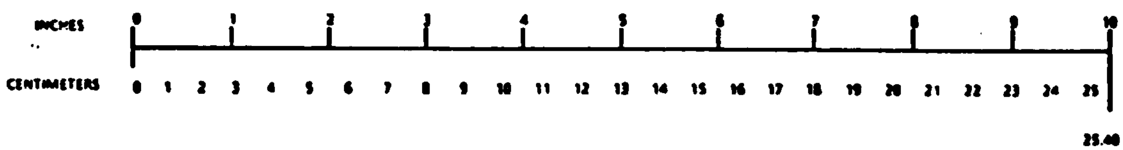
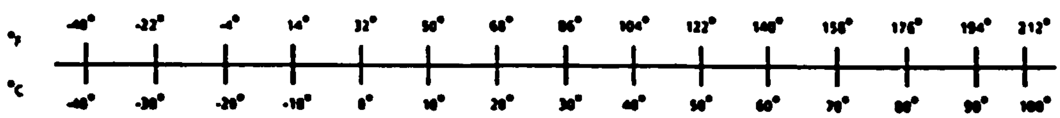
QUICK INCH-CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT-CELSIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NBS Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10286.

TECHNICAL STUDY 1
LAND USE

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TECHNICAL STUDY 1
LAND USE

1.0 INTRODUCTION

This section provides the background, framework, and results of the land use impact analysis. The section is organized into three elements: applicable regulations to which the analysis must conform or address, the existing environment with respect to the project scope, and the anticipated environmental consequences of the proposed action and the recommended actions which would mitigate them.

1.1 REGULATORY SETTING

Although there are no Federal, state, or local regulations that specifically guide the proposed project as it may affect land use, there are a number of programs, policies, and plans that generally guide the development and use of land, and others that provide protection for particular types of land uses. These are discussed below.

1.1.1 Federal Regulations

1.1.1.1 National Environmental Policy Act (42 USC 4321-4347). The National Environmental Policy Act of 1969 (NEPA) and the Council on Environmental Quality (CEQ) regulations (40 CFR Parts 1500-1508) that implement it establish a framework within which Federal agencies must consider impacts to the environment before they undertake major actions. The Act specifically states that Federal agencies must work toward assuring safe, healthful, productive, and aesthetically and culturally pleasing surroundings for all Americans. This Act applies not only to land use, but to all other sections of the Draft Environmental Impact Statement/Report (DEIS/R).

1.1.1.2 Federal Railroad Administration Procedures for Considering Environmental Impacts. These procedures comply with the regulations of the Council on Environmental Quality (CEQ) and procedures of the Department of Transportation (USDOT) and also establish procedures for compliance by the Federal Railroad Administration (FRA) with: the National Environmental Policy Act (NEPA), the Department of Transportation Act, the Clean Air Act, the National Historic Preservation Act, the Coastal Zone Management Act, the Fish and Wildlife Coordination Act, and the Noise Control Act. Included are provisions for actions covered, timing, performing joint actions, applicants seeking financial assistance, the use of consultants, citizen involvement, and the environmental assessment process.

1.1.1.3 Federal Farmland Protection Policy Act (11 USC 590 a-f). The Federal Farmland Protection Policy Act of 1981 requires Federal agencies to evaluate adverse effects of Federal actions on the preservation of farmland and to consider alternative actions that could lessen such effects. Farmland as defined by this Act includes four categories of agricultural land: prime farmland, unique farmland, farmland of statewide importance, and farmland of local importance.

Land is classified into these categories by the U.S. Department of Agriculture Soil Conservation Service (SCS) based on soil type. Compliance with the Act requires consultation with the SCS to identify agricultural lands of importance that may be affected by the proposed action and to evaluate the direct and indirect impacts on them. To the greatest extent possible, agencies must also consider avoidance or mitigation of any adverse effects of the action.

1.1.1.4 Federal Coastal Zone Management Act (43 USC 1241). The Coastal Zone Management Act (CZMA) of 1972 provides states with the authority to establish policies for the protection and use of the coastal zone. The Act is designed to encourage the protection of natural resources in coastal areas, including wetlands, floodplains, and fish and wildlife. States with approved programs must review all Federal funding, permitting, construction, or other actions proposed within the coastal zone for consistency with the state's coastal policies. Federal actions should be consistent with the state plans and the state plans must be consistent with applicable water and air quality laws, hence the state's programs are called Federal Consistency Programs or Reviews. Connecticut, Rhode Island and Massachusetts each have such an approved program, which is described in the appropriate sections below.

1.1.1.5 Section 4(f) of the Department of Transportation Act of 1966 (49 USC 1653). Section 4(f), as it is commonly referred to, prohibits the use of land from a significant publicly owned park, recreation area, wildlife or waterfowl refuge, or any significant historic site unless: 1) there is no feasible and prudent alternatives to the use of the land and 2) the proposed action includes all possible planning to minimize harm to the property from such use.

1.1.1.6 Passenger Rail Service Act. This Act grants Amtrak the right to acquire property by way of eminent domain for intercity rail passenger service.

1.1.1.7 Uniform Relocation Assistance and Real Property Acquisition Regulations for Federal and Federally Assisted Programs (49 CFR Part 24). The purpose of these regulations is to ensure uniform compliance by all affected entities with the Uniform Relccation Assistance and Real Property Acquisition Act of 1970. The Act and Regulations impose certain procedures in connection with the acquisition of real property and entitle persons displaced by Federal or federally assisted programs to certain forms of compensation.

1.1.2 Connecticut Regulations

1.1.2.1 Connecticut Coastal Management Act. The Coastal Resources Management Division (CRMD) of the Connecticut Department of Environmental Protection (ConnDEP) administers the Federal CZMA and regulates activities in all areas seaward of a boundary 1000 feet inland from coastal wetlands. Any proposed action or project within this area is subject to coastal site plan review and evaluation of Federal consistency concurrence. Policies contained within the Act include the protection of life and property, as well as minimization of erosion and other adverse impacts on coastal resources, circulation, sedimentation patterns, water quality, and natural flooding. In addition, the policies address use of fill and conflicts with the riparian rights of landowners.

1.1.2.2 Conservation and Development Policies Plan. The Connecticut Conservation and Development Policies Plan of 1992 is the State's comprehensive plan. One relevant goal of the plan is to provide an integrated, efficient, and economical transportation system which provides mobility, convenience, and safety, and which meets the needs of all citizens, including transit-dependent individuals. The plan specifically states that high speed passenger rail service between Boston and New York with stops in Connecticut is desirable and is feasible through track improvements and electrification. The plan states that such service can be more efficient than air travel, and can save energy and reduce emissions from jet travel while strengthening business development near downtown stations.

1.1.2.3 Environment 2000 Plan. This plan reflects the environmental concerns of the state and the goals, objectives, and strategies for each area of interest. Relevant goals of the plan include protecting public health from harmful exposure to electric and magnetic fields, and from the adverse effects of air pollutants. It also includes the objective of promoting the utilization of vehicles with low level emissions, and transportation which reduces reliance on single-occupant vehicles.

1.1.2.4 Statewide Comprehensive Outdoor Recreation Program of 1992. Connecticut's Statewide Comprehensive Outdoor Recreation Program (SCORP) offers a plan for the wise use of Connecticut's outdoor resources for current and future generations. In order to accomplish this, the program advocates acquisition and preservation of natural and recreational resources in addition to interagency coordination in achieving these goals.

1.1.2.5 Connecticut Transportation Improvement Program, 1992. The objective of the Transportation Improvement Plan (TIP) is to guide the flow of U.S. Department of Transportation (DOT) funds in the region. A five-year program suggests how available Federal, state, and local resources will be used to improve the region's transportation system. Although some general statements are mentioned relating to intercity rail transportation, most projects outlined in the TIP pertain to local commuter rail service.

1.1.2.6 Connecticut Transportation Plan Towards the Year 2000. This 1983 plan guides major highway and transit spending programs within the state. It reflects the objectives of establishing stronger, core-bound transit in major corridors as a high priority, and taking advantage of unique rail opportunities, especially in New Haven.

1.1.3 Rhode Island Regulations

1.1.3.1 Rhode Island Comprehensive Planning and Land Use Regulation Act of 1991. The Rhode Island Comprehensive Planning and Land Use Regulation Act was designed to promote orderly growth and development which recognizes the natural character of the land, its suitability for use, and the availability of existing and proposed public and/or private services and facilities for each community. In doing so, it requires all municipalities to produce a comprehensive plan which adheres to the Act's requirements, and subsequently a zoning ordinance which reflects the general intentions of the plan. This is designed to assure the existence of a document which embodies the collective objectives of the community, that guides the development of the community, and which ensures a zoning ordinance that is not arbitrary and capricious.

1.1.3.2 Rhode Island State Guide Plan. The Rhode Island State Guide Plan acts as the comprehensive plan for the state. It consists of numerous segments, or elements, which each direct distinct areas of development within the state. Pertinent segments include Element 611: Ground Transportation Plan, Element 661: Rail Plan and Element 152: Outdoor Recreation Plan. Element 611 includes improving existing transportation facilities and services in order to provide for safe, dependable, and convenient passenger travel, and developing an energy-efficient transportation system as two of its main goals. Among the major goals of Element 661 are: 1) promoting reliable and frequent high-speed Northeast Corridor (NEC) passenger rail service; 2) promoting the use of new technological innovations in the provision of passenger rail service; 3) continuing grade crossing improvements; and 4) reducing pedestrian accessibility to railroad rights-of-way or eliminating grade crossings wherever feasible to improve safety. Element 152, Rhode Island's equivalent of the SCORP, is designed to provide effective planning strategies for protection of the state's natural resource base and for providing outdoor recreational opportunities for present and future Rhode Islanders and visitors to the state.

1.1.3.3 Coastal Zone Management Program. As authorized by the Federal Coastal Zone Management Act, Rhode Island operates the Coastal Resources Management Council (CRMC) under authority of the Rhode Island Coastal Zone Management Program of 1977. CRMC has regulation and permitting power for any activities taking place within the 200 foot contiguous area landward of all coastal features, which include tidal and coastal waters, beaches, dunes, wetlands, cliffs, bluffs, banks, and manmade shorelines. As such, permit approval must be sought for construction activities including public roads, bridges, and railroad lines.

1.1.3.4 Rhode Island Transportation Improvement Plan. The Rhode Island TIP includes funding for transportation projects on a six-year basis. While the TIP does not directly include electrification in its scope, it does include among its goals passenger rail projects, bridge construction and rehabilitation, and the elimination of the Wolf Rocks grade crossing in Exeter, Rhode Island.

1.1.4 Massachusetts Regulations

1.1.4.1 Massachusetts Environmental Policy Act (30 MGL 61-62H). The Massachusetts Environmental Policy Act (MEPA) is similar to NEPA and provides the framework under Massachusetts law within which the environmental impacts of a proposed action must be evaluated. The Act requires that agencies use all feasible means and measures to avoid or minimize damage to the environment. The MEPA regulations establish a process by which a determination is made as to whether or not preparation of an Environmental Impact Report (EIR) is necessary to determine the impacts of state actions, including permits. Second, it requires that the potential environmental impacts of the project be addressed. Section 61 of the Act defines the term "damage to the environment" and requires that relevant state agencies make determinations regarding such damage as a result relative to the Scope of the EIR will either adopt the FEIR as their Section 61 Finding or prepare a separate Section 61 Finding.

1.1.4.2 Statewide Comprehensive Outdoor Recreation Program (SCORP). The 1992 Massachusetts SCORP is a comprehensive analysis and plan for preserving Massachusetts' natural and cultural heritage while providing recreational opportunities and expanding future economic horizons. The program specifically contains policies requiring increased efforts to provide access to the shoreline and delineation and protection of prime and important farmlands. The program also encourages coordination among state agencies to promote the protection of significant landscapes.

1.1.4.3 Chapter 91 Waterways License and Permit Program. Chapter 91 Waterways Licenses implemented by 310 CMR 9.16 are administered by the Massachusetts Department of Environmental Protection/Division of Water and Wetlands Resources. Chapter 91 controls filling, construction of new structures, dredging, disposal of dredged material, and/or removal of sand and vegetation in tidelands seaward of the historic mean high-water line, in historic or filled tidelands, in certain great ponds and rivers, and in certain portions of Designated Port Areas.

1.1.4.4 Areas of Critical Environmental Concern (ACEC) Program. The ACEC program addresses the acquisition, protection, and use of areas of critical environmental concern to the state. Protection of coastal or inland ACECs does not require new permits or administrative programs. Instead, existing environmental programs provide higher performance standards and greater review by agencies and the public for activities proposed in an ACEC. The NEC passes through two ACECs: the Fowl Meadow/Ponkapoag Bog ACEC in Boston, Dedham, Canton, Sharon, and Westwood, and the Canoe River ACEC in Foxboro, Mansfield, and Sharon.

1.1.4.5 Massachusetts Coastal Zone Management Act. The Massachusetts Office of Coastal Zone Management administers the Federal Coastal Zone Management Act and requires preparation by the proponent of a Federal Consistency Concurrence (FCC). An FCC is required for projects located within the designated coastal zone which involve Federal action (permitting, funding) or for which an EIR is being prepared under MEPA.

1.1.4.6 Massachusetts Transportation Improvement Program (TIP). As in the other two states, the Massachusetts TIP outlines funding and scheduling for Federal, state, and local projects. Similar to Rhode Island, the Massachusetts TIP does not specifically address this project, but many improvements are outlined for bridges and other components within the corridor. Also, as a means to help urban areas achieve the air quality standards mandated by recent amendments to the Clean Air Act, the TIP institutes the Congestion Mitigation and Air Quality Improvement Program. This program is a component of the 1991 Federal Intermodal Surface Transportation Efficiency Act (ISTEA) and provides funding for projects which efficiently maximize the mobility of people and goods through urban areas and minimize transportation-related fuel consumption and air pollution. Some examples include: park and ride programs, train station rehabilitation, parking facility construction, and projects which encourage the use of transit service.

1.1.5 Local Regulations

Potentially relevant local regulations include comprehensive plans, zoning regulations, and conservation and recreation plans. Depending upon the activities to occur in each of the 36 municipalities in the corridor, some or all of these elements will apply. Each of these is generally described below.

1.1.5.1 Connecticut Regulations

Plans of Development. Prepared by each municipality, plans of development reflect proposals designed to protect the health, safety, and welfare of present and future residents. These plans consider social, economic, administrative, and physical factors of towns and dictate the recommended direction each area should take. The primary emphasis is on land use and addresses elements such as housing, recreation, open space, commerce, and other land uses. Other elements include transportation systems, utilities, and public facilities that support land use. Zoning ordinances specifically carry out the general goals of plans of development.

Zoning Ordinances. Zoning ordinances are enacted by local municipal governments pursuant to the provisions of Chapter 124 of the Connecticut General statutes, as amended. As such, the general purposes of zoning ordinances are to: 1) promote the health, safety, general welfare and convenience of the community; 2) conserve property values; 3) encourage the most appropriate use of land; 4) reduce traffic; 5) regulate density; 6) facilitate adequate provisions of public infrastructure and services; 7) regulate and restrict the location of specific land uses; 8) regulate and limit the height and bulk of buildings as well as yards, courts, and other open spaces; 9) conserve and improve the physical appearance of municipalities; and 10) effectively promote plans of development.

1.1.5.2 Rhode Island Regulations

Comprehensive Plan. As dictated by Title 45, Chapter 22.2, the Rhode Island Comprehensive Planning and Land Use Regulation Act of 1991, local comprehensive plans prepared by each municipality must incorporate certain elements including: goals and policies statement, land use, housing, economic development, natural and cultural resources, services and facilities, open space and recreation, circulation, and implementation.

Zoning Ordinances. Zoning ordinances, as required by Title 45, Chapter 24, the Zoning Enabling Act of 1991, must be developed by each municipality and maintained in accordance with the comprehensive plan. The goals of the zoning ordinance generally incorporate those mentioned in the Connecticut zoning ordinance section above, although they may vary in wording.

1.1.5.3 Massachusetts Regulations

Zoning Bylaws. Chapter 40A of the Massachusetts General Laws empowers local communities to enact zoning bylaws and ordinances to regulate the use of land, buildings, and structures to the full extent of the independent constitutional powers of communities to protect the health, safety, and general welfare of their present and future inhabitants.

1.2 AFFECTED ENVIRONMENT

This section characterizes land use in the NEC in four categories: existing land use, prime and important farmland, special protected areas, and expected land use changes. The first category describes the physical type and extent of development on the land and the latter two are Federal jurisdictional categories in which certain development restrictions apply. Each of these are described in detail below.

1.2.1 Existing Land Use

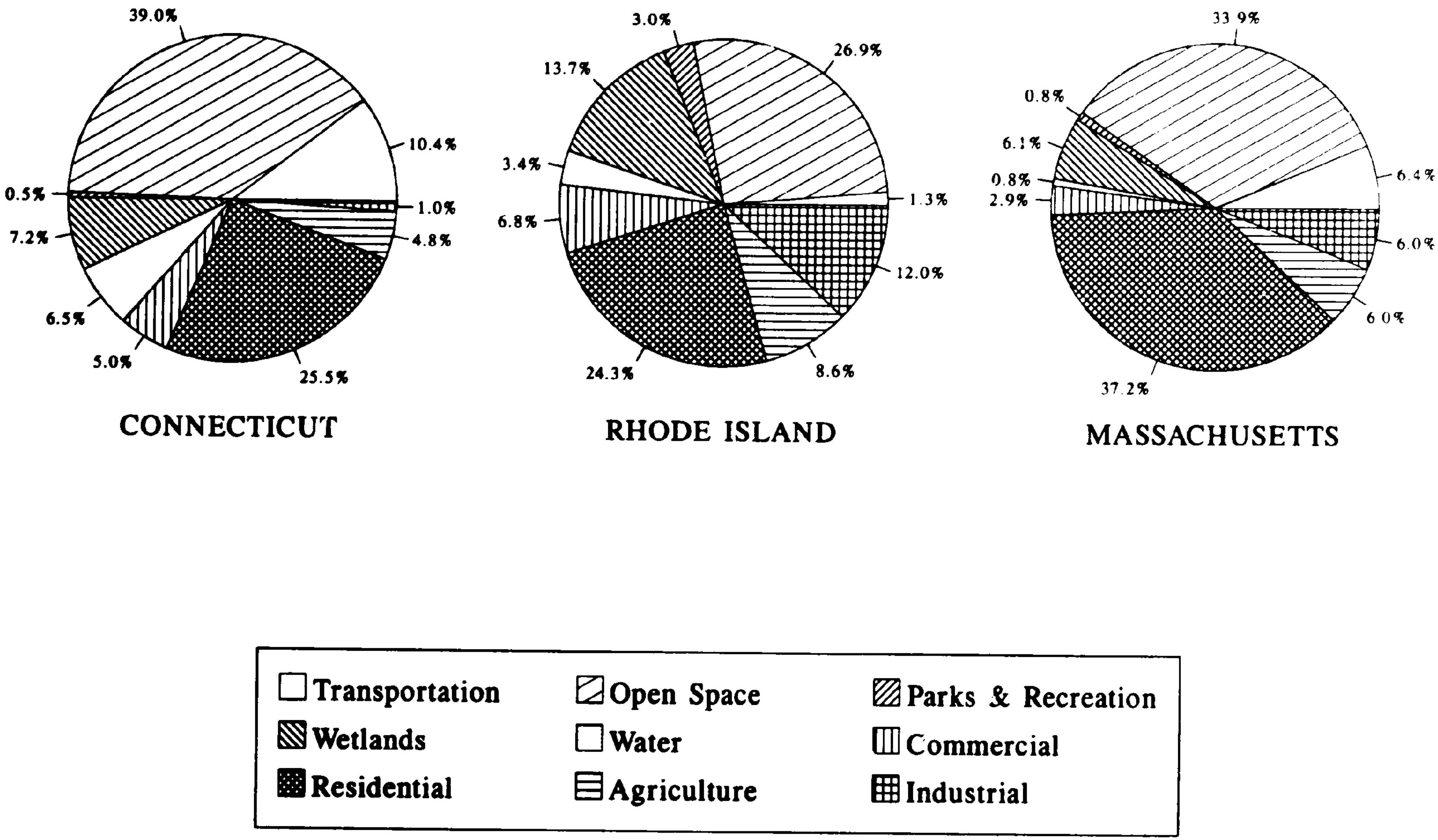
This section includes an inventory of existing land use characteristics within an area of one-half mile on each side of the railroad right-of-way (ROW), in the area immediately adjacent to each of the electrification facilities, and along the approaches and construction detours for proposed bridge modifications. This information is organized by community from New Haven, Connecticut to Boston, Massachusetts. Volume II, Land Use and Regulated Areas, provides a graphic representation of the existing land uses in the NEC and is referred to throughout this section. A detailed breakdown of land use by type and location is contained in Appendix A. Sensitive receptor locations shown in Volume II are listed by town in Appendix B.

Land use classifications used in this section include the following:

- **high density residential:** lot sizes less than 10,000 square feet (approximately one-quarter acre);
- **medium density residential:** lot sizes of 10,000 to 20,000 square feet (approximately one-quarter to one-half acre);
- **low density residential:** lot sizes of over 20,000 square feet (approximately on-half acre or more);
- **commercial:** retail and office;
- **industrial:** manufacturing and warehouse;
- **transportation:** roadways, railways, interchanges, stations, depots, etc.;
- **parks, recreation:** public and private areas for active and passive recreation;
- **open space:** vacant areas;
- **agriculture:** land used for the production of crops, and
- **wetlands:** marshy, boggy and swampy areas, shorelines and other bordering areas not suitable for development.

Figure 1-1 shows the distribution of land to these uses (and the proportion of water) within one-half mile of the NEC in each of the three states. As shown in these figures open space

FIGURE 1-1. LAND USE WITHIN ONE-HALF MILE OF THE NEC



categorizes more than one-quarter of the land in the NEC area with the highest acreage in Connecticut (39.0%) followed by Massachusetts (33.9%), and Rhode Island (26.9%). The atlas in Volume II of this DEIS/R illustrates land uses in 10 categories throughout the NEC.

Land use in the existing (or affected) environment is described herein by municipality from west to east (New Haven to Boston) as indicated by Amtrak track charts. For each municipality, a general description of land uses within one-half mile on each side of the corridor is provided, followed by descriptions of land use around each of the proposed electrification facilities (substations, switching stations, paralleling stations) and around the bridges that have been proposed for raising or replacement (detours in bridge modifications sections are only discussed if complete bridge closure would be required during construction). It is also important to note that a general description of land use within the NEC is provided, and that in many cases inconsistent land uses and densities may exist within an area which has been otherwise generally characterized. The above information was obtained from various sources including: aerial photography, zoning and land use information, public officials, field work, and public scoping and information meetings.

1.2.1.1 New Haven, Connecticut. Approximately 4.8 miles of the NEC pass through New Haven, the southern terminus of the project corridor (Volume II, Sheet 1). No switching, paralleling, or substations are proposed in this city. The section of the corridor which runs through New Haven is characterized by numerous land uses both north and south of the NEC. The most prevalent uses in order of significance are light industrial and general business followed by high to middle density residential, wholesale and distribution, heavy industrial, and low to middle density residential uses, in that order. The majority of the corridor is densely developed and much of the residential development consists of multi-family dwellings. The Quinnipiac River (and associated wetlands) and the region adjacent to Russell Street near the border with East Haven are the only major open space/undeveloped areas that exist in New Haven. Sensitive receptors within one-half mile of the NEC in New Haven include: schools (8), recreation sites (7), churches (16), hospitals (3), a nursing home, and a library.

1.2.1.2 East Haven, Connecticut. Approximately 1.9 miles of the NEC pass through this town for which no switching, paralleling, or substations are proposed (Volume II, Sheet 1). From the New Haven border to the center of East Haven the area north of the NEC is characterized by woodlands. From the center of East Haven to the eastern border with Branford, medium density residential uses exist on the north side of the NEC. The majority of the land uses abutting the railroad south of the NEC are either commercial or industrial, with the exception of the land near the Branford line which contains high density residential uses. The area further south contains high density residential uses near New Haven (west) and medium density residential uses near Branford (east). Sensitive receptors within the East Haven study area include recreation sites (2), a church, a library, and a nursing home.

1.2.1.3 Branford, Connecticut. Approximately 6.7 miles of the NEC pass through this town for which no switching or paralleling stations are proposed (Volume II, Sheets 2 and 3). Most of the Branford section of the NEC contains undeveloped, wooded or wetland areas. In addition to these areas, on the north side of the NEC low density residential development is present immediately at the border with East Haven with commercial and industrial uses from that point east approximately halfway across Branford. Medium to high density residential uses continue to the Guilford border (east). The southern section mirrors the northern section with the exception that the commercial and industrial areas are not as extensive. The major industrial areas in this section are located adjacent to the Branford River and off Tabor Drive. Medium to high density residential uses similar to those north of the NEC predominate. The Pine Orchard Association, which is separate from town zoning and which requires minimum lot sizes of one acre per dwelling unit, controls a large area found on both sides of the railroad. Sensitive receptors within the Branford study area include parks (5), libraries (2), a school, and a church.

Branford Substation. Located at milepost (MP) 79.26 on the northern side of the railroad, this proposed substation would be located adjacent to Interstate 95 in a public zone (Volume II, Sheet 1). North of the substation is an access road and a small forested area and beyond which are three residences. To the west is a former toll plaza and state administration building site. To the east is Hosley Avenue, a secondary road. The corresponding 1,200 foot aerial utility corridor runs north through open fields and wooded areas and between the existing residences.

1.2.1.4 Guilford, Connecticut. Approximately 5.0 miles of the NEC pass through this town for which no switching or substations are proposed (Volume II, Sheet 3). From the western boundary with Branford to the town center, the area north of the NEC contains very low density residential development. Land use in the town center contains industrial, commercial, municipal, and high density residential development. From the town center east to the Madison border are medium density residential uses, with an industrial area adjacent to Soundview Road.

South of the NEC non-residential uses are confined to the town center, which also contains some medium density residential uses. The remainder of the land use around the center is primarily low density residential. The Old Quarry Association, located near the town of Branford, is a residential area with lot sizes up to 12 acres. High density residential development is confined to the Leetes Island and Indian Cove areas. To the south, Guilford Harbor and other bays, coves, and associated wetlands make up much of the study area. Sensitive receptors within the Guilford study area include two public recreation sites.

Leetes Island Paralleling Station. Sited at MP 85.99 on the northern side of the railroad, this proposed facility would be located in a small wooded area between Leetes Island Road to the north and the railroad to the south (Volume II, Sheet 3). Wetlands surround most of the site although one residence is located northwest of the site.

1.2.1.5 Madison, Connecticut. Approximately 4.2 miles of the NEC pass through this town for which no paralleling or substations are proposed (Volume II, Sheets 3 and 4). North of the NEC, between the railroad and I-95, there is low density residential development, although five commercial and two industrial areas are also distributed throughout the section. Beyond I-95, low density residential developments are prominent, although much of this area remains undeveloped. South of the NEC industrial and commercial uses are adjacent to the railroad from the Guilford border (west) to the middle of Madison. The remainder of this section contains low density residential development with the exception of some high density development located along the coastal areas of Long Island Sound. Sensitive receptors within the Madison study area include recreation areas (5), a school, a library, a cemetery, and a public well site.

Madison Paralleling Station. Located at MP 92.41 on the northern side of the railroad, this proposed facility would be located in a primarily undeveloped area (Volume II, Sheet 3). The northern, eastern, and western sides of the site are flanked by woodlands, and a residence is located directly across the railroad tracks to the south. Although other residences do exist in the general area, they are buffered by wooded areas.

1.2.1.6 Clinton, Connecticut. Approximately 4.1 miles of the NEC pass through this town for which no switching, paralleling, or substations are proposed (Volume II, Sheets 4 and 5). The area to the north of the NEC is characterized by varied land uses. Between the railroad and I-95 medium density residential uses are prominent, although a large part of this area is zoned for industrial use. A golf course is also located to the east near the Westbrook border. Medium and low density residential development is located north of I-95, with the more concentrated development occurring near the Madison border (west). This section also contains vacant and agricultural land and the old town dump which is located adjacent to East Shore Drive. To the south of the NEC a mix of industrial, commercial, municipal, and high density residential development is present. There are also two large wetlands, one near Madison and the other near Westbrook, south of the corridor. Sensitive receptors within the Clinton study area include: schools (2), churches (4), cemeteries (3), a nursing home, a funeral home, and recreation sites (5) including Boulder Lake and Upper Mill Pond.

1.2.1.7 Westbrook, Connecticut. Approximately 3.5 miles of the NEC pass through this town for which no switching or substations are proposed (Volume II, Sheet 5). Some low density residential development is present from the western border with Clinton to the center of the corridor in the mostly undeveloped area north of the NEC. Further east is the most concentrated area, characterized by industrial and commercial uses abutting the ROW and medium density residential uses further out. East of this point, towards the Old Saybrook border, is low density residential development. Interstate 95 is also located in this area.

South of the NEC is medium density residential development. Some higher density residential development exists along coast, commercial areas abut most of the Boston Post Road, and an industrial area skirts the railroad near the Old Saybrook border (east). Sensitive receptors within the Westbrook study area include: the Salt Meadow National Wildlife Refuge, schools (3), recreation sites (5), a library, and a church.

Grove Beach Paralleling Station. Located at MP 99.11 on the southern side of the railroad, this proposed facility would be located in an undeveloped area between the railroad to the north and wetlands to the south and west (Volume II, Sheet 5). A trailer park is located east of the site.

1.2.1.8 Old Saybrook, Connecticut. Approximately 4.4 miles of the NEC pass through this town for which no paralleling or substations are proposed (Volume II, Sheets 5 and 6). To the north, Old Saybrook is divided by I-95, which runs parallel to the railroad. The majority of the rail corridor is undeveloped except for some commercial and residential development located near Old Lyme (east). To the south of the NEC primarily industrial and commercial uses occur along Boston Post Road with medium density residential development beyond them. The most undeveloped areas south of the NEC occur near Old Lyme. Sensitive receptors within the Old Saybrook study area include: schools (3), nursing homes (2), a cemetery, a funeral home, and recreation sites (3).

Westbrook Switching Station. Located at MP 103.53 on the southern side of the railroad, this proposed facility would be located on an triangular undeveloped parcel created by the railroad north, and access road to the south and Schoolhouse Road to the west (Volume II, Sheet 5). There are industrial uses to the east and west and a residence directly north across the railroad.

1.2.1.9 Old Lyme, Connecticut. Approximately 5.6 miles of the NEC pass through this town for which no switching or substations are proposed (Volume II, Sheets 6 and 7). North of the NEC there are some low density residential uses, but the majority of this area remains undeveloped from Johnnycake Hill Road east to the East Lyme border where a small commercial area abuts the railroad. Also, a small industrial area exists off Shore Road near Old Saybrook to the west. Because of extensive wetland areas, the area south of the NEC is also relatively undeveloped. Residential development, most concentrated in the Sound View and Point of Woods sections, ranges from medium to low density. Bordering Route 156 are an industrial zone, which runs along the railroad near Buttonball Road, and two adjoining commercial areas. A golf course is also located off Buttonball Road. Sensitive receptors within the Old Lyme study area include recreation sites (5).

Old Lyme Paralleling Station. Located at MP 109.50 on the southern side of the railroad, this proposed facility would be located in a wooded area between the railroad to the north and Buttonball Road to the south and west (Volume II, Sheet 6). A small farm exists to the east and woods and wetlands are located across the railroad.

Johnnycake Hill Road Bridge. Located at MP 108.51, this bridge is situated in an area with several residences on the approach roads (Volume II, Sheet 6). The remainder of the area is comprised of wooded areas and a golf course.

1.2.1.10 East Lyme, Connecticut. Approximately 4.4 miles of the NEC pass through this town for which no switching, paralleling, or substations are proposed (Volume II, Sheet 7). North of the corridor are a mix of uses and residential densities. Residential development is most concentrated near the borders with Old Lyme (west) and Waterford (east) and ranges from medium to low density. The majority of the commercial and light industrial uses are found to the east along Main Street near Waterford. Medium density residential uses are prominent south of the NEC but more than half the study area on this side is comprised of Long Island Sound and Niantic Bay. Because of direct access to Long Island Sound, sensitive areas in the East

Lyme study area include three beaches in addition to other, unmarked, private recreational areas (4), and funeral homes (2).

1.2.1.11 Waterford, Connecticut. Approximately 4.2 miles of the NEC pass through this town for which no substations or switching stations are proposed (Volume II, Sheets 7 and 8). The majority of the area north of the NEC is comprised of open space, despite its industrial and residential zoning designations. The areas north of Rope Ferry Road tend to contain more concentrated residential development than those to the south, with the exception of the medium density development adjacent to Great Neck Road. The area south of the NEC also contains significant open space, although the most prominent use is medium density residential development. Sensitive receptors within the Waterford study area include recreation areas (10), a hospital, and a school.

Millstone Paralleling Station. Located at MP 117.56 on the southern side of the railroad, this proposed facility would be located between the existing Millstone Substation and the railroad, beneath two 345kV power lines (Volume II, Sheet 7). The majority of the surrounding areas are vacant or wooded areas, with no residences nearby.

Millstone Point Road Bridge. Located at MP 117.31, and requiring no detour, this bridge is situated in an area of some medium density residential development to the north and a single residence to the south (Volume II, Sheet 7). The remainder of the land is undeveloped and wooded.

1.2.1.12 New London, Connecticut. Approximately 3.0 miles of the NEC pass through this city for which no switching or paralleling stations are proposed (Volume II, Sheet 8). North of the NEC the area is characterized by industrial and commercial uses adjacent to the railroad and high density residential uses beyond. Some residences abut the railroad near Waterford (west). The area south of the NEC is comprised almost entirely of water except for the residences near Waterford and the industries near Walbach Street (mid-corridor) and the State Pier to the east. Sensitive receptors within the New London study area include: parks (7), hospitals (2), schools (2), a church, funeral homes (3), and a nursing home.

New London Substation. Located at MP 123.55 on the northern side of the railroad, this proposed facility would be located in a waterfront commercial/industrial zone on a vacant lot which is completely surrounded by rail lines and Interstate 95 (Volume II, Sheet 8). The proposed site is sited between two branches of the Central Vermont Railroad line to the east and west, the Amtrak line to the south, and I-95 to the north. This substation includes a 4,800 foot underground feeder which will run along existing road rights-of-way through high density residential development.

1.2.1.13 City of Groton, Connecticut. Approximately 1.0 mile of the NEC passes through this city for which no switching, paralleling, or substations are proposed (Volume II, Sheet 8). In addition to I-95, which is north of the railroad, the area north of the NEC contains industrial uses near New London (west) and high density residential uses and open space near the town of Groton (east). Throughout the area south of the NEC commercial and industrial uses are predominant adjacent to the railroad with high density residential uses located beyond. Sensitive receptors within the city of Groton study area include recreation sites (5) and schools (2).

1.2.1.14 Town of Groton, Connecticut. Approximately 7.1 miles of the NEC pass through this town for which no switching or substations are proposed (Volume II, Sheets 8 and 9). The majority of the area north of the NEC contains medium density residential uses, open spaces (including Haley Farm State Park), and coastal features (the railroad crosses over approximately 7 waterways). Commercial areas are also found to the north at Bridge Street and surrounding Long Hill Road (Route 1), and industrial areas are located in the vicinity of the Groton - New London Airport and Bluff Point State Park. A majority of the south side of the NEC is made up of coastal wetlands (Mystic Harbor) associated with Long Island Sound. The two largest land masses are Bluff Point State Park and the airport. Small pockets of high and medium density residential uses are found throughout this section, and small commercial and industrial areas exist near the airport and the state park. Sensitive receptors within the town of Groton study area include state parks (2), schools (2), and numerous recreation areas.

Noank Paralleling Station. Located at MP 129.46 on the southern side of the railroad, this proposed facility would be located between the railroad to the north and an abandoned parking lot to the south (Volume II, Sheet 9). Groton Long Point Road is the site's eastern boundary and undeveloped land is found to the west. South of the site is a residential area which abuts the ROW.

1.2.1.15 Stonington, Connecticut. Approximately 9.0 miles of the NEC pass through this town for which no substations are proposed (Volume II, Sheets 9-11). The majority of the land area in the Stonington study area consists of open space, although the mainline passes through some concentrated areas. North of the NEC are some medium and low density residential uses. Near Westerly to the east, medium density development occurs. Industrial and commercial uses also occur throughout the corridor, most frequently between the Borough of Stonington (mid-corridor) and Groton (west). To the south, a large percentage of the corridor includes Long Island Sound and associated wetlands. Aside from these, the existing development is similar to that north of the NEC. Sensitive receptors within the Stonington study area include numerous recreational areas (5), nursing homes (2), schools (3), a cemetery, churches (2), and the Barn Island Hunting Area.

Stonington Paralleling Station. Located at MP 134.65 on the southern side of the railroad, this proposed facility would be located within a wooded wetland area (Volume II, Sheet 9). The nearest residential development is northwest of the site and is buffered by a substantial wooded area.

State Line Paralleling Station. Located at MP 139.93 on the southern side of the railroad, this proposed facility would be located within a wooded area on an undeveloped section of a lot on which an oil company operates (Volume II, Sheet 10). The land north, south, and east of the site is undeveloped, and buildings and storage tanks exist to the west.

1.2.1.16 Westerly, Rhode Island. Approximately 5.3 miles of the NEC pass through this town for which no switching or substations are proposed (Volume II Sheets 10 and 11). The area north of the NEC is characterized primarily by multi-use industrial and commercial activities, with the exception near Stonington (west) where there are high density residential uses. To the south of the NEC dense residential uses stretch from the Stonington border (west) to RI Route 78. The remainder of the corridor includes low density residential uses, open space, protected land, and a small area of mixed-use development. Sensitive receptors within the Westerly study area include: recreation areas (2), Burlingame State Park, Chapman Pond, a nursing home, churches (3), and a library.

Bradford Paralleling Station. Located at MP 145 19 on the northern side of the railroad, this proposed facility would be located within a completely undeveloped section of Westerly (Volume II, Sheet 11).

1.2.1.17 Hopkinton, Rhode Island. Approximately 1.0 mile of the NEC pass through this town for which no switching, paralleling, or substations are proposed (Volume II, Sheets 11 and 12). The entire section of the NEC runs through an undeveloped area, a large portion of which are wetlands.

1.2.1.18 Charlestown, Rhode Island. Approximately 4.6 miles of the NEC pass through this town for which no switching, paralleling, or substations are proposed (Volume II, Sheets 11-13). Some low density residential development exists on both sides of the corridor. In addition, there are some industrial uses within a large industrial zone in the south-central section of the corridor. The majority of Charlestown is characterized by open space and conservation areas. Protected land in Charlestown consists of the Burlingame State Park Management Area near Hopkinton (west) and the Great Swamp Management Area near Richmond (east), both of which are found on both sides of the railroad. The Pawcatuck River and associated wetlands also contribute to the open space character of this section. Other sensitive receptors within the Charlestown study area include a school, state protected areas (2), a church, and a recreation site.

Burdickville Road Bridge. Located at MP 148.41, and requiring no detour, this bridge is situated in a region which is completely undeveloped and wooded, with the exception of a residence located on the south approach (Volume II, Sheet 12).

1.2.1.19 Richmond, Rhode Island. A total of approximately 3.7 miles of the NEC traverse this town in three places (Volume II, Sheets 12 and 13). No paralleling or substations are proposed for these areas. The majority of the land is open space with low density residential zoning. The Great Swamp Management Area, a large protected open space district, is located on both sides of the track near the Hopkinton border (west). No other sensitive areas are located in Richmond. South of the NEC three industrial clusters which abut the ROW are intermingled with open space and residential development.

Richmond Switching Station. Located at approximately MP 150.35 on the northern side of the railroad, this proposed facility would be located in an undeveloped area just west of the Pawcatuck River (Volume II, Sheet 12). The only nearby use, which is industrial in nature, is located northwest of the site across Route 91.

Kenyon School Road Bridge. Located at MP 154.04, this bridge is situated in a primarily undeveloped area which contains some residential development (Volume II, Sheet 12). An industrial complex also exists to the south. A detour of approximately 2.6 miles, which passes through primarily undeveloped areas, would be required for a duration of three months.

1.2.1.20 South Kingstown, Rhode Island. Approximately 4.5 miles of the NEC pass through this town for which no switching or substations are proposed (Volume II, Sheets 13 and 14). The Great Swamp Management Area comprises over half of the South Kingstown section of the corridor and is on both sides of the railroad. The remainder of the land is zoned for very low density residential use, although a small section of medium density residences, along with some commercial and industrial uses, surround Kingston Station. Numerous wetlands and other environmentally sensitive features are scattered throughout the landscape. These areas include the University of Rhode Island facilities, which are to the east towards North Kingstown, Hundred Acre Pond, and Thirty Acre Pond.

Kingston Paralleling Station. Located at MP 157.11 on the southern side of the railroad, this proposed facility would be located in a wooded area delineated by the railroad to the north and Great Neck Road to the south and east (Volume II, Sheet 13). Undeveloped land exists across the railroad; beyond the woods to the west is a commercial area.

RI Route 138 Bridge. Located at MP 158.32, and requiring no detour, this bridge is situated within a small area of concentrated development in the vicinity of Kingston Station (Volume II, Sheet 13). This area is characterized by industrial and agricultural uses to the north, some commercial uses to the south, and low density residential uses beyond.

1.2.1.21 Exeter, Rhode Island. Approximately 1.7 miles of the NEC pass through this town for which no switching or substations are proposed (Volume II, Sheet 14). North of the NEC are rural residential uses of very low density near North Kingstown (west) and low density near East Greenwich (east). South of the NEC industrial uses are near North Kingstown and low density residential development occurs near East Greenwich. Agricultural uses, mainly turf farming, are prevalent in the areas abutting the right-of-way. A groundwater aquifer recharge zone in the vicinity of the East Greenwich border (east) is the only sensitive receptor in the Exeter study area.

Exeter Paralleling Station. Located at MP 161.78 on the southern side of the railroad, this proposed facility would be located in a rural area between Slocum Road and the railroad (Volume II, Sheet 14). To the south are a small wooded area, turf fields, and one residence. Yorker Mill Pond is located on the opposite side of the railroad to the north.

1.2.1.22 North Kingstown, Rhode Island. Approximately 7.9 miles of the NEC pass through this town for which no switching or substations are proposed (Volume II, Sheets 14-16). On both sides of the ROW most of the land use adjacent to the railroad is industrial, with some commercial and medium to low density residential uses distributed throughout. In addition, there is a large parcel of vacant U.S. Naval property in Davisville which is located south of the NEC. Undeveloped and open space areas are more prevalent towards Exeter (west) than East Greenwich (east). Sensitive receptors within the North Kingstown study area include: schools (2), parks (2), well sites (7), churches (6), nursing homes (2), and cemeteries (2).

East Greenwich Paralleling Station. Located at MP 169.80 on the southern side of the railroad, this proposed facility would be located in a vacant area across the railroad from a lumber yard (Volume II, Sheet 16). The land to the east and south is vacant, as is the land to the west up to Post Road (Route 1).

1.2.1.23 East Greenwich, Rhode Island. Approximately 1.3 miles of the NEC pass through this town for which no switching, paralleling, or substations are proposed (Volume II, Sheets 15 and 16). North of the NEC East Greenwich is characterized by industrial, commercial, and residential development. The commercial and industrial uses tend to abut the railroad while high density residential uses lie beyond. The region to the south contains commercial and industrial development abutting the railroad. The existing residential uses in this area consist primarily of high density development. Open and protected areas make up more than half of the south side of the corridor, including Greenwich Cove and Goddard State Park. Sensitive receptors within the East Greenwich study area include: recreational areas (5), churches (4), schools (2), a hospital, and a hospital.

1.2.1.24 Warwick, Rhode Island. Approximately 7.7 miles of the NEC pass through this city for which no paralleling or switching stations are proposed (Volume II, Sheets 16-18). North of the corridor near East Greenwich (west) is primarily medium density residential development. Commercial uses are prevalent in the Apponaug section of Warwick and industrial functions dominate the area from the beginning of Jefferson Avenue to the Cranston border (east). Apponaug Cove covers the majority of the area south of the NEC from East Greenwich (west) to West Shore Road (east). High density residential uses lie between the Cove and the Greenwood section of Warwick. From there, industrial and commercial uses are prevalent to the Cranston border (east). T.F. Green State Airport accounts for a large portion of the area south of the corridor. In addition, because of Greenwich Bay, Apponaug Cove, and other salt and fresh water resources, many sensitive recreational sites (parks, marinas, beaches) are located within the Warwick study area in addition to three schools and a cemetery.

Warwick Substation. Located at MP 176.91 on the northern side of the railroad, this proposed facility would be located in an industrial area on a parcel which contains a building supply company (Volume II, Sheet 18). North and south of the site are commercial offices while industrial uses are west of the site. Across the railroad, approximately 150 feet, are residential uses. An existing warehouse associated with the supply company would have to be removed before the substation could be constructed.

Pettaconsett Avenue Bridge. Located at MP 178.46, the area north of this bridge is commercial and industrial in nature, and the area to the south is high density residential (Volume II, Sheet 18). A detour of approximately 0.9 miles, which passes through primarily high density residential development, would be required for a duration of 4.5 months.

1.2.1.25 Cranston, Rhode Island. Approximately 2.0 miles of the NEC pass through this city for which no switching, paralleling, or substations are proposed (Volume II, Sheets 18 and 19). To the north, between the railroad and I-95, are industrial and manufacturing uses and a small commercial district near Wellington Avenue. Beyond I-95 is high density residential development and a small commercial district adjacent to Park Avenue. While industrial uses are the most prominent south of the NEC, this area also contains high density residential uses and a large commercial district bordering on Elmwood Avenue. Sensitive receptors within the Cranston study area include: schools (2), parks and recreation sites (3), churches (2), a funeral home, and elderly housing.

Park Avenue Bridge. Located at MP 180.29, this bridge is situated in an area which is predominantly industrial (Volume II, Sheet 18). The residential areas that do exist are high density and primarily multi-family. A detour of approximately 2.8 miles, which passes through industrial and high density residential development, would be required.

1.2.1.26 Providence, Rhode Island. Approximately 6.8 miles of the NEC pass through this city for which no switching or substations are proposed (Volume II, Sheets 18-20). Most of the land directly abutting the railroad to the north is industrial, beyond which are commercial and high density residential uses. To the south residential uses are prominent near Cranston (west), and non-residential uses are prevalent from I-95 to the Pawtucket border (east). Because of the highly urbanized character of Providence there are many public and private facilities that are sensitive receptors. These include: schools (18), recreation sites (24), churches (7), a hospital, elderly housing, a cemetery, and a library.

Elmwood Paralleling Station. Located at MP 181.70 on the southern side of the railroad, this proposed facility would be located in a vacant area that formerly served as a parking area for the Gorham Plant Complex, next to Mashapaug Pond (Volume II, Sheet 19). Across the railroad to the north is a commercial building; Mashapaug Pond to the south and east, and two garages and another parking area are to the west.

1.2.1.27 Pawtucket, Rhode Island. Approximately 2.6 miles of the NEC pass through this city for which no switching or substations are proposed (Volume II, Sheets 20 and 21). Between the Providence border (west) and the Pawtucket River, industrial and commercial functions characterize the majority of the NEC area. High density residential uses make up the rest of the corridor and are clustered primarily in the Woodlawn area, in the vicinity of Weeden Street, and in the Darlington section west of I-95. Sensitive receptors within the Pawtucket study area include: schools (9), recreation sites (11), libraries (2), churches (2), and a cemetery.

Providence Paralleling Station. Located at MP 187.55 on the southern side of the railroad, this proposed facility would be located in a vacant industrial area between the railroad to the north and I-95 to the south (Volume II, Sheet 20).

1.2.1.28 Central Falls, Rhode Island. Approximately 0.6 of a mile of the NEC passes through this city for which no switching, paralleling, or substations are proposed (Volume II, Sheets 20 and 21). The north side of the corridor is characterized by a mix of commercial and industrial activities near and abutting the railroad, and high density residential development beyond. To the south are mostly commercial uses, with some industrial uses along the Pawtucket River and some scattered high density residential uses. Sensitive receptors within the Central Falls study area include: schools (4), recreation sites (3), churches (3), a nursing home, a hospital, and a library.

1.2.1.29 Attleboro, Massachusetts. Approximately 8.5 miles of the NEC pass through this city for which no substations are proposed (Volume II, Sheets 21-23). To the north, from the Pawtucket (west) border to the center of the city, is a mix of industrial and medium density residential uses surrounded by large, undeveloped, wooded areas. The center of the city contains industrial and commercial uses, with a significant amount of residential development on its outskirts. From the center to the Mansfield border (east), large undeveloped tracts are dominant. Similar patterns exist on the south side of the corridor. Sensitive receptors within the Attleboro study area include recreation areas (2), churches (2), and a school.

Attleboro Paralleling Station. Located at MP 193.40 on the northern side of the railroad, this proposed facility would be located in a vacant area between the railroad and some distant residential and industrial uses (Volume II, Sheet 21). Vacant areas exist to the south and west while an industrial use exists to the east and some residential uses are located north of the site.

Norton Switching Station. Located at MP 198.99 on the northern side of the railroad, this proposed facility would be located at the current site of an existing private grade crossing (Volume II, Sheet 22). The entire area is wooded with the exception of the residence served by the crossing which is directly adjacent to the proposed substation site.

1.2.1.30 Mansfield, Massachusetts. Approximately 5.5 miles of the NEC pass through this town for which no switching, paralleling, or substations are proposed (Volume II, Sheets 23 and 24). On both sides of the NEC there is low density residential development from the Attleboro border (west) almost to I-495, where industrial uses begin and continue until Route 140. Beyond Route 140 are a mix of medium to high density residential uses to the Foxboro border (east). Sensitive receptors within the Mansfield study area include the Canoe River Area of Critical Environmental Concern (ACEC), a school, churches (2), and recreation sites (2).

1.2.1.31 Foxboro, Massachusetts. Approximately 2.7 miles of the NEC pass through this town for which no switching or substations are proposed (Volume II, Sheet 24). Except for a small part of the northern section near Mansfield which contains industrial uses, the entire corridor is undeveloped or contains low density residential uses. A large part of this section is protected part of the Canoe River ACEC which is located west of I-495. Other sensitive receptors within the Foxboro study area include Fulton Pond, Sweets Pond, and other small waterbodies.

East Foxboro Paralleling Station. Located at MP 205.70 on the southern side of the railroad, this proposed facility would be located in an undeveloped and wooded area west of Summer Place (Volume II, Sheet 24). Directly across the railroad from the site is a residential dwelling. Some homes are also located behind (south) the site, although they are some distance away and are buffered by trees and open spaces.

1.2.1.32 Sharon, Massachusetts. Approximately 5.1 miles of the NEC pass through this town for which no switching or substations are proposed (Volume II, Sheets 24-26). This area contains six public well or well development sites, and therefore land use is restricted to low density development in an effort to protect ground and surface water resources. North of the NEC residential development is restricted from medium to low density. The area to the south, is similar with two exceptions. First, one large area near Foxboro (west) is very low density residential development, and second, a business district exists within Sharon Heights in the central part of the corridor. In addition to the well sites, sensitive receptors within the Sharon study area include the Fowl Meadow and Ponkapoag Bog ACEC, the Canoe River ACEC, recreation sites (4), a hospital, a funeral home, and a church.

Canton Paralleling Station. Located at MP 212.40 on the southern side of the railroad, this proposed facility would be located within a large wooded area (Volume II, Sheet 26). Residential areas to the south are buffered from the site by woods.

Depot Street Bridge. Located at MP 211.04, this bridge is situated adjacent to an MBTA commuter station in a primarily undeveloped area (Volume II, Sheet 25). In addition to the station, some residential development occurs adjacent to the street to the north and a major commercial area lies approximately 1/4 mile to the south. A detour of approximately 2.3 miles, which passes through low density residential uses and undeveloped areas, would be required for a duration of nine months.

Maskwonicut Street Bridge. Located at MP 211.62, this bridge is surrounded by wooded areas and residential development (Volume II, Sheet 25). The area north of the bridge is primarily undeveloped, with some medium density development along Maskwonicut Street. The area south of the bridge contains residential development along, above, and below Maskwonicut Street. A detour of approximately 2.3 miles, which passes through low density residential uses and undeveloped areas, would be required for a duration of three months.

1.2.1.33 Canton, Massachusetts. Approximately 3.7 miles of the NEC pass through this town for which no switching, paralleling, or substations are proposed (Volume II, Sheets 26 and 27a). The majority of the area north of the NEC is industrial, commercial, and undeveloped. Near Sharon (east), low density residential uses exist. South of the NEC are medium to low density residential. As the railroad approaches Westwood (east), the land uses change to light industrial which continue to the Westwood border. Sensitive receptors within the Canton study area include the Fowl Meadow and Ponkapoag Bog ACEC, schools (3), a library, and public trail sites (2).

1.2.1.34 Westwood, Massachusetts. Approximately 0.8 of a mile of the NEC passes through this town for which no switching, paralleling, or substations are proposed (Volume II, Sheet 27). This section of the corridor contains industrial uses, wetlands, and some open space. A portion of one sensitive receptor, the Fowl Meadow and Ponkapoag ACEC, exists in Westwood.

1.2.1.35 Dedham, Massachusetts. Approximately 1.7 miles of the NEC pass through this town for which no switching, paralleling, or substations are proposed (Volume II, Sheet 27). The majority of the Dedham section contains undevelopable wetlands which are part of the Neponset River Reservation and the Fowl Meadow and Ponkapoag Bog ACEC. Some industrial uses exist at both ends of the corridor near Westwood (west) and Boston (east). Also, high density residential uses are found to the north near Boston.

1.2.1.36 Boston, Massachusetts. Approximately 10.1 miles of the NEC pass through this city (Volume II, Sheets 27-29) for which no switching stations are proposed. Boston's metropolitan character makes it difficult to describe all of the approximately 10.1 miles of the Boston section of the NEC except in general terms. This area contains numerous uses and densities, many of which are intermingled. Many sensitive receptors such as a portion of the Fowl Meadow and Ponkapoag Bog ACEC, schools (52), recreation areas (37), hospitals (10), churches (5), nursing homes (4), and libraries (2) also exist in the Boston study area.

Roxbury Crossing Substation. Located at MP 226.02 on the northern side of the railroad, this proposed facility site, which is in an industrial district, would be located on a primarily undeveloped site, with the exception of an existing pumping station (Volume II, Sheet 29). The site is abutted by: Gurney Street to the north; the railroad to the south; Tremont Street to the east; and Station Street to the west. Uses directly abutting the site are industrial and commercial with residential uses beyond. The corresponding 300 foot underground utility corridor is located within the Tremont Street ROW.

Readville Paralleling Station. Located at MP 219.10 on the southern side of the railroad, this proposed facility would be located in a small vacant area on MBTA property which is the MBTA/NEC mainline and two freight rail lines (Volume II, Sheet 27).

1.2.2 Prime and Important Farmland

Prime and other farmland of statewide and local importance refer to land which contains soil types which are determined to possess high agricultural value, or lands which are of value because of dependence on them for agriculture. The United States Department of Agriculture Soil Conservation Service (SCS) defines prime farmland as the land that is best suited to producing food, feed, forage, fiber, and oilseed crops. It also has the soil quality, growing season, and moisture supply needed to produce a sustained high yield of crops; and requires minimal amounts of energy and economic resources; and farming it results in the least damage to the environment. For an area to be identified as prime farmland it must be used for producing food or fiber or must be available for those uses. Thus, urban and built up land and water areas are not classified as prime farmland. This section identifies those proposed switching, paralleling, or substation sites and/or corresponding utility corridors which contain prime or important farmland, or land which has the potential for agricultural use as determined by the SCS.

1.2.2.1 Substations and Utility Corridors. The New London, Warwick and Roxbury Crossing substation sites and utility corridors contain no prime or important farmlands.

Branford Substation. While the proposed substation site does not contain prime or important farmland, its corresponding utility corridor does. This substation requires a 1,200 foot aerial feeder to supply power which will connect with an existing 115kV transmission line (Volume II, Sheet 1). The utility corridor is composed of two types of soils, Ludlow silt loam (LpB) and Whethersfield loam (WkC). LpB is considered a prime farmland soil because it is very suited to cultivated crops. WkC is considered a farmland soil of statewide importance and is primarily used for the production of corn, hay, fruit orchards and other ground cover crops. Although the aerial utility corridor may not prevent agricultural use on these properties, utility poles or apparatus may restrict agricultural operations.

1.2.2.2 Switching Stations. Of the three proposed switching station sites, the Norton site is the only site which does not contain a prime or other important farmland soil type. The Westbrook site contains Hinckley gravelly sandy loam, 3 to 15 percent slopes (HkC) which is considered an additional farmland of statewide importance. Although this soil is generally poorly suited to cultivated crops because of steep slopes some areas may be suitable for cultivation. The Richmond site contains Hinckley gravelly sandy loam, 0 to 3 percent slopes (HkA) which is an additional farmland of statewide importance. This soil is suitable for cultivated crops and most areas are farmed or idle.

1.2.2.3 Paralleling Stations. Many proposed paralleling station sites are not considered to be available for agricultural use because of their location in the ROW. Of those that were considered available, only one site, the proposed State Line paralleling station contains a prime or important farmland soil type. The State Line site contains Merrimac sandy loam, 0 to 3 percent slopes (MyB). This soil is well suited for cultivated crops because it is droughty during the dry summer periods, requires minimum tillage, and the hazard of erosion is slight.

1.2.3 Special Protected Areas

Protected areas include any region in which land use or development may be limited by covenants, easements, regulations, or other restrictions.

1.2.3.1 Areas of Critical Environmental Concern (ACEC). The Fowl Meadow and Ponkapoag Bog ACEC is located in corridor sections of Boston, Canton, Dedham, Sharon, and Westwood. The Canoe River ACEC is located in Foxboro, Mansfield, and Sharon. These protected areas are described in detail in Technical Study 11, Natural Resources. With the exception of the East Foxboro paralleling station, no substation, switching station, paralleling station, train station, or bridge modification falls within an ACEC boundary. Although the East Foxboro paralleling station encroaches upon the Canoe River ACEC, the extent to which the facility would be located in this protected area would be minimal, as described in the Natural Resources Study.

1.2.3.2 Coastal Zones. The coastal zone designation is made by each state pursuant to the Federal Coastal Zone Management Act, with special restrictions on such areas, as described in section 1.2 of this study. In Connecticut, the coastal zone consists of areas 1000 feet inland from coastal features (as designated by the Office of the Long Island Sound Program). As shown in Volume II, Sheets 1-10, the NEC study area from New Haven, CT to Stonington, CT enters and exits coastal zones throughout its span. The Branford substation and Millstone Point Road Bridge are the only proposed electrification facility or bridge modification sites located in the Connecticut coastal zone.

In Rhode Island, the coastal zone consists of areas 200 feet inland from coastal features (as designated by the Coastal Resources Management Council). As shown in Volume II, Sheets 10, 16, 17, and 19, the coastal zone boundary enters the NEC in Westerly, East Greenwich, and Providence. No proposed electrification facility or bridge modification sites are located in the Rhode Island coastal zone.

In Massachusetts, the coastal zone consists of all areas inland of coastal features up to the first major transportation route (as designated by the Office of Coastal Zone Management), plus 100 feet. Volume II, Sheet 1 shows coastal zone in the vicinity of South Station and surrounding areas in Boston, which are the only sections in Massachusetts which enter the coastal zone. No proposed electrification facility or bridge modification sites are located in the Massachusetts coastal zone.

1.2.3.3 Other Protected Areas. Aside from those previously mentioned, other protected natural areas exist throughout the area within one-half mile of the NEC. These include conservation areas, land trusts, state parks, dedicated open space, parks, and other protected areas. Because there are numerous protected parcels, including many of small acreage, only the major parks or management areas are listed in Table 1-1. All protected areas, in addition to those in Table 1-2, are included in Volume II and may fall under, but may not be limited to, the categories of protected open space, recreation and institutional, or wetlands.

1.2.4 Areas of Potential Secondary Development Effects

This section will concentrate on the five main train stations which are expected to serve as stops for the Boston, Massachusetts to New York, New York express trains. Because this project includes an existing railroad right-of-way and no major alignment or infrastructural modifications will take place, the land surrounding the stations listed below are the most likely places for secondary development impacts to be experienced. The main premise is that an increased

TABLE 1-1. OTHER PROTECTED AREAS

NAME	LOCATION	VOLUME II REFERENCE
Salt Meadow National Wildlife Refuge	Westbrook, CT	Sheet 5
Rocky Neck State Park	East Lyme, CT	Sheet 7
Bluff Point State Park	Groton, CT	Sheets 8 and 9
Haley Farm State Park	Groton, CT	Sheet 9
Burlingame Management Area	Charlestown, RI	Sheet 12
Great Swamp Management Area	Richmond, RI S. Kingstown, RI	Sheet 13
Goddard State Park	E. Greenwich, RI	Sheet 16
Canoe River ACEC	Foxboro, MA Sharon, MA Mansfield, MA	Sheets 24 and 25
Fowl Meadow and Ponkapoag Bog ACEC	Dedham, MA Canton, MA Boston, MA	Sheets 26 and 27

amount of patrons travelling through these stations could stimulate commercial development in their immediate vicinity.

1.2.4.1 South Station. South Station is currently a major interchange for many modes of transportation as well as a major business center (Volume II, Sheet 29). All of the land surrounding the station is developed and no substantial vacant areas exist.

1.2.4.2 Back Bay Station. Back Bay Station is very similar to South Station in that most of the land surrounding the station is developed, no substantial vacant areas exist, and it is part of the contiguous Boston business center (Volume II, Sheet 29). Despite this, some possible commercial opportunities exist. To the northwest, the proposed Pavilion development at Park Plaza could offer additional commercial services. And to the northeast two possibilities are a parcel currently serving as a ground level parking area which is delineated by Clarendon Street and Columbus Avenue, and the former Greyhound bus station on Saint James Street (Abrams, 1993).

1.2.4.3 Route 128 Station. Route 128 Station has many surrounding vacant areas. Some potentially developable areas exist in Westwood, Massachusetts. Although a large part of this area is protected as part of the Fowl Meadow Area of Critical Environmental Concern or are undevelopable because they are wetlands (Volume II, Sheet 27). Most of this area is already regulated by a strict water resource protection district but an industrial park is located south of the station off of University Avenue. One parcel and a few of the existing buildings within the park are vacant and have the potential to be commercially developed (Chiofolo, 1993). In Dedham no immediate opportunities exist because those areas which are not protected are zoned for residential development. In the future much or all of the area may be included within a water resource protection district when new town wells are drilled nearby (Zaleski, 1993).

1.2.4.4 Providence Station. Although Providence Station is within a highly urbanized area which already contains many commercial services, some areas exist where expansion of such services may occur (Volume II, Sheet 19). The CIC complex located south of the station between I-95, Promenade Street, West River, and Bath Street is a former manufacturing complex which may be targeted for mall development. Also, south of the station at the present site of the University of Rhode Island's Providence Campus (Hayes Street), Providence Place, a retail development may be built. Finally, another southern site is a wholesale food and produce center between I-95, I-195, Killingly Street, and Dean Street, which will soon be vacated (Mallo, 1993).

1.2.4.5 New Haven Station. The city of New Haven, although very developed, does contain vacant commercial properties and parcels surrounding the station which could potentially house new services (Volume II, Sheet 1). Some commercial development proposals are currently being considered including the Ninth Square Project, the Downtown South Project, and the Air Rights Super Regional Mall (Bolduc, 1993).

1.3 ENVIRONMENTAL CONSEQUENCES AND MITIGATION

This section provides a discussion and analysis of the impacts of the electrification project on land use in the corridor, particularly in the areas surrounding the proposed electrification facilities, and recommends actions to mitigate adverse impacts.

1.3.1 Impact Evaluation Criteria

Evaluation criteria are the measures against which anticipated impacts related to the electrification project are analyzed to determine their significance. The criteria for evaluating land use impacts address the compatibility of the proposed action with existing land uses and with land use policies and plans. The electrification project would create an adverse impact if any of its components or operations would result in:

- a direct conflict with Federal, state or local land use policies or plans, or surrounding land uses;
- severe limitations on the use of recreational facilities;
- adverse secondary growth impacts directly resulting from increased ridership at express stations;

- displacement of residential or commercial land use;

- taking of prime farmland or farmland of statewide importance currently in agricultural use or with a high potential for agricultural use;

Conflicts with land use policies, which are discussed in section 1.3.2.1, are possible anywhere within the project corridor. Adverse secondary growth impacts may occur only directly around the express stations in New Haven, CT; Providence, RI and at Route 128, Back Bay and South Station in Massachusetts. Severe limitations on the use of recreation facilities, displacement of existing land uses, or taking of prime or important farmland would only occur on the sites to be acquired by Amtrak - specifically, on proposed substation, switching station or paralleling station sites, collectively referred to as the electrification facilities. In addition, direct conflicts with land use policies and plans, as well as existing land use, may occur at these sites, which are described in section 1.3.3.

1.3.2 Land Use Impacts Resulting from the Overall Project

This section is divided into four parts. First, consistency of the overall project with land use policies and plans is evaluated. Second, project-induced limitations of the electrification project on the use of recreational facilities are identified. Third, the potential for secondary growth impacts around each of the express railroad stations is assessed. Finally, an assessment is made of the effects of the proposed electrification facilities siting on land use policies and plans, displacement of existing land uses, and the prime and important farmland.

1.3.2.1 Conflicts with Land Use Policies and Plans. The Federal, state and local land use policies and plans relevant to the electrification project are described in detail in section 1.1 of this study. Conflicts of the overall electrification project with these policies and plans are discussed below.

1.3.2.2 Conflicts with Federal Policies and Plans. There are five Federal land use policies relevant to this project, each of which is described in detail in section 1.1.1.

This EIS/R and its attendant technical studies, including this one, fulfill the requirements of The National Environmental Policy Act (NEPA), for ensuring that Federal agencies work toward assuring safe, healthful, productive, and aesthetically and culturally pleasing surroundings for all Americans, as well as the requirements of the FRA Procedures for Considering Environmental Impacts. The Federal Coastal Zone Management Act requires that Federal programs be consistent with state programs implemented under the Act, as well as with relevant air and water quality regulations. The state programs are discussed later in this section. Technical Studies 10 and 12, respectively, address consistency with Federal and state air and water quality regulations. The proposed electrification is not, overall, in direct conflict with the Federal Farmland Protection Policy Act or Section 4(f) of the Department of Transportation Act of 1966, which addresses impacts to recreational and cultural resources. The consistency of the individual electrification facilities siting with these Acts is evaluated in section 1.3.4.

1.3.2.3 Conflicts with Connecticut Policies and Plans. There are several Connecticut land use policies and plans relevant to this project, each of which is described in detail in section 1.1.2. The conflicts of the electrification project with these policies and plans are discussed below.

The electrification project does not conflict with the policies and goals of the Conservation and Development Policies Plan, which specifically endorses railroad electrification. The electrification project is also generally consistent with the Connecticut Transportation Improvement Program of (TIP) of 1992 and the Connecticut Transportation Plan Towards the Year 2000, which deal primarily with commuter rail services, but also support an improved regional transportation system.

The project is also consistent with the elements of Connecticut's Environment 2000 policy which promotes the utilization of vehicles with low level emissions and reduced reliance on single-occupancy vehicles. As the electromagnetic field (EMF) effects of the project are not expected to create impacts, as described in detail in Technical Study 5, the project does not conflict with the goal of protecting the public from harmful EMFs. Any adverse effects on the scenic character of Connecticut's coastline would conflict with Section 22a-93(15)(F) of the Connecticut Coastal Zone Management Act. As discussed in section 4.11 of the DEIS/R any visual impacts that would occur would be mitigated. In areas where the railroad right of way is currently used for access to beaches, fencing associated with the electrification project would conflict with the Statewide Comprehensive Outdoor Recreation Program (SCORP) of 1992. As discussed in the Public Safety Study (Technical Study Eight) no proposed fencing would reduce access to any recreational area.

1.3.2.4 Conflicts with Rhode Island Policies and Plans. There are four Rhode Island land use policies and plans relevant to this project, each of which is described in detail in section 1.1.3 of this study. Conflicts of the electrification project with these plans are discussed below.

The electrification project would further elements of the Rhode Island State Guide Plan and the Rhode Island Transportation Improvement Plan (TIP). The guide plan elements include improving existing transportation facilities, developing a more energy-efficient transportation system and using innovative technology. The TIP generally supports passenger rail. The proposed action would not conflict with any of the policies of the Rhode Island Comprehensive Planning and Land Use Regulation Act and also the Coastal Zone Management Program if it was determined that the catenary wires would not obstruct views along the coastal zone.

1.3.2.5 Conflict with Massachusetts Policies and Plans. There are several Massachusetts land use policies and plans relevant to this project, each of which is described in detail in section 1.1.4 of this study. Conflicts of the electrification project with these plans are discussed below.

The EIS/R and its attendant technical studies, including this one, fulfill the requirements of The Massachusetts Environmental Policy Act (MEPA), for evaluating the environmental impacts of a major development project. The project is not in conflict with the Statewide Comprehensive Outdoor Recreation Program (SCORP), Massachusetts Coastal Zone Management Act, or

Massachusetts Transportation Improvement Program because this project would not adversely affect prime farmlands or be detrimental to the coastal zone, and would attempt to improve air quality and maximize the mobility of people while minimizing transportation-related fuel consumption. Although the area between Back Bay to South Station is considered historic tidelands, the electrification would not involve use of additional tidelands seaward of the historic mean high-water line. Therefore, it does not conflict with Chapter 91 Waterways License and Permit Program.

1.3.2.6 Local Conflicts. The potential for conflicts with local policies and plans is important because the residents within the towns where facilities are proposed will be the most affected. Conflicts with local comprehensive plans, plans of development, and zoning ordinances are discussed below.

Comprehensive Plans/Plans of Development. None of the comprehensive plans or plans of development from the project communities address inter-city rail or rail projects of this size. This is not uncommon because these types of plans are not usually regional in nature and rarely discuss aspects beyond their borders. Sometimes inter-community coordination occurs but only if those communities share a common resource. Plans for cities which do discuss rail are often large in size and refer mainly to commuter rail and other mass transit opportunities. A relevant exception exists in North Kingstown, RI where the Town's comprehensive plan specifically discusses freight operations from the former Naval base in Davisville, including a provision for double-stack freight cars. Such operations have not yet been initiated and are not expected in the near future due to existing restrictions of the overhead roadway bridges. The proposed project does not directly conflict with community comprehensive plans or plans of development.

Zoning Ordinances. Zoning ordinances, as described in section 1.1.5.1, divide a municipality into districts in order to regulate the use of land, and should be directly related to the goals of plans of development and comprehensive plans. Table 1-2 indicates the proposed facility sites, their zoning districts, whether the site would conflict with the uses generally allowed in each zone, and with the existing land uses on the site.

1.3.3 Secondary Growth Impacts Around Express Stations

The expected increases in ridership outlined in Technical Studies Two (Socioeconomics) and Nine (Transportation) are not expected to generate adverse secondary growth impacts. Despite the expected increased stops at the five express stations, the existing and vacant commercial and retail services around the stations should accommodate any increased demand and the necessary infrastructure is in place to accommodate it. An exception is at Route 128 Station in which there is little existing commercial and retail space available and the majority of the undeveloped land is protected.

TABLE 1-2 FACILITY ZONING AND CONFORMANCE

FACILITY	ZONING	DIRECT CONFLICT WITH ZONING	DIRECT CONFLICT WITH EXISTING LAND USE
Branford SS	Public	no	no
Leetes Island PS	Residential 5	no***	no
Madison PS	Residential (RU-2)	no*	no
Grove Beach PS	Commercial (C)	no*	no
Westbrook SwS	Industrial (I-1)	no	no
Old Lyme PS	Industrial (LI-80)	no	no
Millstone PS	General Industrial (I-G)	no	no
New London SS	Commercial/Industrial (WCI)	no	no
Noank PS	Residential (R-20)	yes	yes
Stonington PS	Coastal (RC-120)	yes	no
State Line PS	Marine Commercial (MC-80)	no*	no
Bradford PS	Industrial (M-1)	no	no
Richmond SwS	Industrial (I)	no	no
Kingston PS	Industrial (M1)	no	no
Exeter PS	Industrial	no	no
East Greenwich PS	Industrial	no	no
Warwick SS	General Industrial	no	yes
Elmwood PS	Industrial (M1)	no	no
Providence PS	Industrial (MO)	no	no
Attleboro PS	Single Residence D	no**	no
Norton SwS	Single Residence D	no**	yes
East Foxboro PS	Residential (R-40)	no*	no
Canton PS	Single Residence A	no*	no
Readville PS	Industrial (M-1)	no	no
Roxbury Crossing SS	Industrial (M2)	no	no

KEY
SS - Substation
PS - Paralleling Station
SwS - Switching Station
***allowed with special use permit**
****public or private utilities for essential services permitted**
*****considered exempt (McAvoy, 1993)**

Sources: Municipal Zoning Departments, 1992

1.3.4 Site Specific Land Use Impacts

A site specific analysis was performed to determine if the project, specifically individual electrification facilities, would conflict with land use policies and plans, severely limit access to specific recreation sites, displace existing land uses, or take prime or important farmland. This section discusses those site specific impacts to surrounding areas or uses.

1.3.4.1 Prime Farmland. The Branford substation, Westbrook switching station, State Line paralleling station, and Richmond paralleling station sites are all located on soils identified as prime farmland or farmland of statewide importance. Currently none of these sites are in agricultural use nor do they have little potential for agricultural use due to surrounding land use and/or actual site conditions.

1.3.4.2 Rocky Neck Beach. The public's perceived fears of the EMF health effects may make some recreation sites less attractive to residents and visitors. One such site is Rocky Neck State Park in East Lyme, CT. Rocky Neck Beach directly abuts the ROW and although the catenary would be positioned very high because the ROW is elevated, the wires would be very visible to visitors there. Even though a conclusive link between EMF and health problems has not been proven, recreation sites near catenary components may experience a decrease in use due to negative public perceptions regarding EMF. However, no particular limitaıion to use of this site exists as a result of the proposed action.

1.3.4.3 Noank Paralleling Station. The site of the proposed Noank paralleling station at Groton, CT currently serves as the parking lot for Esker Point Beach, a town recreation facility. As currently proposed, this facility would require taking much of the lot, which is generally filled to capacity most summer days. There is no other parking available, and therefore, vehicular access to the beach would be restricted.

Section 4(f) of the Department of Transportation Act of 1966 (Section 1.1.5) provides that the Department may not approve a project that involves the use of any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, State, or local significance or any land from an historic site of national, State or local significance unless there is no prudent or feasible alternative to such use and the project includes all possible planning to minimize harm resulting for the use.

1.3.4.4 Stonington Paralleling Station. Location of the proposed facility at this site conflicts with an approved development plan which includes the facility site property. According to the plan, the facility falls within the boundaries of two residential lots and the intersection of two roads. However, this site is not likely to be developed due to wetlands restrictions and economic conditions (Dodd, 1993).

1.3.4.5 Warwick Substation. Placement of this facility at the proposed site would displace an existing commercial use. Since this proposed site is not vacant, the current use would have to be displaced in order for the facility to be constructed. The current use, a lumber company, would have to relocate because the site is not large enough to accommodate both the substation and the main warehouse which is located within the boundary of the substation. Because the existing use would be displaced, this facility would adversely affect the existing use.

1.3.4.6 Norton Switching Station. Placement of this facility at the proposed site would displace an existing residential use. Because the station site is located on a residential parcel and is very close to the primary residence, and the proposed use would not conform to the existing use, the residents would be required to relocate. Because the existing use would be displaced, this facility would adversely affect the existing use.

1.3.4.7 East Foxboro Paralleling Station. Although the majority of the East Foxboro paralleling station is sited in the MBTA right-of-way, part of the facility falls within the Canoe River Area of Critical Environmental Concern (ACEC) boundary. Despite this, no adverse impacts would occur because the majority of the site is located within the MBTA ROW and there would be no affect on nearby water resources (Fougere, 1993).

1.3.5 Summary of Impacts and Mitigation

Potential adverse impacts are expected at four electrification facility sites. The Warwick substation, Norton switching station, and the Noank paralleling station would conflict with existing or surrounding land. The Warwick and Norton site impacts would be mitigated under the auspices of Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 and subsequent regulations, since Amtrak has eminent domain powers.

Location of the Noank paralleling station in the recreational facility parking lot would constitute a use within the meaning of section 4(f). FRA has contracted Amtrak regarding the applicability of section 4(f) to this part of this project plans and suggested that the paralleling site be relocated. If it is found that it is not feasible or prudent to relocate this site outside this recreation area, the Final EIS/R will include a section 4(f) determination and will document the analysis required to make the necessary findings.

APPENDIX A
Land Use by Municipality

Appendix A. Land Use by Municipality – Connecticut

Municipality		Transpo. and Other	Open Space	Water	Wetlands	Parks, Rec. & Inst.	Agriculture	Residential	Commercial	Industrial	TOTAL (acres/%)
New Haven	Acres	362	385	214	175	7	81	1,253	874	352	3,702
	%	10	10	6	5	0	2	34	24	10	100
East Haven	Acres	94	340	58	47	17	61	509	108	4	1,238
	%	8	27	5	4	1	5	41	9	0	100
Branford	Acres	263	1,534	291	336	30	236	1,475	141	11	4,316
	%	6	36	7	8	1	5	34	3	0	100
Guilford	Acres	84	1,283	120	557	34	216	496	8	3	2,801
	%	3	46	4	20	1	8	18	0	0	100
Madison	Acres	310	1,261	114	279	20	173	751	45	1	2,954
	%	11	43	4	9	1	6	25	2	0	100
Clinton	Acres	310	1,077	96	234	6	144	562	57	7	2,494
	%	12	43	4	9	0	6	23	2	0	100
Westbrook	Acres	284	1,251	79	201	10	83	386	21	0	2,315
	%	12	54	3	9	0	4	17	1	0	100
Old Saybrook	Acres	389	1,169	169	326	6	89	461	116	5	2,730
	%	14	43	6	12	0	3	17	4	0	100
Old Lyme	Acres	188	1,789	213	202	17	305	573	7	0	3,294
	%	6	54	6	6	1	9	17	0	0	100
East Lyme	Acres	142	802	220	41	20	58	565	36	1	1,884
	%	8	43	12	2	1	3	30	2	0	100
Waterford	Acres	261	1,384	213	126	7	123	425	38	9	2,587
	%	[illegible]	54	8	5	0	5	16	1	0	100
New London	Acres	274	83	112	7	3	21	513	311	8	1,332
	%	[illegible]	6	8	1	0	2	39	23	1	100
Groton*	Acres	704	1,642	357	117	21	154	1,211	147	4	4,357
	%	[illegible]	[illegible]	8	3	0	4	28	3	0	100
Stonington	Acres	572	1,861	369	198	17	214	1,194	113	2	4,539
	%	[illegible]	[illegible]	8	4	0	5	26	2	0	100

KEY: Acres (white cells); Percent of Total (shaded cells)

*Includes both the city and town of Groton

Source: Applied Geographics Inc., 1992.

Appendix A. Land Use by Municipality – Rhode Island

Municipality	Transpo. and Other	Open Space	Water	Wetlands	Parks, Rec. & Inst.	Agriculture	Residential	Commercial	Industrial	TOTAL (acres/%)
Westerly	37	1,090	235	622	60	99	845	140	278	3,406
	1	32	7	18	2	3	25	4	8	100
Hopkinton	0	446	48	230	3	15	11	0	2	755
	0	59	6	30	0	2	1	0	0	100
Charlestown	0	2,043	73	490	2	265	322	24	63	3,281
	0	62	2	15	0	8	10	1	2	100
Richmond	2	676	69	671	0	194	200	6	40	1,858
	0	36	4	36	0	10	11	0	2	100
South Kingstown	13	957	175	919	12	656	213	69	60	3,073
	0	31	6	30	0	21	7	2	2	100
Exeter	0	671	22	120	29	192	129	0	12	1,175
	0	57	2	10	2	16	11	0	1	100
North Kingstown	141	1,669	33	855	139	636	890	133	460	4,958
	3	34	1	17	3	13	18	3	9	100
East Greenwich	9	76	7	53	73	6	332	158	18	733
	1	10	1	7	10	1	45	22	2	100
Warwick	64	615	82	242	158	84	1,718	573	879	4,415
	1	14	2	5	4	2	39	13	20	100
Cranston	11	43	28	51	12	0	549	121	367	1,180
	1	4	2	4	1	0	47	10	31	100
Providence	124	72	129	14	425	0	1,402	976	991	4,132
	3	2	3	0	10	0	34	24	24	100
Central Falls	0	7	7	5	8	0	186	146	89	449
	0	2	2	1	2	0	41	33	20	100
Pawtucket	12	82	27	26	137	0	844	366	519	2,013
	1	4	1	1	7	0	42	18	26	100

KEY: (unshaded) Acres; (shaded) Percent of Total

Source: Applied Geographics Inc., 1992.

Appendix A. Land Use by Municipality – Massachusetts

Municipality	Transpo. and Other	Open Spac[e]	Water	Wetlands	Parks, Rec. & Ins[t]	Agricultur[e]	Residential	Commercia[l]	Industrial	TOTAL (acres/%)
Attleboro	251	1,925	51	185	36	243	1,564	206	448	4,909
	5	39	1	4	1	5	32	4	9	100
Mansfield	123	1,719	37	70	35	172	839	93	243	3,329
	4	52	1	2	1	5	25	3	7	100
Foxboro	14	1,032	32	74	0	0	364	0	26	1,541
	1	67	2	5	0	0	24	0	2	100
Sharon	39	1,745	31	137	4	38	1,231	24	28	3,277
	1	53	1	4	0	1	38	1	1	100
Canton	208	936	12	568	3	18	866	111	130	2,851
	7	33	0	20	0	1	30	4	5	100
Westwood	4	30	0	55	0	0	62	0	223	373
	1	8	0	15	0	0	17	0	60	100
Dedham	58	73	2	278	0	171	0	0	37	620
	9	12	0	45	0	28	0	0	6	100
Boston	796	498	29	67	101	29	3,816	997	281	6,613
	12	8	0	1	2	0	58	15	4	100

KEY: Acres / (shaded) Percent of Total

Source: Applied Geographics Inc., 1992.

APPENDIX B
Sensitive Receptors in the NEC Study Area

APPENDIX B. SENSITIVE RECEPTORS IN THE NEC STUDY AREA

Community	School	Recreation Site	Library	Hospital	Nursing Home	Cemetery	Church	Funeral Home
CONNECTICUT								
New Haven	8	7	1	3	1	0	16	1
East Haven	0	2	1	0	1	0	1	0
Branford	1	5	2	0	0	0	1	0
Guilford	0	2	0	0	0	0	0	0
Madison	1	5	1	0	0	1	0	0
Clinton	2	2	0	0	1	3	4	1
Westbrook	3	5	1	0	0	0	1	0
Old Saybrook	3	2	0	0	2	1	0	1
Old Lyme	0	5	0	0	0	0	0	0
East Lyme	0	4	0	0	0	0	0	2
Waterford	1	10	0	1	0	0	0	0
New London	2	7	0	2	1	0	1	3
Groton*	3	9	0	0	2	0	0	0
Stonington	3	5	0	0	2	1	2	0
RHODE ISLAND								
Westerly	0	2	1	0	1	0	3	0
Hopkinton	0	0	0	0	0	0	0	0
Charlestown	1	1	0	0	0	0	1	0
Richmond	0	0	0	0	0	0	2	0
South Kingstown	0	0	0	0	0	0	1	0
Exeter	0	0	0	0	0	0	0	0
North Kingstown	2	2	0	0	2	2	6	0
East Greenwich	2	5	0	1	0	0	4	0
Warwick	3	5	0	0	0	1	3	0
Cranston	2	3	0	0	1	0	2	1
Providence	18	24	1	1	2	1	7	0
Central Falls	4	3	1	1	1	0	3	0
Pawtucket	9	11	2	0	0	1	2	0
MASSACHUSETTS								
Attleboro	1	2	0	0	0	0	2	0

APPENDIX B. SENSITIVE RECEPTORS IN THE NEC STUDY AREA (CONTINUED)

Community	School	Recreation Site	Library	Hospital	Nursing Home	Cemetery	Church	Funeral Home
Mansfield	1	1	0	0	0	0	1	0
Foxboro	0	1	0	0	0	0	0	0
Sharon	0	4	0	1	0	0	1	1
Canton	3	0	1	0	0	0	0	0
Westwood	0	0	0	0	0	0	0	0
Dedham	1	0	0	0	0	0	0	0
Boston	52	37	2	10	4	0	5	0

*Includes both the city and town.

REFERENCES

Abrams, 1993. Personal communication with Marianne Abrams, Back Bay Association, by James Duncan of DMJM/Harris. January 11, 1993.

Bolduc, 1993. Personal communication with Phillip R. Bolduc, Zoning Director, City of New Haven, by James Duncan of DMJM/Harris. January 11, 1993.

Chiofolo, 1993. Personal communication with Marie Chiofolo, Westwood Planning Department, by James Duncan of DMJM/Harris. January 12, 1993.

Dodd, 1993. Personal communication with Stephen J. Dodd, President, Lord's Point Association Inc., by James Duncan of DMJM/Harris. May 27, 1993.

Fougere, 1993. Personal communication with James Fougere of The Smart Associates, by James Duncan of DMJM/Harris. June 3, 1993.

Mallo, 1993. Personal communication with Bruno Mallo, Providence Planning Department, by James Duncan of DMJM/Harris. January 11, 1993.

McAvoy, 1993. Personal communication with Bill McAvoy, Zoning Enforcement Officer, Town of Guilford, CT, by James Duncan of DMJM/Harris. June 9, 1993.

Zaleski, 1993. Personal communication with Alexander V. Zaleski, Director of Planning, Dedham Planning Department, by James Duncan of DMJM/Harris. January 12, 1993.

TECHNICAL STUDY 2
SOCIOECONOMICS

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TECHNICAL STUDY 2
SOCIOECONOMICS

2.0 INTRODUCTION

Socioeconomic analysis is vital to determining the social impacts on residents and businesses which would be created by a proposed action. This section provides the background, framework, and results of the socioeconomic impact analysis and is organized into three elements: applicable regulations to which the analysis must conform or address, the existing environment with respect to the project scope, the anticipated environmental consequences of the proposed action, and the recommended actions which would mitigate them.

2.1 REGULATORY SETTING

Although not specifically addressed in state or Federal regulations, socioeconomic impacts are discussed generally in NEPA and MEPA. NEPA contains a goal addressing fulfillment of the social and economic requirements of present and future generations of Americans, and the balancing between population and resource use which will permit higher standards of living and a wide sharing of life's amenities. NEPA requires Federal agencies to identify and compare the potential economic and social effects of proposed alternatives. MEPA requires that in the decision-making process, state agencies balance critical environmental, economic, and social objectives.

2.2 AFFECTED ENVIRONMENT

The project alternatives may result in a range of public and private socioeconomic impacts during construction and operation. The potential geographic and institutional extent of such impacts will be identified and their significance evaluated. Socioeconomic aspects such as real estate values, local tax revenues, employment, income, tourism and effect on minority populations are discussed below.

2.2.1 Real Estate Values

The proposed project may produce negative externalties such as increased noise and vibration, electromagnetic fields, visual intrusions, decreased access, and other impacts which may have adverse effects on the value of adjacent properties. These effects are discussed in other technical reports, but their potential effects on property values will be included in this report. Residential uses within the areas directly abutting the railroad (one whose lot shares a boundary with the railroad property) are most susceptible to the effects of such externalities while those buffered by other uses or distance will be affected less. Generally, the greater the distance between a site and the extent of a project, the smaller the effect of the project on the site. Residential uses directly abut the railroad right-of-way in all communities throughout the corridor except in Hopkinton, Rhode Island and Westwood, Massachusetts.

Real estate taxes are assessed for each property in a community and are based on the assessed value of a piece of land plus any structures located on it, multiplied by the local tax rate. The tax rate is defined as the mil rate, or tax per $1,000 of value, which is determined by the community. Since real estate reassessments are not performed yearly, and do not always reflect current values, a percentage of assessed value (percent of valuation) is often applied to reflect the current value of property and to ensure fair taxation. If values in a community have decreased since the last reassessment, the percent of valuation will be less than one hundred percent, and if property values have risen the opposite is true.

Table A-1 in Appendix A lists total assessed value, residential and non-residential mil rates, percent of valuation, and year of the last reassessment for each community within the project scope. As shown, the total assessed value of real estate is highest in Boston, Massachusetts at $28,265,659,108 and lowest in Exeter, Rhode Island at $65,763,084. The community with the highest mil rate is New Haven, Connecticut at $79.80/$1000 and that with the lowest is Westerly, Rhode Island at $10.64/$1000. Finally, percent of valuation ranges from 100% in many communities to 31.5% in New Haven.

2.2.2 Tax Revenues

The tax base of a community is made up of sales, school, excise (automobile), personal property, and most importantly, real estate taxes, which are the highest revenue producers. Negative externalities such as those mentioned previously have the potential to adversely affect the attractiveness, and thus, the value of affected properties; the number of tourists at affected sites; and the revenues collected by a community. Table A-2 in Appendix A lists the total taxes collected (revenues) by the communities within the project. As shown, Boston, Massachusetts with $626,703,693 collects the most taxes, and the city of Groton, Connecticut with $3,359,974, collects the least.

2.2.3 Employment

This project may have an affect on employment during and after construction. Depending on the employment opportunities created, a demand for both temporary and permanent employees may arise. Community employment characteristics may dictate whether a community will be able to provide the necessary workers and facilities or whether other regions will be drawn upon. As shown in Tables A-3 a and b in Appendix A, the service industry is the leading employer in 32 of the 36 project communities.

2.2.4 Income

Median income is a general measure of the income characteristics of a population and represents the middle number of all incomes if arranged from lowest to highest. This measure is preferred to the mean or average income because it is not unduly influenced by very low or very high numbers, as is the mean. A higher median income is symbolic of a more affluent population.

As shown in Table A-4 in Appendix A, median income in the corridor ranges from a high in Madison, Connecticut of $61,871 to a low in Central Falls, Rhode Island of $18,617.

2.2.5 Tourism

Tourism generates personal income, tax revenues, and creates employment opportunities. The attractiveness of an area is a key factor in its ability to lure tourists. Any element which reduces or increases the appeal for or access to attractions could greatly affect both business and tax revenues, as well as employment and income in a region. Tourism usually generates a demand for goods and services from the following industries: public transportation, auto transportation, lodging, food service, entertainment, recreation, and general retail trade. Connecticut tourism would likely be the most affected by the project because the NEC traverses the majority of the coastline in this state. As such, this area attracts many visitors and seasonal residents. Externalities such as access, noise, and aesthetics, which will be discussed in greater detail by other sections of the DEIS/R, may substantially affect tourism. Table A-5 in Appendix A outlines tourism revenues throughout the project area.

2.2.6 Minority Populations

As discussed in section 1.2.1, the majority of the NEC runs through vacant land and sparsely populated rural areas without concentrated minority populations, as well as both high and low income areas. The cities of New Haven, Providence, and Boston contain the highest concentrations of minority populations. In New Haven, the NEC runs through two minority neighborhoods, Hill and Fair Haven, in which large proportions of Afro-Americans and Hispanics reside (Ford, 1993). The Providence section of the NEC runs through industrial areas, except for a small section of multi-family residences near Huntington Avenue where the railroad is depressed (Mallo, 1993). The Boston portion of the NEC runs through three minority neighborhoods: Roxbury, which is primarily Afro-American; Jamaica Plain which is primarily Hispanic; and Hyde Park which is a mix of minorities and non-minorities. The Roxbury Crossing substation, located in the minority neighborhood of Roxbury in Boston, is one of two substations proposed in close proximity to residential areas.

2.2.7 Freight Operations

As discussed in Technical Study Nine, Transportation, Traffic, and Circulation, two freight railroads operate within the NEC, Consolidated Rail Corporation (Conrail) and the Providence and Worcester Railroad (P&W). Conrail operates freight service along NEC route segments in Massachusetts and P&W operates along the NEC in Connecticut and Rhode Island.

2.3 IMPACTS AND MITIGATION

This section analyzes the anticipated impacts of the project on employment, income, property values, tax revenues, tourism, and minority populations. Mitigation recommendations are provided for areas where adverse impacts are expected.

2.3.1 Employment and Income Impacts

This project is expected to have a slight positive effect on employment and income in all three states, particularly in those communities containing the five express stop train stations. Both the construction period and operation of the completed system would produce direct and indirect employment benefits. Direct impacts are those relating to jobs generated by the project, including new, permanent Amtrak positions and temporary positions associated with construction of the project. Indirect impacts are the spin-off effects of increased business orders (equipment and other goods) associated with the project and impacts due to increased consumer spending by the additional workers or riders drawn to the region. In general, however, the anticipated 269-279 permanent and 600-700 temporary positions directly created by the project would have a minimal but beneficial effect on the three state regions, as this constitutes only 0.1% of the current total employment for the project communities.

2.3.1.1 Permanent Employment Impacts. The permanent positions are necessary for the general operation and maintenance of the NEC mainline, as well as railroad station staffing and other employment linked to the project. All the permanent railroad related-positions would be supplied by Amtrak. The projected new permanent employment for Amtrak, listed below in Table 2-1, totals approximately 320-330 employees (Alberstat, 1993). It is expected that 71 new positions would be required for on-board, crew, and support services. A total of 12 support staff, to be based in Boston, would include a combination of computer entry clerk, crew clerk, train manager, on-board services chief, commissary worker, and commissary supervisor positions. On-board services crews would most likely consist of a total of 59 personnel with three lead service attendants in each high-speed trainset. Although these crews would be based in Boston, New York, and Washington, the number of crews to be assigned to each city is not yet available. New train station positions would include various combinations of the following positions: ticket agent, usher, red cap, and extra board. The geographic distribution of the 42 projected new station positions are shown in Table 2-1. Train and engine crews would consist of an engineer, a conductor, and an assistant conductor on high-speed trainsets creating a total of 75 new positions. A total of 12 new maintenance of way personnel, stationed at the New Haven, New London, or Providence maintenance of way facilities, would be required for jobs involving a combination of electric traction and communication and signals positions. About 120-130 new maintenance of equipment positions would be created as a result of the project. Based either the New Haven or Boston maintenance of equipment stations, these positions would include coach cleaner, electrician, foreman, machinist, sheet metal worker, carman (mechanic), and pipe fitter.

Other permanent employment may be generated by new demand for retail services around the express stations as a result of increased pedestrian and vehicular traffic generated by the anticipated increases in ridership. As discussed in section 1.2.4 of the Land Use Study, express service railroad stations with available land or space near them have the greatest potential for business development. Any new development built or commercial space filled to meet demand in these areas would create new employment opportunities for each station community.

TABLE 2-1. ESTIMATED NUMBER OF PERMANENT RAILROAD-RELATED POSITIONS RESULTING FROM THE BUILD SCENARIO

POSITION TYPE	LOCATION	NO. OF POSITIONS CREATED	TOTAL WAGES[1]
On-board Service Support	Boston	12	573,600
On-board Service Crews	Boston, New York City Washington, D.C	59	2,495,700
Station Staffing	South Station Back Bay Route 128 Providence New London New Haven	9 7 5 10 4 7	1,709,400
Train and Engine Crews	Boston, New York	24[2]	1,228,800
Maintenance of Way Personnel	Boston or New Haven	12	592,800
Maintenance of Equipment Personnel	Boston or New Haven	120-130	5,700,000-6,175,000
TOTAL		269-279	12,300,300-12,775,300

[1] Average annual salary including benefits, in current dollars at current wages.
[2] Fifty-one additional existing positions would be transferred from New Haven to either New York or Boston.

Source: Amtrak, 1993

Available land and commercial space is most prevalent around Providence and New Haven and least prevalent around South Station and Route 128 Station.

As a result of this project, South Station would experience an increase of 21% (4,601 passengers) over the current number of approximately 21,910 total Amtrak and commuting passengers using this station daily. Back Bay Station would experience an increase of 11% (1,403 passengers) over the current number of 12,759 total passengers using this station daily. Route 128 Station would experience an increase of 110% (2,941) over the current number of approximately 2,674 total passengers using this station daily. Providence Station would experience an increase of 159% (2,722 passengers) over the current number of approximately 1,712 total passengers using this station daily. New Haven Station would experience an increase of 28% (1,504 passengers) over the current number of approximately 5,372 total passengers using this station daily. Each of these changes could have a minor effect on local retail business expansion or development and consequently, on employment.

2.3.1.2 Temporary Employment Impacts. All employment related to the construction phases of the project, including design and construction of the electrification facilities and bridge construction, would be temporary. The types of jobs typically created for this type of construction, as defined by the U.S. Census Bureau Industry-Occupation tables, are construction trades, laborers, electricians, machinery and vehicle equipment operators, managers, office workers, and other transportation workers. The project design and management is being performed by the joint venture of Morrison Knudsen/L.K. Comstock/Spie Group (Joint Venture) from their offices based in Dedham, Massachusetts. Approximately 50 individuals have been hired or transferred by the joint venture to the Boston area for the design stages of the project. About 1.5 million manhours per year are expected to go into design and construction for a three-year period (Gazillo, 1993). Construction would be performed by union members of the International Brotherhood of Electrical Workers (IBEW). IBEW Local 42 would perform work in Connecticut, and IBEW Local 104 would perform work in Rhode Island and Massachusetts. Some local contractors would be hired in each region for additional functions in the area (Gazillo, 1993). Bridge improvement design and construction would be put out to bid on each of the 9 bridges individually, and would involve local contractors. While this could create new jobs, more likely it would temporarily maintain current employment levels and/or reduce the number of layoffs. Some of the temporary work also would include Amtrak employees involved with construction, such as foremen, inspectors, flagmen, and other construction workers.

About 26 new trainsets are likely to be ordered for use in the NEC as part of the NECIP electrification (Carol, 1993). Since Amtrak design specifications for the new trainsets have not yet been completed, it is difficult to predict the expected employment for, or duration of, the manufacturing process. The likely bidders for trainset construction, and their nearest manufacturing plants, are: Morrison Knudsen Corporation, in Hornell, NY; Asea Brown Boveri Corporation (ABB Traction) in Elmira Heights, NY; and Bombardier Corporation in Barre, VT. The effect of the manufacturing process on local economies is unclear because the production site is unknown. Despite this, the lack of suitable facilities in any of the project states is likely to restrict assembly from taking place there and limit the local economic benefit.

2.3.1.3 Income Impacts. There would not be a change in the median income for the project communities. The income of the individuals to be employed might increase, but the amount of additional income generated would be so small it would have no overall regional affect on median income. There would, however, be a indirect benefit of new income as a result of transferring in or hiring new employees and increased ridership. New business income would be created by new sales in areas including hotel accommodations, restaurant sales, clothing sales, entertainment and attraction sales, and rents.

2.3.2 Property Value Impacts

Many transportation facilities, such as airports, highways and railroads may generate external effects, such as noise, traffic, potential public health risks (pollution), visual intrusions and other factors of possible negative impact. It is possible that any one of these aspects can affect residential property values and be reflected in sale prices or rents of such properties. However, these environmental factors usually account for only a small proportion of housing price differentials. The major determinants of the differences between prices of different properties at a particular point in time are house quality and size, lot size and characteristics of the municipality (e.g. tax rate) and the quality of services (e.g. schools) (Abelson, 1979). Major determinants of the difference in the price of a single property over time are demand, interest rates and the regional economy. Nevertheless, environmental factors do generally have some effect on residential property values and pertinent situations are described below.

Because each of the properties that could potentially be affected by the proposed project are already sited in proximity to a working railroad, it is anticipated that only those elements of the proposed project that are substantially new and different from the existing situation would have an effect on property values. Such elements are those associated with the actual electrification of the corridor, rather than those associated with operation of the electrified railroad. They include the overhead catenary system (OCS); the electrification facilities (substations, switching stations and paralleling stations); and the transmission lines that will supply power from the local utilities to the substations and subsequently, to the OCS. Any effects of these facilities on property values would likely be the result of actual or perceived effects that they may have on existing environmental conditions, particularly visual intrusions and the public health effects of EMF. Thus, this section addresses the potential for such impacts to adversely affect residential property values.

A literature search was conducted to identify studies which address the effects of railroad electrification or catenary system visual intrusions and public health effects on property values. No literature was found which specifically addresses the effects on property values of a catenary system or its components. However, assuming that such effects could perhaps be inferred from studies of related topics, literature on the effects of a variety of related topics were examined and it was determined that the available literature on the property value effects of transmission lines were most relevant. The methods and results of this evaluation are presented below.

2.3.2.1 Database Search. Several environmental, energy, and general databases were searched for literature relevant to the secondary effect on property values of direct impacts associated with this project. An abstract of each database can be found in Appendix A of this study. The TRIS database (1968 - present) provides transportation research information on air, highway, rail, and other transportation modes. Environline (1971 - present) indexes over 5,000 international sources of publications reporting on all aspects of the environment, including periodicals, government and industry reports, proceedings of meetings, newspaper articles, films, and monographs. Environmental Bibliography (1973 - present) covers more than 300 periodicals in the fields of general human ecology, atmospheric studies, energy, land resources, water resources, nutrition, and health. Electric Power Database (1972 - present) covers U.S. and Canadian research on 13 major electric power categories including hydroelectric power, fossil fuels, nuclear power, transmission, economics, and environmental assessment. Energy, Science & Technology (1974 - present) is a U.S. Department of Energy database that covers journal articles, reports, conferences, books, patents and dissertations on nuclear, wind, fossil, geothermal, tidal, and solar energy and related topics such as environment, energy policy and conservation. As described above, the search for pertinent data uncovered nothing based exclusively on railroad improvements or electrified high speed rail, its components, or their impact on property values. However, some information was found which dealt with related topics including electric transmission lines, EMF, and aesthetics.

2.3.2.2 Results of the Literature Search. The possible effect of a high voltage overhead transmission line on residential property values has been of continuing interest to electric public utilities and residential property owners located in the immediate vicinity of the proposed alignments for new transmission lines (Blinder, 1979). Many studies have been performed to determine whether or not electrical facilities have an impact on property values but there is no clear answer among the collective literature on this subject. Some studies found a negative impact, some a positive impact, and still others were inconclusive. Mountain West Research performed a review of empirical studies pertaining to the effects of transmission lines on property values and found 27 fundamental studies. Of those, ten found that transmission lines had no adverse effect on land values, ten were inconclusive, and five concluded that the overall effect of transmission lines on land was negative (Furby, 1987). Surveys of professional appraisers found that they almost uniformly maintain that transmission lines rarely reduce the value of residential properties they cross or lie near. Both Furby and Blinder felt, however, that the quality of the transmission line studies varied widely and that many were improperly conducted, subjective or not comprehensive enough.

While Furby concluded that most of the 27 studies were methodologically flawed and have not produced useful data, two studies were found to be relatively more sound in methodology. Significantly, both of these studies were among the five that concluded that the construction of transmission lines adversely affect land value. In a 1979 study, Colwell and Foley used regression analysis to demonstrate that in two central Illinois neighborhoods, a negative relationship exists between selling price and proximity to transmission lines for residential properties within 200 feet of the line. In the second study Boyer (1978) found that agricultural properties with transmission line easements were found to have lower per acre values than those without such easements. This latter study is less relevant to the proposed project, however, because the easements are known to inhibit efficient farm operations, by, for example, requiring circuitous routes for moving equipment, which could be responsible for a majority of the effects.

While most of the 27 studies Furby reviewed deal with properties on which easements have been granted, mention of decreases in value of adjoining land is common in the literature. Obstruction of favored views, for example, may lead to decreases in the selling price of properties (Furby, 1987). In most cases, however, such properties are not legally eligible for compensation. In some cases proximity damages may be granted for visual damages (Kellough, 1980). Compensation for aesthetic losses is usually denied, however, not because such claims are not legitimate, but based on the claim that such payments would constitute an unfair burden on the taxpayers or ratepayers. Decisions that endorse this principle attribute no value to the losses.

As noted earlier, many studies were found to be improperly conducted, subjective, or not comprehensive. Also many of the 27 studies were conducted at a time when the publics's perception of transmission line effects, their attitudes toward technology, their feelings regarding their social and legal rights, and their willingness to accept biological and environmental risks were quite different than today (Furby, 1987). Today people are better informed about scientific and technological information (some of which may be unproven or inaccurate) and are less willing to subject themselves to situations they perceive as harmful. Wall (1972) found that this greater awareness adds to the subjectivity of some impact analysis, property values assessment, and court decisions because they are often based on emotion, prejudice, or sentiment rather than on facts. Although scientific opinion varies widely about whether EMF causes cancer, for example, public apprehension over potential EMF hazards has prompted a host of political, legal, and market reactions. These include delays in power line construction, growing numbers of court filings involving EMF-induced health damage, property value losses along transmission corridors, the introduction of "low-field" consumer and office products, and the growing tendency of utilities to adopt design measures for new powerlines that reduce EMF exposure (Florig, 1992). Although electric transmission lines have recently been portrayed as high EMF producers, electric appliances and household wiring often pose the largest exposure to EMF. Public perception research performed to date has shown, for instance, that people are much less concerned about EMF risks from household sources than they are about EMF risks from transmission lines (Morgan, 1988), even though household sources may be more harmful. Therefore, a definite link between EMF and cancer has not been accepted by the scientific community but public perception of potential harm could potentially affect the value of properties near EMF sources.

2.3.2.3 Limitations to the Analysis. Correlating property value effects with the characteristics of transportation facilities is an inexact "science" in which findings of no effect occur with significant frequency. For the most part, the studies surveyed do not attempt to attribute the effect on property values to a specific external effect of transmission lines, but rather attribute the effect to the transmission lines in general. Although it is generally assumed from the literature and demonstrated public perceptions that the environmental effects of the project most likely to have a property value effect are visual intrusions and perceived EMF effects, limits on the precision of the reported studies limit the ability to make inferences from these studies on the property value effects of the proposed project.

By studying the effects of such related subjects, this analysis can only attempt to forecast the possible impact the proposed project would have on property values. Caution must also be applied in making broad assumptions in regard to the similarity of the effects of the subjects discussed in the literature and the proposed project. The transmission lines and electrification facilities associated with the proposed project are of a much smaller scale than the standard transmission lines and facilities addressed in the literature. While the OCS is similar to transmission lines in that it is a series of overhead wires, the number and size of the wires is substantially smaller and the poles hardly resemble transmission towers. While this is less relevant to the perceived EMF impacts and resultant property value effects, it is an important difference in drawing conclusions about visual intrusions and the resultant property value effects.

Finally, many transmission lines were constructed before technological advances were made and EMF concerns arose, thus conventional wiring configurations did not attempt to mitigate EMF emissions. Today there are ways to design current carrying equipment so that EMF is greatly reduced and these techniques are incorporated into this project (See "Mitigation" in Technical Study 5). If the public is made aware of the technological advances that would be used, their response to EMF could be less negative and thus the potential impact on property values less significant.

2.3.2.4 Application of the Literature and Property Values. Assuming that: 1) the property value approach is a viable method for estimating the effects of environmental impacts on property values and 2) some of, or parts of the studies discussed above are relevant to the proposed project, then some inferences can be drawn regarding the potential effects of the electrification proposal on property values. These studies show that there can be a range of effects on property values as a result of the proximity of transmission lines. These inferences include:

- The electrification project may result in an adverse effects on property values as a result of the direct visual intrusions of the project. These effects can be identified but not quantified.

- Any adverse property value effects would only occur at properties with favored, or unusual aesthetic visual character, where that visual character is intruded upon by the proposed project. Specifically, these properties include those along Long Island Sound in Branford and Stonington, Connecticut and those along Greenwich Bay in Warwick, Rhode Island that are listed in Table 2-2 and discussed in detail in section 4.11 of the DEIS/R (Volume I) as being adversely affected by the proposed project.

- The property value effects attributable to the visual intrusion of the overhead catenary system (OCS) will be substantially less notable than the impacts described in the literature for transmission lines because the OCS is significantly less intrusive.

- There may be property value effects attributable to perceived EMF effects of the project. These effects would be most adverse for properties in closest proximity to the substations and OCS, and least adverse for properties further from these facilities. Properties that may be adversely affected by EMF's are generally identified in Technical Study 5 (Electromagnetic Fields and Interference). However, this information is unrelated to existing public perceptions regarding EMF effects. Therefore, those properties that are likely to suffer such effects are those closest to the facilities but the effects cannot be quantified.

- Property value effects attributable to perceived EMF impacts may be short-term if media attention on the subject dies down. Conversely, should the media focus on this subject continue, the effects may be longer lasting.

TABLE 2-2. VISUAL MODIFICATION DETERMINATIONS FOR VISUALLY SENSITIVE RECEPTORS

LOCATION OF VISUALLY SENSITIVE RECEPTOR	VISUALLY SENSITIVE RECEPTOR	DISTANCE (in ft.) FROM VSR	VIEW FROM VSR	VISUAL COMPLEXITY	VMC[1]
33 Thimble Island Rd. Branford, CT	Residence	240	Long Island Sound	High	2
45 Thimble Island Rd. Branford, CT	Residence	320	Long Island Sound	Moderate	4
49 Thimble Island Rd. Branford, CT	Residence	500	Long Island Sound	High	3
53 Thimble Island Rd. Branford, CT	Residence	470	Long Island Sound	Moderate	3
59 Thimble Island Rd. Branford, CT	Residence	160	Long Island Sound	Moderate	4
63 & 71 Thimble Island Rd. Branford, CT	Residence	160	Long Island Sound	Moderate	4
76 Thimble Island Rd. Branford, CT	Residence	350	Long Island Sound	High	3
78 Thimble Island Rd. Branford, CT	Residence	350	Long Island Sound	High	3
82 Thimble Island Rd. Branford, CT	Rectory	340	Long Island Sound	High	2
W. of 229 Leetes Island Rd. Guilford, CT	View from Road	320	Cockaponset State Forest	Moderate	4
229 Leetes Island Rd. Guilford, CT	Residence	200	Long Island Sound	High	2
429 Stone House Lane Guilford, CT	Residence	140	Long Island Sound	High	2
40 Nod Place Guilford, CT	Residence	30	L.I. Sound/East R.	High	2
21 Clark St. Old Saybrook, CT	Residence	170	Connecticut R. & Long Island Sound	High	2
45 Old Black Point Rd. East Lyme, CT	Residence	60	Wooded area, Pettagansett River	High	3
43 Old Black Point Rd. East Lyme, CT	Residence	50	Wooded area, Pettagansett River	High	3
265 Lake Shore Rd. Waterford, CT	Residence	730	Wooded area, Jordan Cove	High	2
268 Lake Shore Rd. Waterford, CT	Residence	730	Wooded area, Jordan Cove	Moderate	2
71 Lamphere Rd. Waterford, CT	Residence	360	Wooded area, Jordan Cove	Moderate	3
211 Seneca Drive Groton, CT	Residence	140	Residential uses, Palmer Cove	Moderate	4
235 Seneca Drive Groton, CT	Residence	160	Palmer Cove, L.I. Sound, Esker Point Beach	Moderate	4
Groton Long Point Rd. Groton, CT	View from Road	920	Palmer Cove	Low	2
239 Elm St. Groton, CT	Residence	1600	Beebe Cove	High	1
63 Cedar Rd. Groton, CT	Residence	1100	Mystic River	Moderate	3

TABLE 2-2, CONTINUED. VISUAL MODIFICATION DETERMINATIONS FOR VISUALLY SENSITIVE RECEPTORS

LOCATION OF VISUALLY SENSITIVE RECEPTOR	VISUALLY SENSITIVE RECEPTOR	DISTANCE (in ft.) FROM VSR	VIEW FROM VSR	VISUAL COMPLEXITY	VMC[1]
21 Buttonwood Lane Groton, CT	Residence	480	Mystic Harbor	High	2
20 & 23 Wilcox Ave. Stonington, CT	Residence	170	Long Island Sound, vegetation	Low	4
34 Wilcox Ave. Stonington, CT	Residence	130	Long Island Sound	Moderate	4
36 Wilcox Ave. Stonington, CT	Residence	170	Long Island Sound	Low	4
44 Wilcox Ave. Stonington, CT	Residence	250	Long Island Sound	Low	4
162 Wilcox Ave. Stonington, CT	Residence	480	Long Island Sound	Low	2
Harbor View Ter. Stonington, CT	View from Road	1280	Stonington Harbor	Moderate	1
3 Lambert's Lane Stonington, CT	Residence	880	Stonington Harbor	Moderate	1
13 Lambert's Lane Storington, CT	Residence	880	Stonington Harbor	Moderate	1
End of Summit St. Stonington, CT	View from Road	140	Long Island Sound	Low	4
13 Bayview St. Stonington, CT	Residence	80	Long Island Sound	Low	4
Elihu St. Stonington, CT	Residence	50	Long Island Sound	Low	4
15 Bradley St. Stonington, CT	Residence	40	Long Island Sound	Moderate	4
8 Cheesbro St. Stonington, CT	Residence	320	Wequetequock Cove	Moderate-High	4
End of Island Rd. Stonington, CT	View from Road	80	Wequetequock Cove	Moderate	3
9 Ladd Rd. Warwick, RI	Residence	50	Greenwich Cove/Bay	Low-Moderate	4
7 Ladd Rd. Warwick, RI	Residence	50	Greenwich Cove/Bay	Moderate	3
20 Blackstone St. Warwick, RI	Residence	125	Greenwich Bay	Moderate-High	3
10 Williams St. Warwick, RI	Residence	125	Greenwich Bay	Moderate	2
5 Williams St. Warwick, RI	Residence	125	Greenwich Bay	Low	3
4496 Boston Post Rd. Warwick, RI	Condos	75	Greenwich Bay	Low	4
4490 Boston Post Rd. Warwick, RI	Condos	50	Greenwich Bay	Low	4
4480 Boston Post Rd. Warwick, RI	Condos	50	Greenwich Bay	Low	4
4456 Boston Post Rd. Warwick, RI	Residence	125	Greenwich Bay	Moderate	3
4158 Boston Post Rd. Warwick, RI	Condos	125	Greenwich Bay	Low	4
4090 Boston Post Rd. Warwick, RI	Condos	125	Greenwich Bay	Low	4

TABLE 2-2, CONTINUED. VISUAL MODIFICATION DETERMINATIONS FOR VISUALLY SENSITIVE RECEPTORS

LOCATION OF VISUALLY SENSITIVE RECEPTOR	VISUALLY SENSITIVE RECEPTOR	DISTANCE (in ft.) FROM VSR	VIEW FROM VSR	VISUAL COMPLEXITY	VMC[1]
3986 Boston Post Rd. Warwick, RI	Nursing Home	500	Greenwich Bay	Moderate-High	3

* Depicted in Figures 4.11-1 through 4.11-10.
[1] Visual Modification Classification (VMC) of 3 of 4 indicates an adverse impact.

- Finally, reduced values on some properties in a community could result in a lower tax base on which the community raises its revenue. As a result, communities must either forgo some revenues, or increase the tax rate, transferring the tax burden to all other property owners in the community. This indirect impact of property value effects is not expected to be notable.

2.3.3 Tourism Impacts

Tourism is a significant contributor to the local economy in the coastal Connecticut area traversed by the NEC. The beaches in this area draw visitors from throughout the region. Mystic Seaport and Aquarium in Stonington, Connecticut is one of the largest tourist attractions in the state, drawing visitors from all over the United States. Both access and aesthetics are important elements of the attractiveness to visitors of these resources. Changes in these elements may have an effect on their attractiveness to visitors, and thus, on the regional economy.

It is not expected that the electrification project would adversely affect access to the attractions that draw visitors to coastal Connecticut. In fact, the more comfortable trains and more frequent service may encourage additional tourism in this area. As indicated in the Visual Impact Assessment (Technical Study 11), no adverse visual effects are anticipated in public locations that attract tourism. The databases listed in section 2.3.2.1 were searched for literature relevant to the impacts on tourism and recreation of electrification facilities. No literature on this subject or related subjects was found as a result of the search.

2.3.4 Minority Population Impacts

Over the years some major transportation projects have been targeted for areas that contain minority populations because such populations often lack the organization or power to prevent them. The resulting negative effects of projects such as highway construction include the disruption of neighborhood cohesion, increases in crime, noise, and pollution, and an overall adverse effect on quality of life. As discussed in section 1.2.1 , the majority of the NEC runs through vacant land and sparsely populated rural areas without concentrated minority populations, as well as through both high and low income areas.

The cities of New Haven, Providence, and Boston contain the highest concentrations of minority populations. In New Haven, the NEC runs through two minority neighborhoods, Hill and Fair Haven, in which large proportions of Afro-Americans and Hispanics reside (Ford, 1993). In both of these areas, the railroad is fully depressed to reduce its impacts. The Providence section of the NEC runs through industrial areas, except for a small section of multi-family residences near Huntington Avenue where the railroad is depressed (Mallo, 1993). The Boston portion of the NEC runs through three minority neighborhoods: Roxbury, which is primarily Afro-American; Jamaica Plain which is primarily Hispanic; and Hyde Park which is a mix of minorities and non-minorities. The railroad in the Roxbury and Jamaica Plain neighborhoods is fully depressed but it varies from at grade to depressed in Hyde Park (McBride, 1993). Given the fact that this is an existing railroad and is depressed below grade in the majority of the areas populated by minorities, this project is not expected to adversely affect the minority populations. For substations, the facility at Roxbury Crossing, which would be located in a minority neighborhood, is one of two substations proposed for residential neighborhoods. The other proposed substation, in Warwick would be located adjacent to a primarily Caucasian population. Since these facilities are proposed for both minority and non-minority neighborhoods, minority populations would not be disproportionately affected. However, other studies within this report may find adverse impacts at specific locations which would require mitigation before the project could proceed.

2.3.5 Impact on Freight Operations

As discussed in Technical Study Nine, if the NEC is electrified three aspects would have the greatest impact on freight operations: the increased number of passenger trains operating in the corridor, height restrictions created by the catenary, and construction impacts. Impacts related to construction would be minimal since most construction would occur at night while the majority of freight operations occur in the daylight hours. Although the catenary could restrict the use of double stack and enclosed automobile carrier cars in the NEC, other major restrictions exist which would also restrict their use, namely existing height and width restrictions in tunnels and at numerous overhead bridge locations. The most immediate concern would be the anticipated increase in the number of high speed and conventional passenger trains operating in the NEC. Electrification could create operational delays and/or restrictions which could create additional operating costs, force operators to abandon or curtail current service, or restrict business expansion. The Providence and Worcester Railroad Company anticipates that electrification could force P&W to reschedule, curtail, or abandon all or most of its shoreline operations resulting in substantial revenue and employment losses. Conrail is primarily concerned with restrictions to future double stack car operations in Massachusetts.

2.3.6 Summary of Impacts

No adverse impacts to employment, income, or tourism, or minority populations are expected to result from the proposed electrification project.

No literature could be found which specifically addresses the effects of the railroad electrification, visual intrusion of railroads, or public health effects of railroads on property values. Although there are limitations to their similarity, some inferences can be drawn from the literature on the property value effects of transmission lines. First, the proposed electrification may have an adverse effect on property values as a result of visual intrusions. This impact would occur only at properties with existing favored views or unusual aesthetic visual character. Such properties are listed in Table 2-2 and discussed in detail in Section 4.11 of the DEIS/R (Volume I). Public perceptions regarding the health effects of EMF may also have a adverse effect on property values. As these effects are determined by perceptions rather than by quantifiable EMF levels, the geographic extent of such effects can not be identified. It is presumed, however, that those properties closest to the electrification facilities would suffer the greatest effects, while those further away would not be adversely affected. None of the adverse impacts on property values are likely to adversely affect local municipal revenues.

Impacts to freight operations are expected due to the increased number of passenger trains operating on the NEC, and because of height restrictions and construction activities. As suggested in Technical Study Nine, these aspects should be addressed in detail in the Final EIS/R.

APPENDIX A
Data Tables

TABLE A-1. COMMUNITY TAX CHARACTERISTICS

Municipality	Total Assessed Value	Mil Rate/$1000		Percent of Valuation		Last Assessment
		Residential	Non-residential	Residential	Non-residential	
CONNECTICUT						
New Haven	3,432,879,018	79.80	same as residential	31.5	same as residential	1991
East Haven	885,861,041	34.67	same as residential	70	same as residential	1991
Branford	1,654,424,759	20.60	same as residential	70	same as residential	1991
Guilford	856,577,640	31.86	same as residential	70	same as residential	1985
Madison	1,219,617,445	21.20	same as residential	70	same as residential	1990
Clinton	60[illegible] 978,856	26.12	same as residential	70	same as residential	1990
Westbrook	453,846,556	18.60	same as residential	70	same as residential	1991
Old Saybrook	1,083,265,593	13.60	same as residential	70	same as residential	1989
Old Lyme	698,922,969	15.40	same as residential	70	same as residential	1990
East Lyme	709,540,940	25.00	same as residential	70	same as residential	1991
Waterford	3,517,015,960	12.66	same as residential	70	same as residential	1986
New London	802,932,031	27.72	same as residential	70	same as residential	1988
Groton-city	338,926,810	40.97	same as residential	70	same as residential	1982
Groton-town*	533,019,732	33.90	same as residential	70	same as residential	1982
Stonington*	608,484,510	32.25	same as residential	70	same as residential	1984
RHODE ISLAND						
Westerly	2,007,874,990	10.64	same as residential	100	same as residential	1990
Hopkinton	126,529,060	38.37	same as residential	80	same as residential	1982
Charlestown	444,076,580	17.89	same as residential	100	same as residential	1984
Richmond	239,483,872	19.24	same as residential	80	same as residential	1991
South Kingstown	791,767,345	26.92	same as residential	100	same as residential	1983
Exeter	65,763,084	51.56	same as residential	60	same as residential	1982
North Kingstown	777,344,534	30.64	same as residential	100	same as residential	1982
East Greenwich	611,202,900	25.40	same as residential	100	same as residential	1986
Warwick	2,949,934,800	31.00	same as residential	100	same as residential	1985
Cranston	2,144,147,900	36.84	same as residential	100	same as residential	1983
Providence	5,434,818,100	28.17	same as residential	65	100	1988
Central Falls	154,298,000	55.50	same as residential	100	same as residential	1983
Pawtucket	1,024,518,575	37.60	52.09	100	same as residential	1983
MASSACHUSETTS						
Attleboro	1,639,839,5[illegible]0	11.77	19.38	100	same as residential	1992
Mansfield	1,229,292,7[illegible]0	12.28	14.31	100	same as residential	1990
Foxboro	963,122,100	13.49	same as residential	100	same as residential	1992
Sharon	1,010,174,300	18.24	same as residential	100	same as residential	1992
Canton	1,688,218,700	11.27	14.95	100	same as residential	1992
Westwood	1,275,516,250	12.80	25.55	100	same as residential	1991
Dedham	1,671,698,335	11.89	25.90	100	same as residential	1992
Boston	28,265,659,108	12.88	39.99	100	same as residential	1992

***The value listed represents the town-wide mil rate for which an additional district rate is levied depending on location.**

Sources: Municipal Tax Assessors' Offices, 1992

TABLE A-2. TAX BASE INFORMATION BY COMMUNITY

Municipality	Total Taxes Collected	Total Real Estate Taxes Collected
CONNECTICUT		
New Haven	121,133,565	83,026,224
East Haven	26,429,760	21,902,226
Branford	37,202,727	33,675,075
Guilford	28,168,537	24,830,306
Madison	24,898,160	NA
Clinton	16,680,010	NA
Westbrook	7,691,683	NA
Old Saybrook	14,734,102	12,646,715
Old Lyme	10,448,988	NA
East Lyme	18,319,265	NA
Waterford	43,889,167	41,890,748
New London	24,842,421	20,018,240
Groton-city	3,359,974	NA
Groton-town	39,359,974	NA
Stonington	20,492,482	17,469,573
RHODE ISLAND		
Westerly	19,162,190	NA
Hopkinton	5,541,229	NA
Charlestown	7,157,600	NA
Richmond	5,078,033	NA
South Kingstown	23,402,006	NA
Exeter	4,274,435	NA
North Kingstown	25,077,463	22,585,503
East Greenwich	15,770,963	13,869,985
Warwick	104,816,150	86,421,458
Cranston	73,639,118	NA
Providence	165,821,000	NA
Central Falls	10,120,541	NA
Pawtucket	53,337,726	46,602,502
MASSACHUSETTS		
Attleboro	29,322,937	20,123,699
Mansfield	15,556,913	14,593,444
Foxboro	12,376,314	12,065,427
Sharon	18,722,635	17,564,748
Canton	21,323,623	19,935,950
Westwood	20,576,382	18,612,368
Dedham	25,715,237	23,822,750
Boston	626,703,693	531,206,182

NA-real estate collections not generally listed separately and therefore this information is not available.
Sources: Municipal Tax Collectors' Offices, 1992

TABLE A-3A. MUNICIPAL EMPLOYMENT BY INDUSTRY

Municipality	Agriculture	Mining	Construction	Manufacturing	Transportation	Communications	Wholesale Trade	Retail Trade	Finance	Services	Public Administration	TOTAL
New Haven	243	17	2,267	9,545	1,961	1,855	1,813	8,060	3,418	26,473	2,526	58,178
New Haven	79	22	1,009	2,687	768	552	726	2,406	1,166	4,043	442	13,900
Branford	120	22	995	2,510	605	634	660	2,614	1,293	5,904	464	15,821
Guilford	153	37	677	1,991	360	466	467	1,634	725	4,301	231	11,062
Madison	74	0	498	1,305	233	302	325	1,302	856	2,648	216	7,759
Clinton	135	0	491	1,398	234	321	413	1,342	506	2,067	133	7,040
Westbrook	45	0	210	536	92	113	85	534	195	963	74	2,847
Old Saybrook	71	7	382	941	139	199	211	1,041	353	1,478	159	4,981
Old Lyme	44	0	384	520	96	165	73	486	295	1,154	172	3,389
East Lyme	111	7	547	1,490	169	386	180	1,291	526	2,700	497	7,904
Waterford	44	6	666	1,902	228	339	214	1,578	440	3,056	598	9,071
New London	128	15	755	2,225	354	213	260	2,191	570	4,952	708	12,371
Groton*	99	11	1,053	4,403	476	369	251	3,254	693	5,213	959	16,781
Stonington	114	7	601	2,476	234	231	155	1,574	400	2,694	379	8,865
Westerly	61	32	668	2,554	234	272	174	2,130	572	3,223	459	10,379
Hopkinton	117	10	275	1,183	138	19	106	547	126	769	66	3,356
Charlestown	116	0	271	638	47	51	70	660	101	1,098	152	3,204
Richmond	62	0	214	733	123	38	57	418	158	860	155	2,818
South Kingstown	448	0	758	1,309	296	131	269	2,454	587	5,221	489	11,962
Exeter	130	0	184	605	120	83	76	371	163	835	128	2,695
North Kingstown	282	0	667	2,206	376	168	522	2,224	810	4,498	606	12,359
East Greenwich	101	0	218	1,058	146	172	215	1,163	711	2,047	230	6,061
Warwick	530	8	2,209	8,731	1,895	969	1,698	8,048	3,877	13,655	2,149	43,769
Cranston	260	31	2,086	6,985	1,453	771	1,429	6,358	3,380	11,676	2,032	36,461
Providence	417	39	2,780	16,706	1,792	1,177	2,253	10,544	4,230	26,007	3,255	69,200
Central Falls	34	0	360	3,554	186	57	276	1,044	179	1,543	161	7,394
Pawtucket	233	23	1,751	12,447	925	553	1,269	6,658	2,088	9,383	1,026	36,356
Attleboro	147	6	1,239	6,556	532	321	992	3,084	1,083	5,351	606	19,917
Mansfield	56	0	557	2,024	281	246	566	1,738	961	2,497	318	9,244
Foxboro	102	5	532	1,547	247	206	466	1,426	664	2,585	209	7,989
Sharon	117	7	303	1,124	150	223	580	1,450	846	3,326	232	8,358
Canton	87	0	613	1,528	387	277	649	1,653	907	3,446	453	10,000
Westwood	39	0	264	789	130	212	353	918	769	2,659	307	6,440
Dedham	65	5	842	1,470	477	502	602	2,117	1,270	4,375	595	12,320
Boston	1,440	142	11,416	28,602	12,778	7,291	7,810	40,072	31,239	131,867	16,047	288,704

Source: U.S. Census Bureau, 1990 *includes both the city and town of Groton

TABLE A-3B. MUNICIPAL PERCENT EMPLOYMENT BY INDUSTRY

Municipality	Agriculture	Mining	Construction	Manufacturing	Transportation	Communications	Wholesale Trade	Retail Trade	Finance	Services	Public Administration	TOTAL
New Haven	0.42	0.03	3.90	16.41	3.37	3.19	3.12	13.85	5.88	45.50	4.34	100
East Haven	0.57	0.16	7.26	19.33	5.53	3.97	5.22	17.31	8.39	29.09	3.18	100
Branford	0.76	0.14	6.29	15.86	3.82	4.01	4.17	16.52	8.17	37.32	2.93	100
Guilford	1.38	0.33	6.12	18.00	3.44	4.21	4.22	14.77	6.55	38.88	2.09	100
Madison	0.95	0.00	6.42	16.82	3.00	3.89	4.19	16.78	11.03	34.13	2.78	100
Clinton	1.92	0.00	6.97	19.86	3.32	4.56	5.87	19.06	7.19	29.36	1.89	100
Westbrook	1.58	0.00	7.38	18.83	3.23	3.97	2.99	18.76	6.85	33.83	2.60	100
Old Saybrook	1.43	0.14	7.67	18.89	2.79	4.00	4.24	20.90	7.09	29.67	3.19	100
Old Lyme	1.30	0.00	11.33	15.34	2.83	4.87	2.15	14.34	8.70	34.05	5.08	100
East Lyme	1.40	0.09	6.92	18.85	2.14	4.88	2.28	16.33	6.65	34.16	6.29	100
Waterford	0.49	0.07	7.34	20.97	2.51	3.74	2.36	17.40	4.85	33.69	6.59	100
New London	1.03	0.12	6.10	17.99	2.86	1.72	2.10	17.71	4.61	40.03	5.72	100
Groton*	0.59	0.07	6.27	26.24	2.84	2.20	1.50	19.39	4.13	31.06	5.71	100
Stonington	1.29	0.08	6.78	27.93	2.64	2.61	1.75	17.76	4.51	30.39	4.28	100
Westerly	0.59	0.31	6.44	24.61	2.25	2.62	1.68	20.52	5.51	31.05	4.42	100
Hopkinton	3.49	0.30	8.19	35.25	4.11	0.57	3.16	16.30	3.75	22.91	1.97	100
Charlestown	3.62	0.00	8.46	19.91	1.47	1.59	2.18	20.60	3.15	34.27	4.74	100
Richmond	2.20	0.00	7.59	26.01	4.36	1.35	2.02	14.83	5.61	30.52	5.50	100
South Kingstown	3.75	0.00	6.34	10.94	2.47	1.10	2.25	20.51	4.91	43.65	4.09	100
Exeter	4.82	0.00	6.83	22.45	4.45	3.08	2.82	13.77	6.05	30.98	4.75	100
North Kingstown	2.28	0.00	5.40	17.85	3.04	1.36	4.22	17.99	6.55	36.39	4.90	100
East Greenwich	1.67	0.00	3.60	17.46	2.41	2.84	3.55	19.19	11.73	33.77	3.79	100
Warwick	1.21	0.02	5.05	19.95	4.33	2.21	3.88	18.39	8.86	31.20	4.91	100
Cranston	0.71	0.09	5.72	19.16	3.99	2.11	3.92	17.44	9.27	32.02	5.57	100
Providence	0.60	0.06	4.02	24.14	2.59	1.70	3.26	15.24	6.11	37.58	4.70	100
Central Falls	0.46	0.00	4.87	48.07	2.52	0.77	3.73	14.12	2.42	20.87	2.18	100
Pawtucket	0.64	0.06	4.82	34.24	2.54	1.52	3.49	18.31	5.74	25.81	2.82	100
Attleboro	[illegible].74	0.03	6.22	32.92	2.67	1.61	4.98	15.48	5.44	26.87	3.04	100
Mansfield	0.61	0.00	6.03	21.90	3.04	2.66	6.12	18.80	10.40	27.01	3.44	100
Foxboro	1.28	0.06	6.66	19.36	3.09	2.58	5.83	17.85	8.31	32.36	2.62	100
Sharon	1.40	0.08	3.63	13.45	1.79	2.67	6.94	17.35	10.12	39.79	2.78	100
Canton	0.87	0.00	6.13	15.28	3.87	2.77	6.49	16.53	9.07	34.46	4.53	100
Westwood	0.61	0.00	4.10	12.25	2.02	3.29	5.48	14.25	11.94	41.29	4.77	100
Dedham	0.53	0.04	6.83	11.93	3.87	4.07	4.89	17.18	10.31	35.51	4.83	100
Boston	0.50	0.05	3.95	9.91	4.43	2.53	2.71	13.88	10.82	45.68	5.56	100

Source: U.S. Census Bureau, 1990 *includes both the city and town of Groton

TABLE A-4. MEDIAN INCOME BY COMMUNITY

Municipality	Median Income
CONNECTICUT	
New Haven	25,811
East Haven	37,220
Branford	43,578
Guilford	56,115
Madison	61,871
Clinton	45,884
Westbrook	37,534
Old Saybrook	48,223
Old Lyme	50,813
East Lyme	46,979
Waterford	44,167
New London	26,336
Groton-city	30,952
Groton-town	33,967
Stonington	39,651
RHODE ISLAND	
Westerly	34,884
Hopkinton	36,737
Charlestown	36,040
Richmond	40,975
South Kingstown	36,481
Exeter	38,179
North Kingstown	40,419
East Greenwich	50,896
Warwick	35,786
Cranston	34,528
Providence	22,147
Central Falls	18,617
Pawtucket	26,541
MASSACHUSETTS	
Attleboro	36,631
Mansfield	47,080
Foxboro	45,405
Sharon	61,692
Canton	53,492
Westwood	58,559
Dedham	45,687
Boston	29,180

Source: U.S. Census Bureau, 1990

TABLE A-5. TRAVEL AND TOURISM SALES

COUNTY	Tourism Revenues ($ Millions)
New Haven, CT	249
Middlesex, CT	75
New London, CT	229
Washington, RI	227
Kent, RI	217
Providence, RI	434
Bristol, MA	10
Norfolk, MA	19
Suffolk, MA	96

Sources: state and local tourism offices, 1992

APPENDIX B
Database Abstracts

ELECTRIC POWER DATABASE

File 241

Coverage: 1972 to the present
Updates: Monthly
Data Type: Bibliographic
Provider: Electric Power Research Institute (EPRI)
Palo Alto, California

ELECTRIC POWER DATABASE provides references to research and development projects of interest to the electric power industry, and corresponds to the print *Digest of Research in the Electric Utility Industry*. It covers U.S. and Canadian research on 13 major categories related to issues to electric power, including hydroelectric power, fossil fuels, nuclear power, transmission, economics, advanced power systems and environmental assessment. The records include abstracts of project summaries for past and ongoing research projects. Such projects are conducted largely by companies under contract to EPRI or to other utilities, and by EPRI itself. Research from other corporate and utility sources is also covered.

DIALINDEX Categories: ENERGY, ENERGYP

U.S. prices: $1.20/connect minute: $.45/full format online type: $.45/full format offline print

ENVIROLINE

File 40
Menu

Coverage: 1971 to the present
Updates: Monthly
Date Type: Bibliographic
Provider: R.R. Bowker, a Reed Reference Publishing Company, New Providence, NJ

ENVIROLINE covers the world's environmental information. Its comprehensive, interdisciplinary approach provides indexing and abstracting coverage of more than 5,000 international primary and secondary source publications reporting on the aspects of the environment. Included are such fields as: management, technology, planning, law, political science, economics, geology, biology, and chemistry as they relate to environmental issues. Literature covered includes periodicals, governmental documents, industry reports, proceedings of meetings, newspaper articles, films and monographs.

DIALINDEX Categories: ENVIRON, POLLUT

U.S. prices: $2.00/connect minute: $.45/full format online type: $.45/full format offline print; $7.95/monthly DIALOG Alert

ENERGY SCIENCE AND TECHNOLOGY

File 103
Menu

Coverage:	1974 to the present
Updates:	Biweekly
Data Type:	Bibliographic
Provider:	U.S. Department of Energy, Oak Ridge, TN

ENERGY SCIENCE AND TECHNOLOGY (formerly DOE ENERGY), the database of the U.S. Department of Energy, is one of the world's largest sources of literature references on all aspects of energy and related topics. The database provides coverage of journal articles, report literature conference papers, books patents, dissertations, and translations. The following energy topis are included, nuclear, wind, fossil, geothermal, tidal, and solar. Related topics such as environment, energy policy and conservation are also included.

Use of this database is restricted to the United States, Canada, Denmark, Finland, France, Italy, Japan, The Netherlands, Northern Ireland, Norway, Spain, Sweden, Switzerland, and the United Kingdom.

DIALINDEX Categories: EECOMP, ENERGY, ENERGYP, NUCSCI, PETROL, PETROLP, PHYSICS, POLLUT, SAFETY, SCITECH

U.S. prices: $1.50/connect minute: $.65/full format online type: $.65/full format offline print; $13.00/biweekly DIALOG Alert

ENVIRONMENTAL BIBLIOGRAPHY

File 68
Menu

Coverage:	1973 to the present
Updates:	Bimonthly
Data Type:	Bibliographic
Provider:	Environmental Studies Institute, Santa Barbara, CA

ENVIRONMENTAL BIBLIOGRAPHY covers the fields of general human ecology, atmospheric studies, energy, land studies, energy, land resources, water resources, and nutrition and health. More than 300 periodicals are indexed in ENVIRONMENTAL BIBLIOGRAPHY, thereby providing quick and easy access to article references for every environmental research need. Librarians, chemists, land-use planners, government officials, and corporate executives are among those who find this database a functional asset to their work.

DIALINDEX Categories: ENVIRON, POLLUT

U.S. prices: $1.00/connect minute: $.10/full format online type: $.10/full format offline print

TRIS

File 63
Menu

Coverage:	1968 to the present
Updates:	Monthly
Data Type:	Bibliographic
Provider:	U.S. Department of Transportation and Transportation Research Board NAS/NRC, Washington, DC

TRIS provides transportation research information on air, highway rail and maritime transport; mass transit, and other transportation modes. Subjects included are regulations and legislation, energy, environmental and maintenance technology, operations, traffic control and communications. The database records can be either abstracts of documents and data holdings or resumes of research projects.

DIALINDEX Categories: ENERGY, ENERGYP, ENG, SCITECH

U.S. prices: $.90/connect minute: $.25/full format online type: $.25/full format offline print $6.00/monthly DIALOG Alert.

REFERENCES

Abelson, 1979. Peter W. Abelson. Property Prices and the Value of Amenities. Journal of Environmental Economics and Management. Vol, 6, 11-28, 1979.

Alberstat, 1993. Personal communication with Laura Alberstat, Manger of Master Planning, Amtrak, by James Duncan of DMJM/Harris. March 22, 1993.

Assessor, 1993. Personal communication with Municipal Assessors' Offices from CT, RI & MA, by James Duncan of DMJM/Harris. January, 1993.

Blinder, 1979. Calvin L. Blinder. The Effect of Transmission Lines on Residential Property Values. Symposium on Environmental Concerns in Rights of Way Management. EPRI-WS-78-141, October 16, 1979.

Boyer, 1978. J. C. Boyer. The Socioeconomic Impacts of Electric Transmission Corridors. University of Waterloo, Royal Commission on Electric Power Planning. 1978

Carol, 1993. Personal communication with David Carol, Director of Government Affairs, Amtrak, by James Duncan of DMJM/Harris. March 19, 1993.

Florig, 1992. H. Kieth Florig. Containing the Costs of the EMF Problem. Science, Volume 257, July 24, 1992.

Ford, 1993. Personal communication with Joy Ford, City Planner, City of New Haven, CT, by James Duncan of DMJM/Harris. May 14, 1993.

Furby, 1987. Lita Furby, Robin Gregory, Paul Slovic, and Baruch Fischhoff. Electric Power Transmission Lines, Property Values, and Compensation. Journal of Environmental Management, Vol. 27, pgs. 69-83. 1987.

Gazillo, 1993. Personal communication with Steven Gazillo, Public Relations Manager/Utility Coordinator, Morrison Knudsen, by James Duncan of DMJM/Harris. March 23, 1993.

Kellough, 1980. W. R. Kellough. Impact Analysis of Electric Transmission Lines. Right of Way 27, Part 1: October, 50-55; Part 2: December, 19-25. 1980

Mallo, 1993. Personal communication with Bruno Mallo, Transportation Planner, City of Providence, RI, by James Duncan of DMJM/Harris. May 14, 1993.

McBride, 1993. Personal communication with Paul McBride, Transportation Planner, DMJM/Harris, by James Duncan of DMJM/Harris. May 14, 1993.

Morgan, 1988. M.G. Morgan et al. Risk Analysis, Vol. 5, 1988.

TECHNICAL STUDY 3
HISTORIC RESOURCES

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LIST OF FIGURES

3.0 HISTORIC RESOURCES

3.1 INTRODUCTION AND PURPOSE

This report on the historic resources associated with the Northeast Corridor Electrification Project is a technical study in support of the project's Draft Environmental Impact Statement-Draft Environmental Impact Report (DEIS/R). Historic resources are those buildings, districts, structures, objects, and sites that are listed on, or eligible for listing on, the National Register of Historic Places. Section 106 of the National Historic Preservation Act of 1966, as amended, requires federal agencies to take into account the effects of their actions on such properties, and to consider ways of mitigating effects that are adverse. The proposed project is intended to be funded by the Federal Railway Administration and thus falls within the purview of this statute. Similar requirements apply to state-funded or permitted projects.

As part of the DEIS/R and as the initial step toward Section 106 compliance, this document contains (1) a survey of historic properties in the vicinity of the study corridor, and (2) a discussion of potential project impacts on these properties. Preliminary recommendations regarding mitigation of potential adverse impacts are also presented in this report. The information contained herein is intended for review and concurrence by the State Historic Preservation Officers (SHPOs) in Connecticut, Massachusetts, and Rhode Island.

3.2 PROJECT DESCRIPTION

The National Railroad Passenger Corporation (AMTRAK) proposes to electrify the 156-mile rail corridor between Boston, Massachusetts, and New Haven, Connecticut. This railroad line, hereafter referred to as the Northeast Corridor (NEC), passes through 36 cities and towns in three New England states. Electrification will reduce travel time between Boston and New York City by permitting faster and more frequent passenger service and by eliminating the need to switch from diesel to electric locomotives at New Haven's Union Station.

Amtrak's proposal would require (1) installation of approximately 156 miles of overhead catenary, (2) construction of 4 traction power substations with associated power line corridors, 18 paralleling stations and 3 switching stations, and (3) demolition, raising, or replacement of 9 overhead bridges. Each of these elements is described below.

3.2.1 Overhead Catenary Installation

An overhead catenary system (OCS) composed of wires suspended over the railroad tracks supported by pairs of slender steel poles, approximately 28 feet high, placed on either side of the railroad tracks. The poles, which taper from a width of 10 inches at the base to 8 inches at the top, support cantilevered arms from which the wires are suspended. Each set of poles would be spaced approximately 200 feet from the next pair tangent along the track, and closer along curved track sections. The finish of the poles will weather to a metallic-gray color. The catenary will be protected by a solid barrier to be installed on all overhead bridges. Figure 3-1 provides a schematic of a typical catenary pole pair and Figure 3-2 depicts a coastal view with a rendering of the proposed catenary system.

3.2.2 Substations

Substations and utility supply to provide electricity from the local utility company to the substation via a tie-in from the utility's transmission network. The utility tie-in consists of either overhead or underground wires from local transmission lines to the new substation. The substation "steps down" or converts the 115,000 volts (115 kV) on the utilities power line to the 25 kV levels by a transformer at the substation. The 25 kV feed is then connected to the OCS for use by the locomotive. Each of the four substations on the NEC would consist of a fenced area of approximately 0.5 acres. Figure 3-3 provides a schematic of a typical substation.

3.2.3 Switching and Paralleling Stations

Switching stations and paralleling stations, or intermediate power supply points for the OCS. These intermediate supplies are smaller than the substations and contain small transformers that connect the feeder to the catenary. By employing the feeder and these smaller facilities, fewer substations and utility tie-ins are needed, since power can be carried farther down the rail line than if no feeder and intermediate supply points are used. Three switching stations of approximately 0.25 acres and 18 paralleling stations of approximately 0.15 acres will be constructed along the NEC. Figure 3-4 and 3-5 provide schematics of typical switching and paralleling station layouts.

3.2.4 Bridge Modifications

Bridge modifications, which will be required in some areas of the NEC, where overhead structures, such as roadway and pedestrian bridges, currently restrict vertical clearance over the tracks. One of three actions will be taken at these bridges where there is insufficient room to accommodate both the train and proposed catenary. These measures are (in order of least cost and disruption, and therefore highest preference): 1) the railroad tracks would be lowered using a technology known as undercutting; 2) the bridge would be raised; or 3) the bridge would be demolished and replaced.

3.2.5 Rolling Stock

Electric power locomotives capable of 150 mph operation, with quick acceleration and deceleration characteristics and the ability to traverse curves at high speeds.

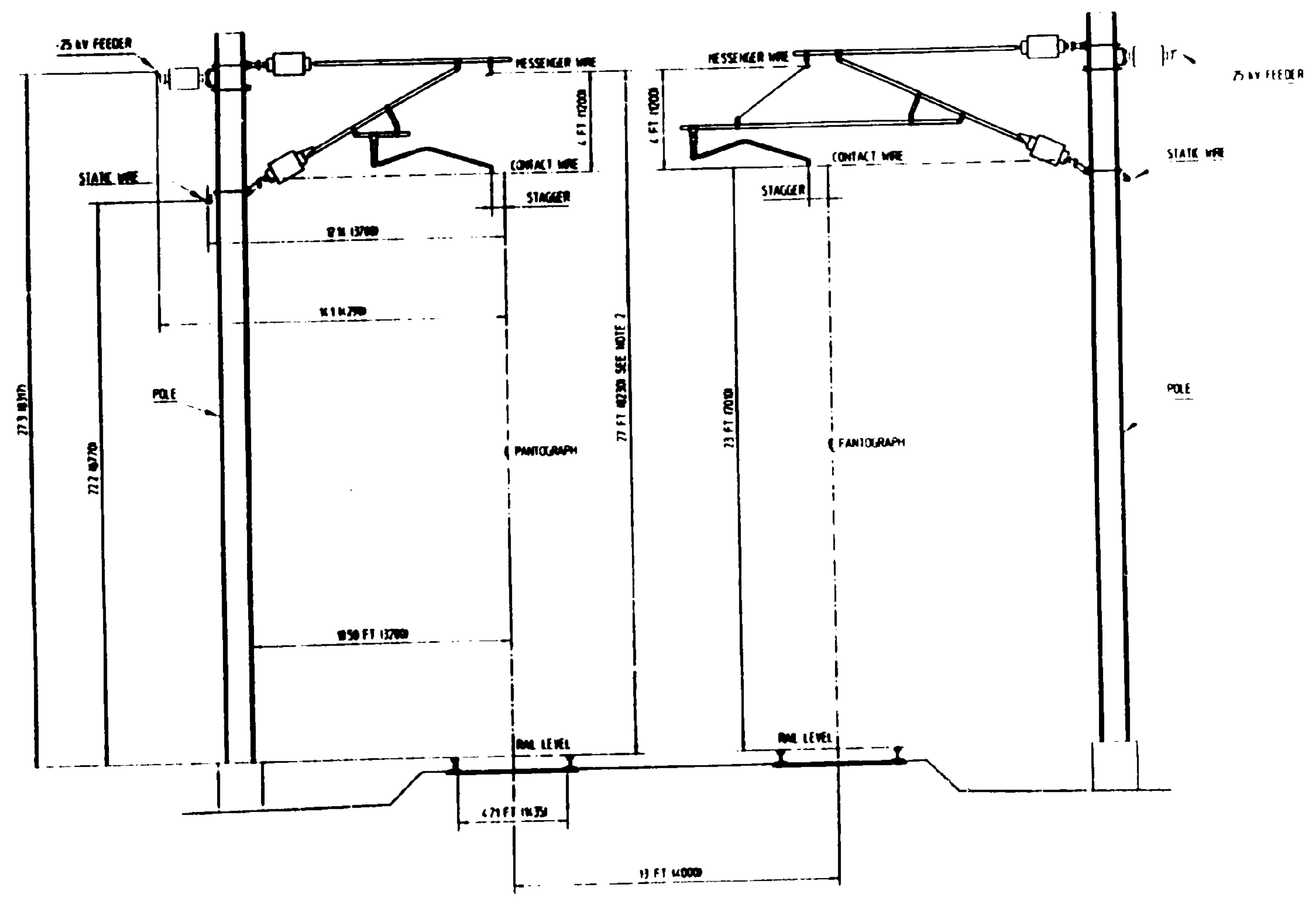

FIGURE 3-1. CATENARY POLE PAIR

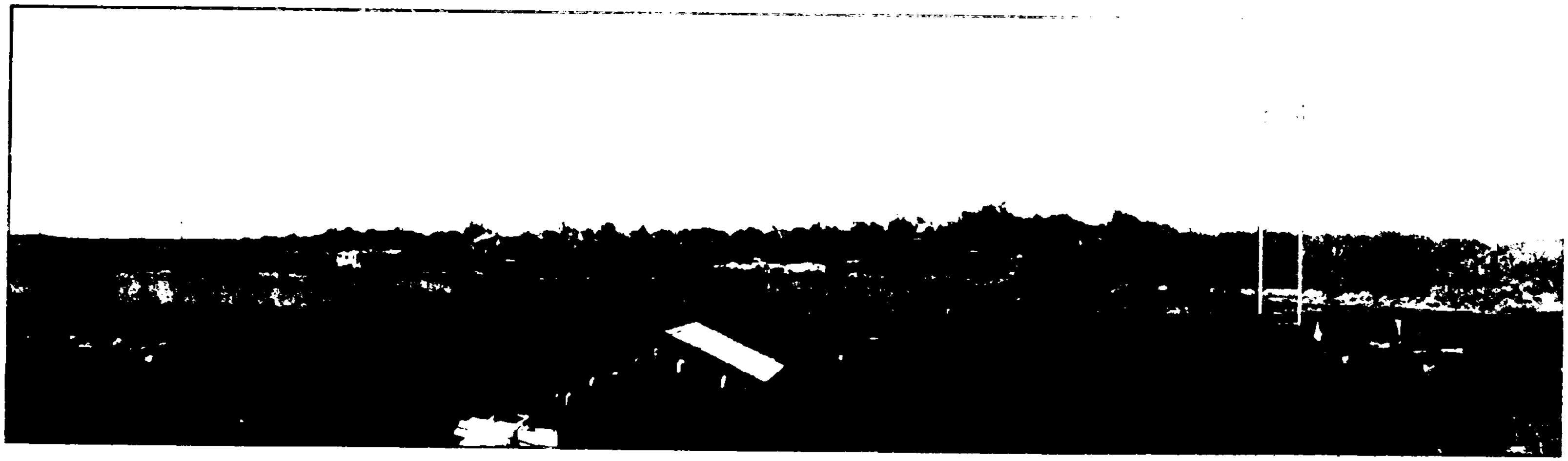

FIGURE 3-2 TYPICAL OVERHEAD CATENARY SYSTEM

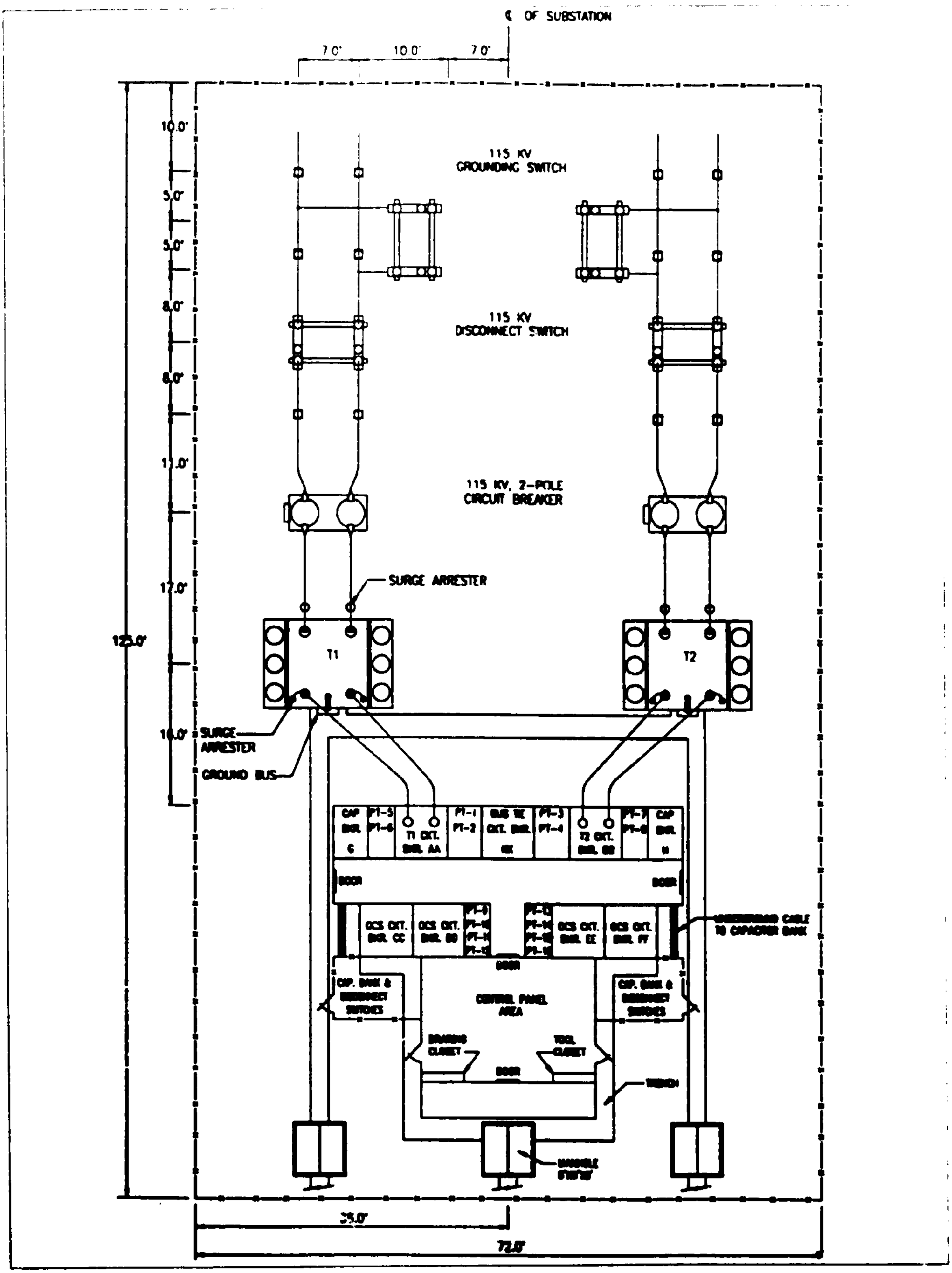

FIGURE 3-3. TYPICAL SUBSTATION PLAN

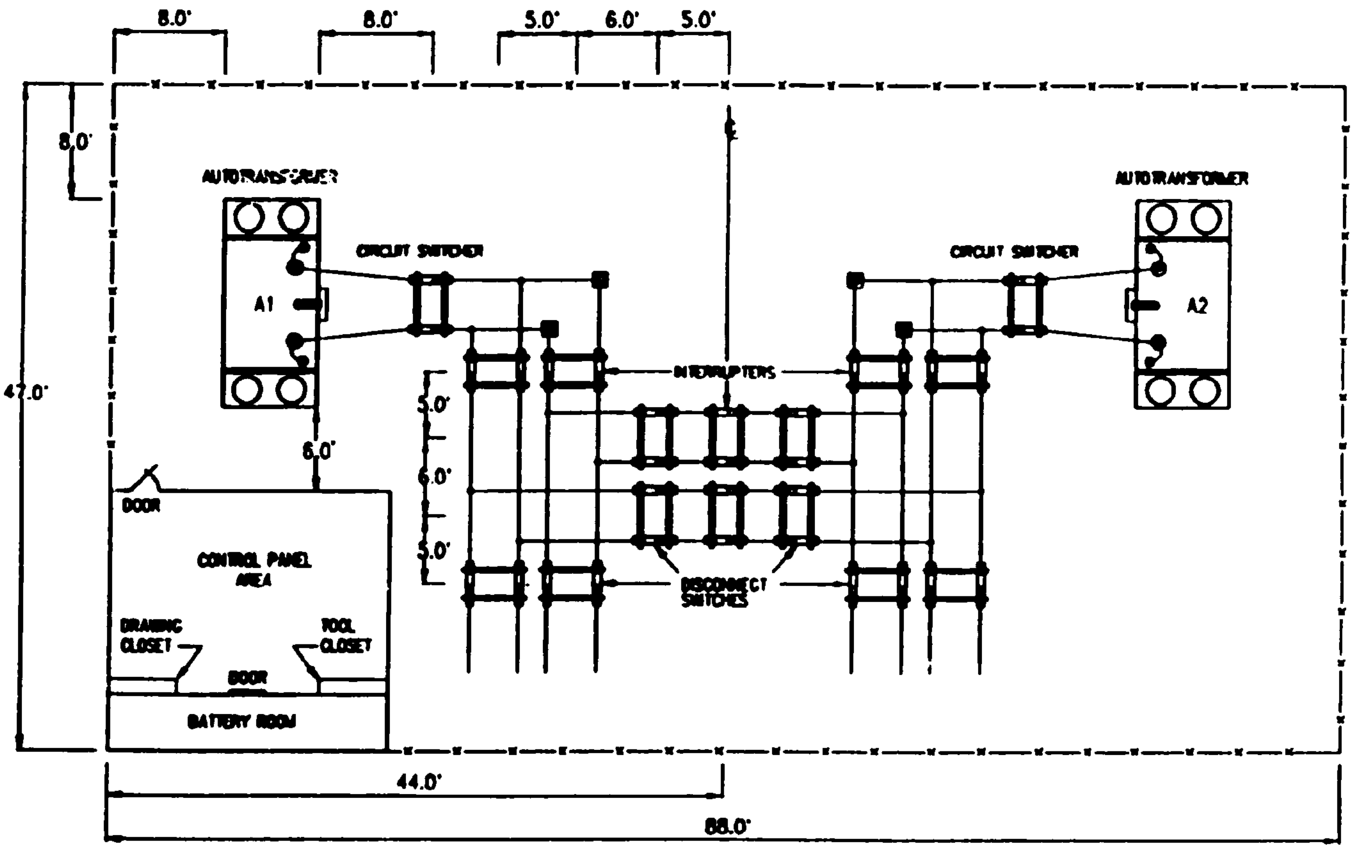

FIGURE 3-4. TYPICAL SWITCHING STATION PLAN

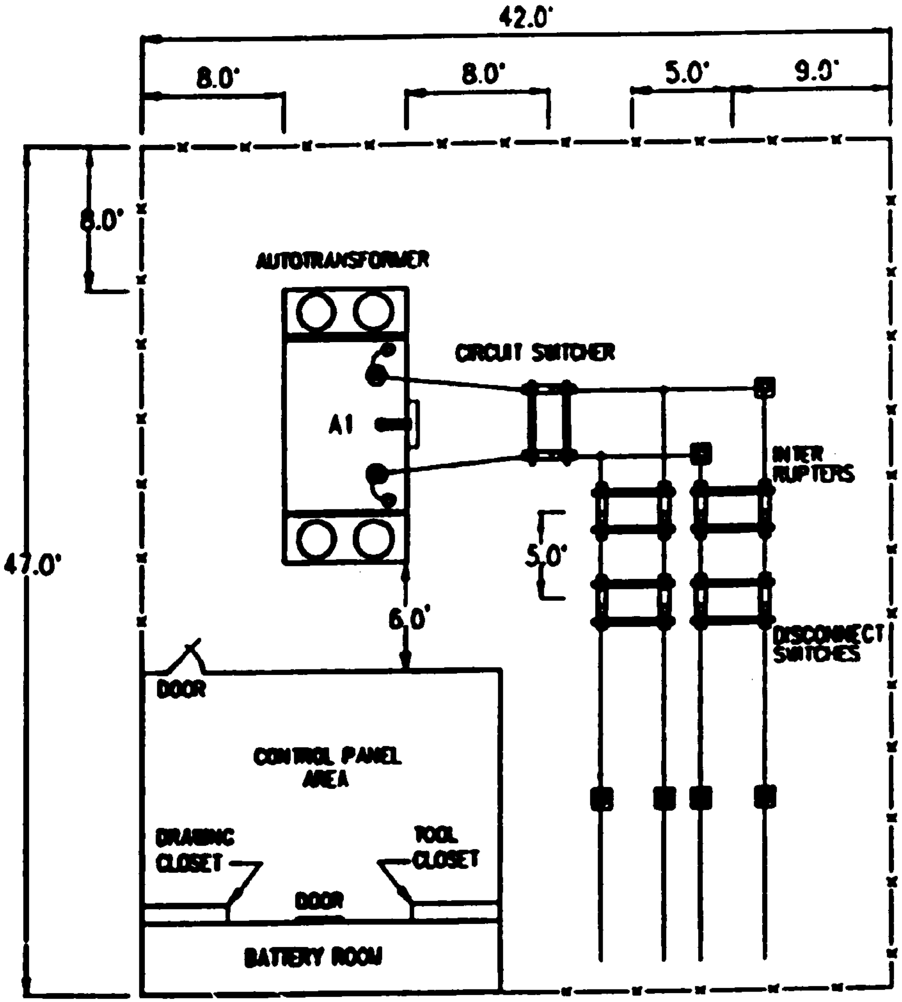

FIGURE 3-5. TYPICAL PARALLELING STATION PLAN

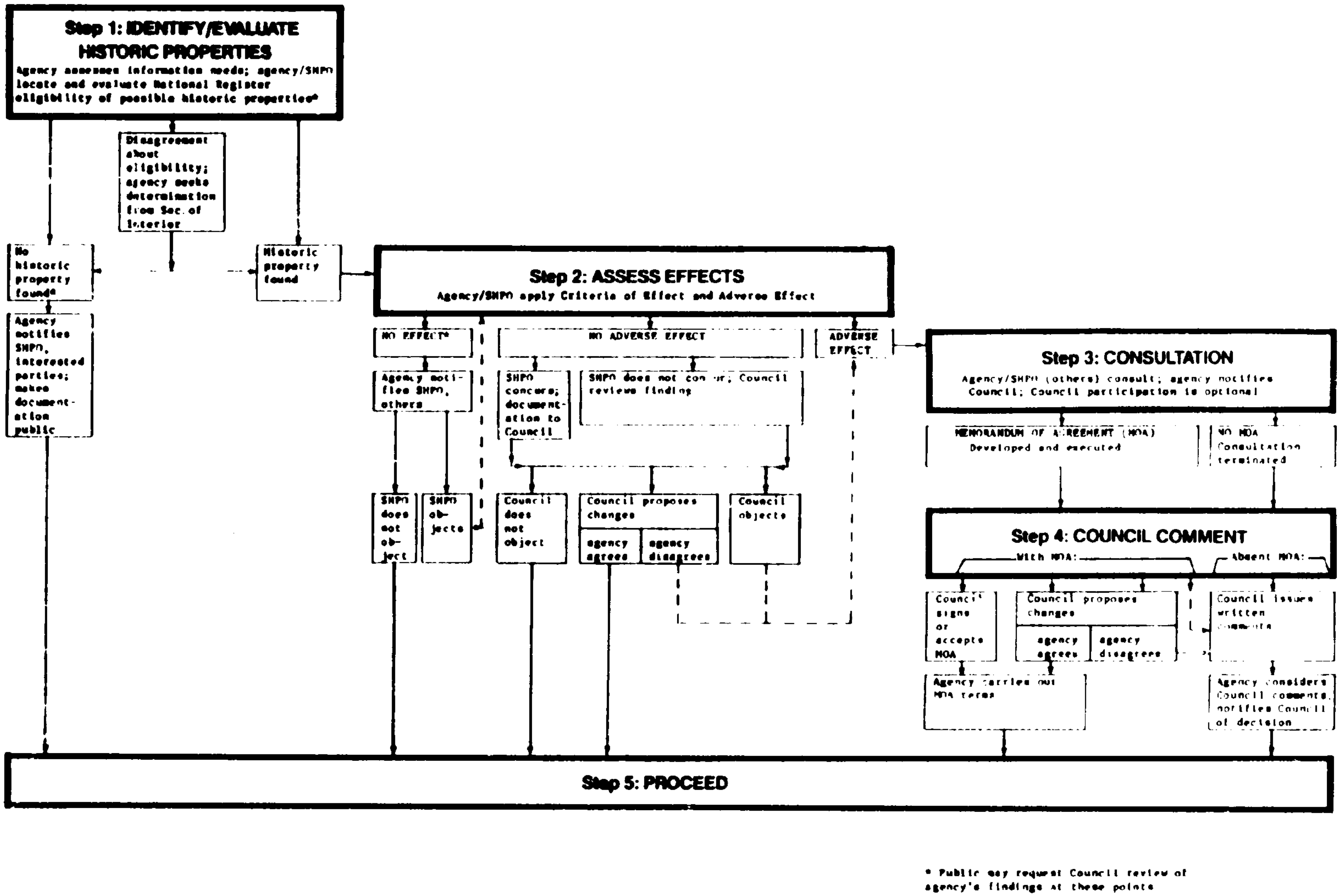

FIGURE 3-6. THE BASIC STEPS OF SECTION 106 REVIEW

A more detailed description of these project elements is provided in Chapter 2 of the DEIS/R.

Amtrak's proposed express service would consist of 16 trains in each direction between Boston and New York on a typical weekday. The express service would make stops at New Haven, CT; Providence, RI; Route 128 Station in Dedham, MA; and Back Bay Station in Boston, MA before terminating at South Station in Boston, MA. Conventional service would continue on a schedule similar to that currently in operation, with 10 trains in each direction on an average weekday. In addition to those stations served by the express service, the conventional train stops would by at Old Saybrook, New London and Mystic, CT and Westerly and Kingston, RI, although not all conventional service would make these stops.

3.3 REGULATORY SETTING

This section describes Federal, state, and local statutes relevant to the effects of the proposed project on historic resources. The federal government as well as all three New England states along the study corridor have regulations affording protection to these resources, as described below.

3.3.1 FEDERAL REGULATIONS

3.3.1.1 National Historic Preservation Act (NHPA) of 1966, as amended (16 USC 470). Section 106 of this statute provides the basis for a review process that requires federal agencies to afford the Advisory Council on Historic Preservation an opportunity to comment on actions that may affect properties listed or eligible for listing on the National Register of Historic Places. Section 106 of NHPA directs the Secretary of the Interior to maintain a National Register of Historic Places and establishes a State Historic Preservation Office within each state to carry out project review under the statute. The procedure for meeting Section 106 requirements is defined in regulations of the Advisory Council, "Protection of Historic Properties," 36 CFR Part 800.

Major steps in the Section 106 review process are as follows:

1. **Identification and evaluation of historic properties**

   This step requires the identification of all historic resources on or eligible for inclusion on the National Register of Historic Places that are within the zone of potential impact for the proposed project. If there are no such properties, and the SHPO concurs, the projects may proceed and no further consultation with SHPO is necessary. If such properties exist, the agency continues to the next step in the process:

2. **Assessment of the effect of the proposed action on each historic property**

This assessment occurs in consultation with the SHPO through the application of the Section 106 "criteria of effect." It requires submittal of documentation to the SHPO explaining the proposed project, the construction staging plan and steps that will be taken to avoid or minimize harm. Based on a review of this information, the SHPO will issue a written finding that the project will have (1) No Effect, (2) No Adverse Effect, or (3) An Adverse Effect on the identified historic resources. A finding of No Adverse Effect may be conditional upon the project being carried out in a particular way.

If a finding of No Effect or No Adverse Effect is made, the agency then submits documentation of the finding to the Advisory Council for its comments. If An Adverse Effect is found, step three in the Section 106 is as follows:

3. **Consultation to consider measures to avoid or minimize potential adverse project impacts**

The agency notifies the Advisory Council that consultation with the SHPO is underway, and then seeks an understanding with the SHPO regarding feasible mitigation measures that will eliminate or reduce the adverse effects. This consultation typically results in a Memorandum of Agreement (MOA) with the SHPO and the Advisory Council. The MOA contains stipulations that 1) specify how the project will be carried out so as to avoid or mitigate adverse effects or 2), if mitigation is not feasible, accept such effects. The steps in the Section 106 review are shown in Figure 3-6.

While Section 106 is the most comprehensive act protecting historic properties and the cornerstone of the federal preservation program, there is other federal legislation governing these properties, as follows.

3.3.1.2 Section 4(f) Department of Transportation Act of 1966 (49 USC 303) and implementing regulations (23 CFR 772). Section 4(f) of this Act directs the Secretary of Transportation to consult with, among others, the Secretary of the Interior; and to minimize any harm to historic properties that may result from transportation programs. Regulations governing 4(f) implementation specify that there can be no taking of a public park or recreation land or historic site, or impairment of such sites without a thorough investigation into whether or not all feasible and prudent alternatives have been considered. Such alternatives include a No Build alternative and various project modifications. If it is determined that the project will take historic sites or parks, or will preclude the use of such sites, a Section 4(f) evaluation must be prepared. The statement should explain the reasons why no other location for the project is prudent or feasible (due to extraordinary social, economic, environmental or other costs) and specify steps to minimize harm.

It is important to note that Section 4(f) applies to public parks and recreation lands, historic sites listed on or eligible for listing on the National Register of Historic Places as well as wildlife and waterfowl refuges. Also the interpretation of "use" is not limited to the actual taking or acquisition of land but includes proximity impacts. If the proximity impacts of a project to a 4(f) site are so great that they prevent the use or enjoyment of that site (referred to as constructive use by the courts), these impacts constitute a taking under the statute. If the Federal Rail Administration determines that the proposed electrification project or a portion thereof would constitute a use of a 4(f) site within the meaning of the law, the Final EIS/R will include a section 4(f) determination and will document the analysis required to make the necessary findings.

3.3.1.3 Executive Order No. 11593 "Protection and Enhancement of the Cultural Environment" (3 CFR 154, 1971) (reprinted in 16 USC 470). This order directs Federal agencies to take a leadership role in preserving, restoring, and maintaining the historic and cultural environment of the Nation. Federal agencies must locate, inventory, and nominate to the National Register of Historic Places all historic properties under their jurisdiction or control.

3.3.1.4 Historic Sites Act of 1935. This act mandated the National Park Service to be the lead Federal agency in historic preservation efforts. It also established three Federal programs: the Historic American Building Survey (HABS), the Historic American Engineering Record (HAER), and the National Survey of Historic Sites and Buildings (Landmarks).

3.3.2 STATE STATUTES

3.3.2.1 Connecticut General Statutes Section 10-321 Et Seq. This statute outlines the tasks of the Connecticut Historical Commission (CHC) including the identification, investigation, and preservation of Connecticut's historic, architectural, and archaeological resources and the issuance of standards and guidelines to assist cities and towns in their preservation activities.

3.3.2.2 Rhode Island Historic Preservation Act of 1968 (RIGL 42-45). This Act directs the Historical Preservation Commission (RIHPC), among other tasks, to advise other state agencies as to the preservation of historic, architectural, and archaeological resources during any state undertakings; to conduct a statewide survey of historic properties; to maintain a state register of historic places; and to develop a historic preservation plan. The RIHPC also serves as the SHPO for Rhode Island.

3.3.2.3 Massachusetts Regulations

Massachusetts General Law (MGL), Chapter 9, Sections 26-27c. This law, which established the Massachusetts Historical Commission (MHC) and the Office of the State Archaeologist and their respective duties, also mandates the MHC to administer the Federal preservation program as the SHPO. Implementing regulations are found in 950 CMR 70 and 950 CMR 71.

Chapter 254 of the Acts of 1988. This law clarifies the historic review process administered by the MHC and provides for review of an entire project, not just the portion of the project which requires state funding or licensing.

3.4 SURVEY OF HISTORIC RESOURCES

This section presents the methods and results of the survey of historic resources along the NEC that might be affected by the proposed project. It also describes the possible impacts of the various elements of the electrification project on those historic resources.

3.4.1 Methodology

The survey of historic properties along the study corridor was undertaken from October 1992 to March 1993. Prior to field investigation, the survey team conducted a thorough search of existing information on historic resources in the files of the three State Historic Preservation Offices. Previous sources of information that have been incorporated into this report inc'ude:

- National Register of Historic Places listings.
- Determinations of National Register eligibility.
- Local historic districts.
- State town-wide surveys of historic resources.
- State surveys of historic highway bridges.
- Resources previously identified in the rail corridor as part of the 1979 EIS for Northeast Corridor improvements. All resources within the present rail corridor that were identified in the 1979 survey were field checked (a large number are no longer extent) and photographed, and their current National Register status was ascertained.

In addition, the survey team reviewed videotapes taken in the late 1980s from the cab of AMTRAK trains running the length of the project corridor, resulting in the identification of numerous other potential historic resources, principally factories along the rail line. The current AMTRAK bridge log was also studied to identify historic bridges that had been previously overlooked. Finally, the survey team undertook a complete visual inspection of the corridor consisting of two end-to-end trips aboard scheduled AMTRAK trains.

The area of potential effect for this project included not only properties on or directly adjacent to the railroad right-of-way but also properties whose setting might be visually impacted by electrification elements. After consultation with all three SHPOs, the survey defined the area of potential effect as including all properties within clear view of the right-of-way or proposed electrification facilities.

All potential historic resources identified through this methodology were then inspected in the field, plotted on U.S.G.S. topographical quadrangles, and photographed. Massachusetts and Rhode Island sites were photographed in November, 1992, and Connecticut sites in February and March, 1993. Follow-up field checking for all three states continued through April, 1993. The resource inventory contained herein is time-dependent; the number and character of historic resources along the corridor is constantly changing as buildings are altered or demolished and bridges are replaced. Every effort has been made to keep the inventory current, but it must be regarded as a "snapshot" of conditions at a particular time.

The photographs, along with other site-specific data, will be made available in a separate format for review by the State Historic Preservation Offices.

3.4.2 Criteria for Inclusion

This survey includes all properties within the area of potential effect 1) that are listed on the National Register of Historic Places, 2) that have been determined eligible for listing by the National Register or the SHPOs, or 3) that appear to be eligible for listing. The National Register's criteria for evaluating the significance of properties are as follows:

> The quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and:

a. that are associated with events that have made a significant contribution to the broad patterns of our history; or

b. that are associated with the lives of persons significant in our past; or

c. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

d. that have yielded, or may be likely to yield, information important in prehistory or history.

Some types of properties, such as those less than 50 years old, those owned by religious organizations, moved structures, and cemeteries are ordinarily not considered for listing, though they may be listed under certain conditions.

In applying these criteria, the preparers of this report considered both a property's integrity and its significance. Most of the properties included herein clearly appear to meet the criteria for listing, and these have been recommended as "Probably Eligible" in the report.

A smaller number of less clear-cut cases have also been identified. These include properties that have some historical significance but questionable integrity, such as railroad stations that have been moved from their original location parallel to the tracks, houses with both architecturally distinguished elements and extensive modern alterations, or historic bridges that have been rebuilt with modern materials. These have been termed "Possibly Eligible" in this report.

Bridges pose some special problems in evaluating their significance. Along the corridor are a number of railroad bridges and highway overpasses that are more than 50 years old but are lacking in exceptional engineering significance. There are, for example, dozens of essentially identical plate-girder bridges from the late 19th and early 20th centuries in each state. Only a small number of the earliest and largest plate-girder bridges were included in the final inventory. Similarly, timber-beam bridges, all of which date from c.1940, were excluded from consideration. In Massachusetts, most concrete highway bridges from the 1930s were already determined not eligible by the SHPO, therefore these bridges were omitted from the inventory. In Rhode Island, however, such concrete structures are relatively rare, and, in consultation with the SHPO, these bridges were included in this report (as "Possibly Eligible") in order to allow for their further review.

3.4.3 Historic Contexts

Historic contexts are developmental patterns, with particular temporal and geographical parameters, that provide the framework for evaluating the significance of the historic resources impacted by the project. Major historic contexts for the project area include the rise and decline of agriculture in the 18th and early 19th century; maritime development in the same period; industrialization from the early 19th to the middle 20th century; and the evolution of urban society. Finally, the evolution of rail transportation itself provides the historic context for many of the resources.

The history of the area that includes the rail corridor from New Haven to Boston dates back to the earliest years of European settlement in New England, and thus rural landscapes of Colonial and early 19th-century farmsteads are found along the entire route. Particularly in Connecticut, where the tracks are closest to the coast, the line passes through small historic fishing and commercial villages such as Stonington, Mystic, and Noank. New England was the birthplace of industrialization, and factories, along with associated worker housing, are also found along the right-of-way, both in the form of mill villages, such as Dodgeville in Attleboro, Massachusetts, and as dense concentrations of industry, such as the greater Providence-Central Falls-Pawtucket corridor in Rhode Island. Finally, the route passes through many neighborhoods whose character typifies some aspect of the historical development of American cities, from downtown commercial areas to Victorian residential neighborhoods to early 20th-century suburbs.

Parts of the rail line represented by the project area were among the first railroads built in New England, and some stone-arch structures date back to the earliest episode of construction. The large number of railroad stations, both urban and small-town, testify to the importance of railroads in the life of their communities, and structures such as switch towers help document railroad technology that is now archaic. Late 19th and early 20th century bridges illustrate the historical development of railroad engineering, and taken together, they recall the massive reconstruction of much of the route associated with the rise of the New York, New Haven, and Hartford Railroad. Formed in 1872, the New Haven, as it was commonly known, came to dominate both passenger and freight service throughout southern New England.

3.4.4 Project Elements That May Affect Historic Resources

The proposed action has the potential for impacting historic resources during the operation of electrified service and through the visual and physical intrusion of above-ground structures. Among the project elements that may affect historic resources are:

- New construction of substations, switching stations, and paralleling stations. New construction (summarized in Tables 3.1 through 3.3) may affect eligible historic properties if they are on the site of, or adjacent to, the locations for substations, switching stations, paralleling stations, or power lines.

- Modification of overhead bridges (also summarized in Tables 3.1 through 3.3) to achieve clearances. Overhead highway bridges that are individually eligible or that are in historic districts may be raised or replaced.

- Installation of poles and wires to carry overhead current along the entire corridor, and installation of protective barriers on all overhead bridges. The visual qualities of the setting of historic properties that are immediately adjacent to or plainly visible from the right-of-way may be affected by the installation of the poles and wires for the overhead catenary. In addition, the method of securing overhead wires to historic railroad bridges (if necessary) may affect them.

Certain actions appear unlikely to have any effect and therefore are not explicitly addressed in this report. Use of existing power lines and new power lines located underground are assumed not to involve any effect on above-ground (non-archaeological) historic properties. Undercutting of the right-of-way to achieve bridge clearance is assumed not to affect historic bridges provided that the integrity of the footings and abutments is maintained. Also, this report does not address any of the following activities, which are not presently part of the electrification project: realignment or reconstruction of the track; replacement or substantial modification to bridges other than to achieve clearance and provide protective barriers, as noted above; high-level platforms or other modifications to stations; changes to signalling systems; or fencing of the right-of-way.

Finally, potential damage to historic and other buildings from increased vibration associated with the proposed project was assessed as part of the Noise and Vibration analysis conducted for this DEIS/R and documented in the Noise and Vibration study (technical study four). Vibration levels were evaluated for various project elements including proposed train operations along the NEC, project-generated vehicular traffic near railroad station, electrical substation facilities, and construction activities at substation and bridge sites. The projected vibration levels may present an annoyance to building occupants but are not expected to cause damage to historic buildings or other structures. Without mitigation, the evaluation projected one school and 1,355 residences would be significantly impacted by train vibration, while 16 residences would experience significant vibration impact from construction at paralleling stations or bridges. The particular buildings affected by increased vibration will be identified as part of the Final EIS/R.

3.4.5 Historic Properties Survey

This section contains a complete listing of historic resources in the project area identified in order from the western boundary of the project (New Haven, Connecticut) to the eastern boundary. (Boston, Massachusetts). The project limits are assumed to begin just east of Court Street Bridge (Milepost 72.80) in New Haven and end at South Station, Boston. (Milepost 229)

Information for the resources, which are grouped by town, includes an approximate milepost (using AMTRAK mileposts), historic or common name of property and other identifiers as appropriate, a brief description, and its National Register of Historic Places status, which includes the following categories:

- Listed on the National Register

- Determined eligible for the National Register as part of an earlier, formal Determination of Eligibility procedure or as part of another comprehensive historic resource survey, such as the state historic bridge inventories.

- Probably eligible, a recommendation by the preparers of this report that the property meets the criteria for inclusion in the National Register.

- Possibly eligible, a judgment applied to properties by the preparers of this report that appear to have some historic interest but whose eligibility is questionable because of limited significance or poor integrity.

Within each town, the resources are grouped according to the major project elements described above. In each entry, the effect of the project on the historic resource is evaluated. The inventory of resources is summarized in Tables 3.4 through 3.6. Mitigation measures are addressed in section 3.5.

3.4.5.1 New Haven, CT

New Haven U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Strouse Corset Factory, Milepost 72.90. 74-84 Olive Street. Brick factory, 1860-1907, occupied by prominent maker of corsets; employed 2,000 workers c.1920 (included in Connecticut HAER inventory). Probably eligible for the National Register.

Because the tracks run along the rear of the mill and are almost out of sight below grade, the visual effect of introducing the catenary to the property's setting is relatively minor; furthermore, catenary supports from the former electrification are still in place. Therefore, the effect will not be adverse.

Grand Avenue Bridge (Bridge #3874), Milepost 72.94. A 1907 concrete-arch structure significant for its technology and for its association with the Cedar Hill yards railroad improvement. Determined eligible in ConnDOT bridge survey.

Although the protective barrier will be somewhat higher than the existing solid wooden barrier on the bridge, its installation will not affect the significant qualities of the bridge, which are inherent in the concrete structure below the level of the roadway. Therefore, no adverse effect is anticipated.

Olive Street Bridge (Bridge #3752), Milepost 73.08. A 1907 through truss bridge significant as an example of early 20th-century truss engineering. Determined eligible in ConnDOT bridge survey.

The installation of solid protective barriers on this bridge will obscure and possibly physically alter the trusses and railings, thereby producing an adverse effect.

Mill River Railroad Bridge, Milepost 73.72. A two-span 1906 concrete arch, 116' long overall, significant as a large, early example of concrete bridge construction, part of the Cedar Hill yards railroad improvement. Probably eligible for the National Register.

Humphrey Street Railroad Bridge, Milepost 73.85. Although somewhat deteriorated through surface spalling, this 1910 beam bridge is an early example of concrete-bridge construction, one that includes decorative railings with circle designs and arched intermediate supports. It carries the street under the tracks. Probably eligible for the National Register.

The size of these two undergrade bridges is such that it will probably be unnecessary to modify them in any way for the catenary; furthermore, catenary supports from the former electrification are still in place. Therefore, no adverse effect is anticipated.

Ferry Street Bridge (Bridge #3998), Milepost 74.38. A 1912 through truss bridge significant as an example of early 20th-century truss engineering. Determined eligible in ConnDOT bridge survey.

The installation of solid protective barriers on this bridge in place of the lower, chain-link barriers now in place will obscure and possibly physically alter the trusses, thereby producing an adverse effect.

Clifton Street Railroad Bridge (Bridge #3879), Milepost 76.24. A c.1885 stone-arch bridge, significant as an example of masonry-arch construction. Determined eligible in ConnDot bridge survey.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

New Haven Tunnel, Milepost 76.64. A 1200'-long brick-arch tunnel cut through a side hill in Fair Haven in 1893. Includes stone ashlar portals and two brick riser structures. Significant as a large and relatively rare (in Connecticut) type of engineering structure. Probably eligible for the National Register.

The tunnel will require modifications to carry the catenary, thereby producing an adverse effect.

3.4.5.2 East Haven, CT

New Haven and Branford U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

No historic resources within the project area were identified in East Haven.

3.4.5.3 Branford, CT

Branford and Guilford U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS:

> **Branford Substation, Milepost 79.26.** No historic resources appear on or near the site, which is a heavily wooded area with one house of modern construction nearby. A 1200'-long aerial power line will connect the substation with a local utility; it passes through a wooded area with no buildings nearby.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

> **Branford Center Historic District, Milepost 81.40-81.87.** A large assemblage of predominantly 19th and early 20th century buildings. The right-of-way passes nearby several 19th-century houses and barns, along the rear of the Atlantic Wire Company factory (c.1910-1930), and directly in front of the Malleable Iron Fittings factory (included in the Connecticut HAER inventory). Listed on the National Register.
>
> *Because the catenary will be erected so near to the Malleable Iron Fittings Factory, and the complex is so big that some uprights will necessarily have to be located right in front of it, the effect of the catenary on this district must be considered adverse. The only feasible mitigation would appear to be to photographically record this structure (along with other vistas in the district) prior to commencing the project (see Section 3.5.4).*

3.4.5.4 Guilford, CT

Guilford U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS:

> **Leetes Island Paralleling Station, Milepost 85.99.** Located between Stony Creek Road (Route 146) and the tracks, within the boundaries of the Route 146 National Register Historic District. The only building nearby, a house across the road, appears to be of modern construction. Therefore, no adverse effect is anticipated.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Route 146 Historic District, Milepost 85.41-88.43. A linear district along Route 146 that includes numerous 18th and early 19th-century houses, barns, and saltwater farms. The tracks pass through the district directly behind one 19th-century barn and two 18th-century houses (559 and 575 Leete's Island Road), all contributing buildings. This barn is part of Leete's Farm (616 Leete's Island Road), one of the best-preserved saltwater farms remaining in Connecticut. The tracks are also visible across Stony Creek Road from a group of three c.1860-1880 houses (968, 974, 988 Stony Creek Road) just east of the Leete's Island Paralleling Station site. Listed on the National Register.

Because in each case the tracks pass at the rear of the historic buildings, or are separated from them by the road and screenings of trees, no adverse effect on the district is anticipated.

Island Creek Railroad Bridge, Milepost 87.27. An 1891 stone-arch bridge, 16' long, significant as an example of masonry arch construction. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

Guilford Historic Town Center Historic District, Milepost 88.43-89.64. A large district of 18th and 19th-century buildings. Among those directly adjacent to the tracks are a collection of three railroad related structures: the Guilford Freight Station, Water Tower, and Engine House, Milepost 89.00-89.20. A Local Historic District. Listed on the National Register.

In general, the right-of-way passes well south of the main concentration of historic buildings in this district. Provided the catenary uprights are located so as not to obscure the three railroad-related buildings cited above, no adverse effect is anticipated.

3.4.5.5 Madison, CT

Guilford and Clinton U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS:

Madison Paralleling Station, Milepost 92.41. The switching station will be located within or immediately adjacent to the railroad right-of-way in a sparsely built area; there appear to be no historic resources in this vicinity. Therefore, there will be no effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

East River/Post Road Historic District, Milepost 90.90-91.20. A grouping of several well-preserved 18th-century, Greek Revival and Victorian-style dwellings on either side of Post Road; open land associated with those on the south side extends to the tracks. Probably eligible for the National Register.

Because the right-of-way borders this potential district only at the south rear edge of the properties on the south side of the road, the effect is not considered adverse.

Greek Revival Style House, Milepost 93.40. A well-preserved 2 1/2-story Greek Revival style house, c.1860, with an Italianate porch, c.1865-1875, north of tracks at Madison station. Probably eligible, either individually or as part of a potential historic district on the south side of the tracks (see below).

Because the house is already separated from the tracks by a dense planting of evergreens, the installation of the catenary will produce no additional adverse effect.

Railroad Avenue Historic District, Milepost 93.20-93.45. A small concentration of c.1870 houses and associated outbuildings that extends along Railroad Avenue and down Wall Street toward Madison center. Possibly eligible for the National Register.

The installation of the catenary represents only a minor visual impact over the existing right-of-way, which lies across the road from this potential district. Because the catenary has been designed to be as unobtrusive as possible, no adverse effect is anticipated.

Jonathan Murray House, Milepost 94.00. 76 River Road (Scotland Road), 2-story house dated 1690. Listed on the National Register.

The house is situated across the road from the right-of-way, which is only partly visible because of trees. Therefore, the additional visual effect of the catenary will be minor, and no adverse effect is anticipated.

3.4.5.6 Clinton, CT

Clinton U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Eighteenth-century House, Milepost 95.50. On Nod Place, off Nod Road; a 1 1/2-story central-chimney house with old barns; possibly eligible for the National Register.

The house faces the existing right-of-way, which represents a substantial disruption of its historical setting. The additional impact of the catenary will therefore be relatively minor. Therefore, no adverse effect is anticipated.

Pond's Extract Company Factory (Cheeseborough Ponds USA), Milepost 96.75. Large concrete and glass-brick factory, 1929-1936, with important local historical associations as a major industry. Probably eligible for the National Register.

The catenary will partly obscure the trackside elevation of the factory. However, the front of the factory and the other side will be unaffected, so the impact is not considered an adverse effect.

Clinton Station, Milepost 96.60. C.1890 station substantially altered with modern additions. Possibly eligible because of its local historical significance as the village's depot.

At the worst, the catenary will partly obscure the trackside elevation of the station. However, as this is the side most thoroughly altered, the impact is not considered an adverse effect.

Railroad Avenue Historic District, Milepost 96.89. A small but cohesive grouping of Greek Revival-style houses just north of Main Street in Clinton Center, on both sides of the tracks. Probably eligible for the National Register.

This potential district is already substantially affected by the existing right-of-way, which runs at an elevated level and bisects the area. The additional visual impact of the modern catenary will therefore be minor and is not considered an adverse effect.

Indian River Cemetery, Milepost 96.93. Though mostly a Victorian landscaped cemetery, it is possibly eligible for the National Register due to the large number of 18th-century sandstone monuments.

This property is already substantially affected by the existing right-of-way, which runs along the southern edge at an elevated level. Because the tracks are at the edge of the property, and the catenary has been designed to be as unobtrusive as possible, any additional visual impact will be minor and is not considered an adverse effect.

Indian River Railroad Bridge, Milepost 97.04. An 1884 stone-arch bridge, 20' long, significant as an example of masonry arch construction. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

Liberty Street Historic District, Milepost 97.49. A small but cohesive grouping of 18th and early 19th-century houses clustered around a small triangular park on both sides of the track. A Local Historic District. Probably eligible for the National Register.

This potential district is already substantially affected by the existing right-of-way, which runs close by the buildings and bisects the area. The additional visual impact of the modern catenary will therefore be minor and is not considered an adverse effect.

3.4.5.7 Westbrook, CT

Essex U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS:

Grove Beach Paralleling Station, Milepost 99.11. The station will be located close to the tracks in a brush filled area a short distance from a mobile-home park. No historic structures appear nearby, and therefore there will be no effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Eighteenth-century House, Milepost 101.10. Pond Meadow Road, 2 1/2-story house, c.1746. Faces the tracks a considerable distance (about 200') north of the right-of-way, separated by mostly open land. Probably eligible for the National Register.

Since the existing right-of-way is a relatively modern element not from the house's period of significance, the introduction of the catenary represents only a small additional impact on its setting. Because the catenary has been designed to be as unobtrusive as possible, the impact is not considered an adverse effect.

Patchogue River Railroad Bridge, Milepost 101.22. An 1882 stone-arch bridge, 45 feet long, significant as an example of masonry arch construction. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

Westbrook Station, Milepost 101.35. Apparently moved and relocated at right angles to the tracks, north of the right of way, and made into a tavern; possibly still eligible due to local history significance. Dates from c.1890.

Since the station appears to have already lost its historic relationship to the right-of-way, the introduction of the catenary represents only a small additional impact on its setting and is not considered an adverse effect.

3.4.5.8 Old Saybrook, CT

Essex U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS:

Westbrook Switching Station, Milepost 103.53. The facility will be located between the right of way and the driveway to R. H. Donnelly, a large modern industrial plant. No historic resources exist in the proximity, and therefore there is no effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Old Saybrook Station And Freight House, Milepost 102.30. One and a half story wood frame structure built c.1900 and recently renovated. Significant for its association with the historical impact of the railroad and as an example of the standard New Haven Railroad plan first used in its 1890s upgrade of the New York to New Haven segment. Probably eligible for the National Register.

Old Saybrook Interlocking Tower, Milepost 102.30. Two story wooden structure built in 1913 significant as a relatively rare type of structure that recalls early railroad signal and switching technology. This complex of buildings includes a c.1900 small brick storage building north of the tower. Probably eligible for the National Register.

Provided that the catenary uprights are placed as far away from the historic buildings as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Connecticut River Railroad Bridge, Milepost 106.89. Through-truss Scherzer rolling lift bascule bridge with numerous approach spans, built in 1907. Listed on the National Register.

The bridge will require substantial modifications associated with installation of the catenary, thereby producing an adverse effect.

3.4.5.9 Old Lyme, CT

Old Lyme U.S G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS:

Old Lyme Paralleling Station, Milepost 109.50. The station will be located close to the tracks in a wooded area. There are no structures nearby; therefore, there will be no effect.

BRIDGE CLEARANCE PROJECTS:

The following bridge replacement involves a small overhead bridge that is more than 50 years old; however, as a 1940 timber-beam bridge, it represents a common type of no particular engineering significance. It is regarded as not eligible, and therefore there will be no effect:

Johnnycake Hill Road Bridge, Milepost 108.51

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Eighteenth-century House, Milepost 108.51. Johnnycake Hill Road. A gambrel-roofed 1 1/2-story house, dated 1690 (but probably c.1780), surrounded by overgrown fields and stone walls. Probably eligible for the National Register.

The catenary will affect the setting of the house, which lies about 200' south of the right-of-way separated by a small field. However, as the existing right-of-way is a relatively modern element not from the house's period of significance, the introduction of the catenary represents only a small additional impact. Therefore, the impact is not considered an adverse effect.

Rocky Neck Park Pavilion, Milepost 112.70. A large stone structure built as a public-relief project during the Depression of the 1930s. Listed on the National Register.

The catenary will affect the setting of the structure, which lies immediately adjacent to the right-of-way, with its north or rear elevation facing the tracks. The tracks run in a cut below the elevation of the surrounding park. Therefore, the additional visual impact of the catenary will be relatively minor, producing no adverse effect.

Rocky Neck Park Trail Bridge, Milepost 112.74. A steel-arch bridge with stone end posts for a hiking trail associated with the Pavilion, above. Although dated 1905 in the railroad's bridge log, it likely was built as part of the park. Listed on the National Register as part of the Park Pavilion.

The installation of solid protective barriers on this bridge will alter the appearance of the bridge because they will be higher than the current wooden barriers and may obscure the ornamental end piers, thereby producing an adverse effect.

3.4.5.10 East Lyme, CT

Niantic U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Bride Brook Railroad Bridge, Milepost 113.18. An 1884 stone-arch bridge, 24' long, significant as an example of masonry arch construction. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

Morton House, Milepost 115.90. Route 156, Niantic. The building is separated from the right-of-way by Route 156, with the beach and Long Island Sound on the other side of the tracks. Although substantially altered with siding and other modernizations, the building retains its characteristic Mansard-roofed form and is possibly eligible due to the rarity (or nonexistence) of similar Victorian seaside hotels in Connecticut.

Provided that the catenary uprights are spaced so that none are immediately in front of the building, obscuring the view of the Sound, no adverse effect will occur.

Niantic River Railroad Bridge, Milepost 116.74. A chain driven deck-girder Scherzer rolling bascule, built in 1907. Listed on the National Register of Historic Places.

The bridge will require substantial modifications associated with installation of the catenary, thereby producing an adverse effect.

3.4.5.11 Waterford, CT

Niantic U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS:

Millstone Paralleling Station, Milepost 117.56. The station is located in a brush filled area near the north end of the Millstone Power Plant property; the only structures nearby are the plant's railroad spur and power transmission lines. Therefore, there will be no effect.

BRIDGE CLEARANCE PROJ. .TS:

The following bridge-clearance project involves an overhead bridge of modern construction; it is regarded as not eligible, and therefore there will be no effect:

Millstone Point Road Bridge, Milepost 117.31. Concrete-beam, built c.1985.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Victorian Stone House, Milepost 119.80. North of tracks off Great Neck Road. Well-preserved Victorian estate, with two barns of similar age. Probably eligible for the National Register.

As the house is situated fairly well above the level of the tracks, faces the driveway off Great Neck Road, and is partly obscured by trees, the visual impact of the catenary will be relatively minor and is therefore not considered an adverse impact.

3.4.5.12 New London, CT

New London U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS:

New London Substation, Milepost 123.55. Located within the Central Vermont railroad yard, between two sets of multiple tracks, an area mostly covered in low brush. Other than the nearby bridge over the Central Vermont tracks, no historic resources appear nearby. The roundhouse and other structures associated with the Central Vermont Railroad lie a considerable distance to the west across several sets of tracks. Therefore, no adverse effect is anticipated.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

J. N. LaPointe Tool Company Milepost 121.90. Pequot Avenue. Large brick factory complex, 1912-1940, formerly occupied by prominent maker of broaching machines, a tool that made non-round holes; employed 200 people. Probably eligible for the National Register.

Because the tracks run along the rear of the factory complex, the visual effect of introducing the catenary to the property's setting is relatively minor; therefore, the effect will not be adverse.

Downtown New London Historic District, Milepost 122.70. An area of 19th and early 20th century business blocks and residences that reflects the commercial development of New London. Listed on the National Register.

The right-of-way runs along the eastern edge of the district, at the rear of the commercial blocks on Bank Street. Provided that the catenary uprights are located so that views of the Thames River waterfront looking down the district's side streets and alleys are unobstructed, the effect of the catenary will not be adverse.

New London Railroad Station, Milepost 122.75.
Built in 1885-87, this two and one half story red brick Romanesque structure was designed by H. H. Richardson; listed on the National Register of Historic Places.

Provided that the catenary uprights are placed as far from this historic building as is feasible, with none immediately in front of the east elevation, the visual impact will be minimal and no adverse effect will occur.

Connecticut Power Company Power Plant, Milepost 123.30. Large brick office and former steam-powered generating plant, c.1900-1920, home of locally significant gas and electric company. Probably eligible for the National Register.

Provided that the catenary uprights are placed as far from the building as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Central Vermont Roundhouse, Milepost 123.75. Though dated c.1875 in a local survey, the structure's concrete foundation and frame construction suggests it is an early 20th-century replacement for an earlier brick roundhouse. Alterations include siding and removal of the turntable. Such facilities are rare in Connecticut and have been nominated to the National Register even as archeological sites; therefore, it should be considered as possibly eligible.

The roundhouse lies about 400' away from AMTRAK's line, which is elevated at this point, in an area of both historic and modern structures, including the overpass for I-95; the visual impact of the catenary will therefore be minor, and no adverse effect will occur.

Central Vermont Railroad Bridge, Milepost 123.80. Through truss built in 1915 to carry New Haven Railroad over the Central Vermont line. Probably eligible as an example of early 20th-century truss technology.

Thames River Railroad Bridge, Milepost 124.09. A Strauss-patent through truss bascule built in 1919; listed on the National Register.

These two bridges will require modifications associated with installation of the catenary, thereby producing an adverse effect.

3.4.5.13 Groton, CT

New London and Mystic U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS:

Noank Paralleling Station, Milepost 129.46. Located on an unused paved parking lot west of Noank village. The only houses visible from this site are modern; therefore, there will be no effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Groton Tower, Milepost 124.40. Brick signal/interlocking tower, c.1920, with concave hip roof; small frame freight station on opposite side of tracks. Probably eligible for the National Register.

Provided that the catenary uprights are placed as far from this historic building as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Haley Farm Historic Rural Landscape, Milepost 129.30-129.50. Haley Farm State Park, Haley Farm Lane. Although only foundations survive of the buildings (possibly of archeological importance), the open fields and stone walls of the Haley Farms property may constitute an eligible property as an historic coastal agricultural landscape, a relatively rare property type in Connecticut.

The catenary represents a modern visual intrusion into this historic landscape, interrupting the view toward the sea, an adverse effect.

Noank National Historic District, Milepost 129.60-130.63. Dense concentration of 18th-century, early 19th-century, and Victorian-period structures exemplifying a coastal Connecticut maritime village. Noank depot, c.1880 board-and-batten building, lies directly adjacent to the tracks. Listed on the National Register.

The right-of-way runs north of the main concentration of historic buildings in Noank and, except for the area around the old depot, it is not easily visible. Provided that the catenary uprights are placed as far from the depot as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Noank Cove Railroad Bridge, Milepost 130.63. Although girder structures have generally not been identified as historic resources in this report, this three-span deck girder bridge is larger than most (126 feet long overall) and bears a relatively early date, 1893. As an example of 19th-century bridge engineering, it is probably eligible for the National Register.

The size of this bridge probably makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

Mystic River Historic District, Milepost 131.30-132.16. A large grouping of 18th and 19th century buildings. The tracks pass close to the West Mystic freight depot, c.1880 and nearly identical to the Noank depot, but otherwise run well south of the main concentration of historic buildings. Listed on the National Register and a local historic district.

Provided that the catenary uprights are placed as far from the station as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

3.4.5.14 Stonington, CT

Mystic, Watch Hill, and Ashaway U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS:

Stonington Paralleling Station, Milepost 134.65. Located in a brushy, overgrown area, with no structures anywhere nearby. Therefore, there will be no effect.

State Line Paralleling Station, Milepost 139.93. Although not far from the historic mills and other buildings in Pawcatuck, the station will be located on a brushy, overgrown site whose nearest neighbor is a complex of oil tanks. Therefore, there will be no effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Mystic Station, Milepost 132.55. Built in 1905, the one story wood-frame structure has a hipped roof and shingled siding. Significant architecturally as a typical small-town depot and for the role of the railroad in the historical development of the community. Probably eligible for the National Register.

Provided that the catenary uprights are placed as far from this historic building as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Packer Tar and Soap Factory, Milepost 132.60. A three-story c.1900 brick factory important in the history of local industry. Probably eligible for the National Register

Because the tracks run along the rear of the factory, the visual effect of introducing the catenary to the property's setting is relatively minor; therefore, the impact will not be an adverse effect.

Mystic Cemetery, Milepost 132.70. A small colonial burying ground separated from the right-of-way by a narrow inlet. Possibly eligible because of the concentration of carved monuments.

The existing right-of-way already constitutes a substantial alteration to the cemetery's historic setting. Because the tracks do not directly adjoin the cemetery, and the catenary has been designed to be as unobtrusive as possible, its installation will have only a minor impact and is not considered an adverse effect.

Wilcox Road Historic District, Milepost 133.77-134.20. A grouping of mostly Victorian houses and barns, many with Gothic Revival detail, set among fields, salt flats, and stone walls. Probably eligible due to the increasing rarity of coastal agricultural landscapes such as this.

The catenary represents a modern visual intrusion into this historic landscape, interrupting the view toward the sea, an adverse effect.

Stonington Borough Historic District, Milepost 136.10-136.60. Dense concentration of 18th, early 19th, and Victorian-period structures exemplifying a coastal Connecticut maritime village. Most structures lie well south of the project corridor, but the tracks pass close to some Greek Revival style houses on Elm Street. A Local Historic District. Listed on the National Register.

The incremental visual impact of the catenary, given the existence of the right-of-way itself, is relatively modest, passing by only a few historic houses at the north end of the village. The catenary has been designed to be as unobtrusive as possible; therefore, no adverse effect is anticipated.

Mechanic Street (Pawcatuck) Historic District, Milepost 140.50. Mid-19th-century, Victorian, and early 20th-century residential and commercial structures. Listed on the National Register.

The railroad right-of-way runs along the rear property lines of the houses on Mechanic Street, visible but not a major element in the district. Because the catenary has been designed to be as unobtrusive as possible, its additional visual impact will be modest and is not considered an adverse effect.

C. W. Campbell Grain Mill, Milepost 141.30. Tin-clad, 7-story, c.1905 grain elevator and feed mill immediately adjacent to the tracks; a relatively rare surviving industrial type for Connecticut. Probably eligible for the National Register.

The height of the building, and the fact that the south and east sides are as important or more important compared with the west (trackside) elevation, makes the visual impact of the catenary relatively minor. Provided that the catenary uprights are placed as far from the building as is feasible, thereby further minimizing their visual impact, no adverse effect will occur.

Pawcatuck River Railroad Bridge, Milepost 141.35. Deck truss, c.1910, substantially altered (60-70%) with substitution of modern materials for historical members; although determined eligible by the Connecticut SHPO, the changes are so extensive that it is recommended that it be considered no longer eligible.

In any case, the size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

3.4.5.15 Westerly, RI

Ashaway and Carolina U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS:

Bradford Paralleling Station, Milepost 145.19. Located far west of the village of Bradford, on a rubbish-strewn wooded site with no buildings nearby. Therefore, there will be no effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Pawcatuck River Railroad Bridge, Milepost 141.35. Deck truss, 1909, substantially altered (60-70%) with substitution of modern materials for historical members; although determined eligible by the Connecticut SHPO, the changes are so extensive that it is recommended that it be considered no longer eligible.

In any case, the size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

Westerly Railroad Station, Milepost 141.60. Railroad Ave. A Mediterranean style station, with tile roof, stuccoed walls, brick quoins, and an arcaded entry, built in 1912 by the New Haven Railroad. Listed on the National Register.

Provided that the catenary uprights are placed as far from this historic building as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Westerly Freight Station, Milepost 141.62. Off Canal St. A c.1910 brick freight station with multiple loading bays and a two story head house. Located north of the main station, beyond the main rail line and adjacent to a switch yard. Probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the freight station's setting will be minimal; therefore, no adverse effect is anticipated.

Downtown Westerly Historic District, Milepost 141.50-141.60. A concentration of significant examples of 19th and 20th-century commercial architecture. One end of the district abuts the railroad corridor near the Westerly Station. Listed on the National Register.

The rail corridor, because of its elevation, already defines an edge of this district. The additional visual impact of the catenary will be relatively minor. Because the catenary has been designed to be as unobtrusive as possible, no adverse effect is anticipated.

Westerly Armory, Milepost 141.65. Railroad Ave. and Dixon St. A fortress-like two-story building of brick and granite built in 1902, with tall, round arched windows and turreted roof corners. Property includes an 8-inch **Parrott rifle**, a Civil War artillery piece cast at West Point Foundry in 1864; it itself is a significant historic resource. The armory is located across the street from the railroad. Probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the armory's setting will be minimal; therefore, no adverse effect is anticipated.

West Street Bridge (RIDOT No. 401), Milepost 141.67. This steel highway and streetcar bridge, built in 1913, is significant as an example of the bridge technology of the early twentieth century. Determined eligible for the National Register in the RIDOT bridge survey.

The installation of solid protective barriers on this bridge will obscure and possibly physically alter the trusses, thereby producing an adverse effect.

Greek Revival-Style House, Milepost 141.67. 17 West St. Two-story house, c.1840, with a full cornice return, corner pilasters, and low pediments over the windows. Significant as a well-preserved example of the Greek Revival style. The building is situated above the rail line across one street. Probably eligible for the National Register.

Immaculate Conception Church, Milepost 141.77. High Street. A Victorian Gothic wood-framed church built in 1889, with pointed arch windows and a stepped tower on the southeast corner, a considerable distance from the rail line. Probably eligible for the National Register.
Though the tracks are visible, the distance is such that the visual impact of the catenary on the preceding two properties' settings will be minimal; therefore, no adverse effect is anticipated.

Westerly Signal Tower, Milepost 142.05. Near High St. Two-story concrete tower built in 1913, with flaring, concave-hipped tiled roof. A standard type now relatively rare, it is significant for recalling an earlier signalling and switching technology. Probably eligible for the National Register.

Provided that the catenary uprights are placed as far from this historic building as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Greek Revival House, Milepost 142.00. High Street. A hip-roofed, 2-1/2 story Greek Revival house with an elegant cornice and portico; it is significant as a well-preserved example of the Greek Revival style. It is located not far from the right of way. Probably eligible for the National Register.

Eighteenth-Century House, Milepost 144.00. Westerly-Bradford Road. Late 18th or early 19th-century gambrel-roofed house, located immediately adjacent to the right-of-way. Probably eligible for the National Register.

Stone-Walled Enclosure, Milepost 144.00. Westerly-Bradford Road. Possibly a cattle pound, in front of the above house on Westerly-Bradford Road. This entire historic rural landscape, very close to the rail line, is probably eligible for the National Register.

The installation of the catenary will produce only a modest additional impact on the settings of the preceding three properties, since the existing right-of-way represents an element completely outside the period of significance of the properties. Therefore, the impact is not considered an adverse effect.

Bradford Historic District, Milepost 145.50-146.39. This mill village, once called Dorrville in honor of the 1840s rebel Thomas Dorr, includes an 1864 stone mill, many mill houses from the 19th and 20th century and an 1855 bank. The district, on both sides of the railroad, has been determined eligible for the National Register.

The project bisects the district and adds a modern element in the form of the catenary. Because the catenary has been designed to be as unobtrusive as possible, its visual impact will be modest and therefore is not considered an adverse effect.

Pawcatuck River Railroad Bridge, Milepost 146.39. Although girder structures have generally not been identified as historic resources in this report, this two-span deck girder bridge is larger than most (146' long overall) and bears a relatively early date, 1887. As an example of 19th-century bridge engineering, it is probably eligible for the National Register.

The size of this bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

3.4.5.16 Hopkinton, RI

Carolina U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

No historic resources within the project area were identified in Hopkinton.

3.4.5.17 Charlestown, RI

Carolina U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS:

Burdickville Road Bridge (RIDOT No. 914), Milepost 148.41. A 1931 timber-stringer bridge on stone abutments. Although more than 50 years old, the bridge is a simple structure of little engineering significance. The bridge was not considered eligible for the National Register in the RIDOT bridge survey. Therefore, there is no effect.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Pawcatuck River Railroad Bridge, Milepost 147.45. This heavy rivetted Pratt pony truss, 104' long, built in 1906, is significant as an example of early 20th-century bridge engineering. Probably eligible for the National Register.

Pawcatuck River Railroad Bridge, Milepost 149.47. Essentially identical to the bridge above, this Pratt pony truss, built in 1906, is also probably eligible for the National Register.

Pawcatuck River Railroad Bridge, Milepost 150.59. Essentially identical to the two previous bridges, this Pratt pony truss, built in 1905, is also probably eligible for the National Register.

Pawcatuck River Railroad Bridge, Milepost 152.71. A double-intersection Warren deck truss built in 1905, this 105'-long bridge is significant as an example of early 20th-century technology (an unaltered example similar to the Pawcatuck-Westerly Bridge, Milepost 141.35). Probably eligible for the National Register.

The size of these bridges makes it unnecessary to modify them in any way for the catenary; therefore, no adverse effect is anticipated.

3.4.5.18 Richmond, RI

Carolina and Kingston U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS:

Richmond Switching Station, Milepost 150.35. Site is overgrown with woods and brush. Nearby is a c.1900 factory, substantially altered and modernized, and a 1905 bridge across the Pawcatuck that appears to be an eligible structure (inventoried in Charlestown, preceding section). Because of the terrain and intervening vegetation, the new construction will have little if any impact on the setting of the bridge. Therefore, no adverse effect is anticipated.

BRIDGE CLEARANCE PROJECTS:

Kenyon School Road Bridge, Milepost 154.04. A simple timber beam bridge built in 1929. Although of doubtful individual significance, the structure is located within a potential National Register historic district at Kenyon.

The bridge is scheduled to be demolished and replaced. Its replacement will affect the visual qualities of the district. If the size, scale, and materials of the new bridge are *such that their visual intrusion on the historic district is minimized, the effect will not be adverse.*

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Greek Revival House, Milepost 150.10. 547 Switch Rd. (former Narragansett Rd.), Wood River Junction. A 2 1/2 story building, c.1850, immediately adjacent to the rail line. The house should be considered as possibly eligible for the National Register.

Victorian-Period House, Milepost 150.00. 878 King's Factory Rd. (extension of former Narragansett Rd. south of the railroad). This c.1870 2 1/2-story house, with Victorian porch detail, should be considered as possibly eligible for the National Register. There is also a historic cemetery nearby, listed as Richmond 36.

Because the catenary has been designed to be as unobtrusive as possible, its installation in the vicinity of these two houses at Wood River will have only a modest visual impact on their setting, and therefore, no adverse effect.

Shannock Historic District, Milepost 152.90-153.50. This mill village includes two mills, worker houses, dams, and the Shannock Baptist Church, which is located just above the railroad tracks. Listed on the National Register.

Kenyon Historic District, Milepost 154.00-154.33. A very well-preserved mill village with an operating textile mill complex (Kenyon Dye Works), many mill houses, farm buildings, an 1862 company store, and a mid-19th-century schoolhouse. One of the stone mills dates from 1844. There is another stone mill built in the 1860s as well as the "big mill" of 1894. This potential historic district, on both sides of the rail line, is probably eligible for the National Register.

Although the project bisects the two preceding districts and adds a modern element in the form of the catenary, the visual impact will be modest because the catenary has been designed to be as unobtrusive as possible. Therefore, no adverse effect is anticipated.

3.4.5.19 South Kingstown, RI

Kingston U.S.G.S. **Quadrangle**

SWITCHING, PARALLELING AND SUBSTATIONS:

Kingston Paralleling Station, Milepost 157.11. Site is in a wooded area with no structures anywhere nearby. Therefore, there is no effect.

BRIDGE CLEARANCE PROJECTS:

RI Route 138 Bridge (RIDOT No. 372), Milepost 158.32. A 1936 three-span concrete-beam bridge, also known as the Kingston Station Railroad Bridge. It is a good example of the concrete beam bridges erected in substantial numbers by the State of Rhode Island in the 1930s. There are two parks in association with the bridge and station in West Kingston, forming a unified historic landscape beside the railroad. Probably eligible for the National Register.

The bridge is scheduled to be raised to create the necessary clearance, creating an adverse effect.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Kingston Railroad Station, Milepost 158.20. Off Kingston Rd. This 1875 Victorian station is an elaborate design with brackets, a flat-roofed central dormer, smaller arched dormers, and a shed roof-canopy. It recently suffered a fire but is scheduled for restoration by the State of Rhode Island. Listed on the National Register.

Provided that the catenary uprights are placed as far away from this historic building as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

RI Route 138 Bridge (RIDOT No. 372), Milepost 158.32. A 1936 three-span concrete-beam bridge, also known as the Kingston Station Railroad Bridge. It is a good example of the concrete beam bridges erected in substantial numbers by the State of Rhode Island in the 1930s. Possibly eligible for the National Register.

The installation of solid protective barriers on this bridge will obscure and possibly physically alter the railings, a significant feature, thereby producing an adverse effect.

Kingston Tower, Milepost 158.35. Off Kingston Rd. A 1930 hip-roofed wood-framed interlocking tower that once stood beside the rail line but has been moved to a nearby park, still within clear sight of the corridor. Probably eligible for the National Register.

Washington County Courthouse, Milepost 158.40. Kingston Rd. An architecturally significant 2 1/2-story Richardsonian Romanesque courthouse built of granite in 1894 and designed by Leslie Langworthy of Providence. Located a considerable distance away from the railroad corridor. Probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the preceding two properties' settings will be minimal; therefore, no adverse effect is anticipated.

Historic Rural Landscape, West Kingston, Milepost 158.35-158.60. Waites Corner Rd. and Fairground Rd. A farm area north of the Main Street Bridge (Kingston Rd.) between Fairground Rd. and the railway, extending to the vicinity of the Kenyon Homestead on Waites Corner Rd. It was probably part of the 160 acre farm that surrounded the homestead at its construction in 1815. This farm landscape adds considerably to the ambience of the Homestead.

Kenyon Homestead/Underwood House, Milepost 158.70. Waites Corner Rd. A center-chimney house built by Weeden Underwood c.1815 and owned by the Kenyon family in the 20th century. It is located not far from the railway (on a street leading to it), within the historic farm landscape described above. Probably eligible for the National Register.

Although the project is immediately adjacent to the historic rural landscape described above and the Kenyon Homestead, and it adds a modern element in the form of the catenary, the visual impact will be modest. The tracks run along the edge of the historic landscape, and the catenary has been designed to be as unobtrusive as possible; therefore it is not considered an adverse effect.

Hundred Acre Pond Railroad Bridge, Milepost 159.37. Although this 18-foot stone arch is dated 1930 in the railroad's bridge log, the date probably refers to the bridge's widening in concrete. The west side is unaltered and represents a good example of stone-arch bridge construction. The ashlar of large rusticated granite blocks suggests an original date of c.1880. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

3.4.5.20 Exeter, RI

Slocum U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS:

Exeter Parallelling Station, Milepost 161.78. Site is located adjacent to an open field that forms part of the setting for the Slocum House (across the town line in North Kingston), an 18th-century farm house that has been determined eligible for the National Register.

The slope of the land and the screening effect of intervening trees appears sufficient so that the station will not be visible from the historic farm, and therefore resulting in no adverse effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Yawgoo Mill And Company Houses, Milepost 161.50. A small potential district consisting of a 2-story stuccoed stone textile mill built in 1861, along with worker houses, dam, and mill pond. Probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the district will be minimal; therefore, no adverse effect is anticipated.

3.4.5.21 North Kingstown, RI

Slocum, Wickford, and East Greenwich U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS:

East Greenwich Paralleling Station, Milepost 169.80. Separated from a golf driving range by a stand of trees, with a modern lumber dealer complex across the tracks. No historic structures appear to be nearby; therefore there is no effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

W. R. Slocum House, Milepost 162.00. 86 Slocum Rd., Slocum. A small farmhouse with a stone central chimney that dates from the mid 18th century, with associated open fields across the road, just to the east of the tracks. Determined eligible for the National Register.

Sod Farm Landscape At Slocum, Milepost 162.30-163.20. Off Indian Corner Rd. The sod farms of Slocum are a significant part of the agricultural heritage of Rhode Island. The area between Indian Corner Road and West Allentown Road, bounded on the West by the railroad line, has vast fields of sod, a tree-lined lane through an historic farm complex (now run by Sodco), and an historic cemetery. It is one of the best examples of this type of landscape and is probably eligible for the National Register.

Although the project is immediately adjacent to the two historic rural landscapes described above, and it adds a modern element in the form of the catenary, the visual *impact will be modest. In each case, the tracks run along the edge of the landscape, and the catenary has been designed to be as unobtrusive as possible; therefore, it is not considered an adverse effect.*

Wickford Junction/Lafayette Historic District, Milepost 165.80-165.95. Ten Rod Rd. This district includes the Lafayette Mill complex (1877-1878) and associated mill village, as well as the site of Wickford Junction, with archaeological features that include the remains of a station, engine house, and turntable. The railway corridor touches the district at its west end. Determined eligible for the National Register.

Because the tracks run along the extreme west end of the historic district, and the catenary has been designed to be as unobtrusive as possible, the visual impact will be modest and therefore is not considered an adverse effect.

Lawton House, Milepost 166.85. 750 Stony Lane. Built c. 1822, this 1 1/2-story farmhouse is surrounded by an historic landscape of fields, stone walls, and outbuildings. A modern house now sits between the Lawton House and the highway bridge over the tracks. Probably eligible for the National Register.

Lawton Farm Landscape, Milepost 166.80-166.90. Stony Lane. Although there are now many modern intrusions, the area retains the character of an historic rural landscape, with pastures, fields, and stone walls stretching west from the Lawton House to the railroad corridor. Probably eligible for the National Register.

Although the project is immediately adjacent to the historic rural landscape described above and the Lawton House, and it adds a modern element in the form of the catenary, the visual impact will be modest because the catenary has been designed to be as unobtrusive as possible. Therefore, no adverse effect is anticipated.

Hunt's River Road Bridge (RIDOT #7), Milepost 169.79. A three-span concrete beam bridge, built in 1930 and carrying Route 1 over the railway. Inventoried but not recommended as eligible in the Rhode Island Historic Bridge Inventory. However, it might be reconsidered as possibly eligible as a good example of typical 1930s bridge construction.

The installation of solid protective barriers on this bridge will obscure and possibly physically alter the railings, a significant feature, thereby producing an adverse effect.

3.4.5.22 East Greenwich, RI

East Greenwich U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Pains Pond Railroad Culvert, Milepost 171.06. This stone arch, said to date from the line's construction in 1837, is significant as an early example of masonry-arch construction. It allows the out-flow of Bleachery Pond (known variously as Pains Pond and Print Works Pond) to reach Greenwich Cove directly under the Amtrak line. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

East Greenwich Historic District, Milepost 171.80-172.25. The district, which includes much of East Greenwich's downtown, contains a wide variety of historic structures from the 18th and 19th centuries. The rail line runs through the center of the district, passing numerous significant structures such as the 1870 East Greenwich Station (146 Duke Street); the Bay Mill, King Street, a 3-story textile mill built c. 1840; King Street Railroad Bridge, a two-span stone-arch bridge built between 1835 and 1836. Listed on the National Register. District boundary of the listed district could logically be extended to include Victorian-period residential neighborhood on Crompton Avenue. Also a Local Historic District.

Provided that the placement of catenary uprights is such as to avoid obscuring historic buildings close to the tracks, the visual effect on the district will be relatively minor; therefore, the effect will not be adverse.

3.4.5.23 Warwick, RI

East Greenwich U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS:

Warwick Substation, Milepost 176.91. The site is presently occupied by a modern steel-framed and sided lumber dealer building, in a mixed commercial-residential area. No historic structures appear to be nearby, and therefore there will be no effect.

BRIDGE CLEARANCE PROJECTS:

Pettaconsett Avenue Bridge (RIDOT No. 921), Milepost 178.46. Pettaconsett Avenue over rail line. This small timber-beam bridge bears a date of 1895, but as the concrete capping on the ashlar abutments indicates, it has been substantially rebuilt, probably c.1940. It does not appear to be eligible for the National Register, and therefore there will be no effect.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Elizabeth Spring, Milepost 171.00. Southeast of right of way, below rail berm. This historic landscape was a stopping point along a Pequot Indian travel route and was later utilized by colonial settlers. Listed on the National Register.

Although the project is nearby the historic property, and adds a modern element to its setting in the form of the catenary, the visual impact will be modest because the catenary has been designed to be as unobtrusive as possible. Therefore, no adverse effect is anticipated.

Post Road Historic District, Milepost 172.35-173.50. 4456-3960 Post Road. This part of Post Road in Warwick contains numerous historic houses, several of which, including some notable examples of the Shingle Style, may also be individually eligible for the National Register. The rail corridor runs just east of Post Road and is visible from the potential district, which is probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the district will be minimal; therefore, no adverse effect is anticipated.

Ocean Point Road Railroad Bridge/Culvert, Milepost 172.75. This stone arch, said to date from the line's construction in 1837, is significant as an early example of masonry-arch construction. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

Rhode Island Historical Cemetery No. 34, Milepost 174.50. Post Road, just north of Brand Avenue. This cemetery contains mid-19th century to early 20th century graves. The rail line and nearby bridge are visible from the rear of this elevated landscape as it overlooks Apponaug Cove. Although cemeteries are not ordinarily eligible for the National Register, the landscape qualities of this site may qualify it as an exception.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the cemetery landscape qualities will be minimal; therefore, no adverse effect is anticipated.

Victorian-Period House, Milepost 174.70. Corner Spruce & Post Roads. An architecturally significant High-Victorian house, c.1890, with decoratively sawn bargeboards, bracketed cornice, and cross-gabled porch. The railroad is located down a hill some distance away. Probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

Greenwood Railroad Bridge (RIDOT #2), Milepost 175.70. A concrete-encased steel-beam bridge, built in 1930 to carry Post Road over the tracks. Inventoried but not recommended as eligible in the Rhode Island Historic Bridge Inventory. However, it might be reconsidered as possibly eligible as a large and relatively intact example of 1930s bridge construction.

The installation of solid protective barriers on this bridge will obscure and possibly physically alter the railings, a significant feature, thereby producing an adverse effect.

Greenwood Inn, Milepost 175.70. 1350 Jefferson Boulevard. This 2 1/2-story early 19th-century structure was a stop-over for stagecoaches travelling Boston Post Road and became a railroad station with the opening of the Stonington Railroad in 1837. The building, now a restaurant and bar, is directly adjacent to the rail line. It is probably eligible for the National Register.

Although the project passes by the property and adds a modern element in the form of the catenary, the additional visual impact will be modest because the catenary has been designed to be as unobtrusive as possible; therefore, no adverse effect is anticipated.

Pontiac Railroad Station, Milepost 176.20. 2245 Post Road. This station, built in 1882 and significant as an example of a small-town depot, was moved in 1964 from its original site in Pontiac Village. It is now attached to an inn and restaurant, along with a New Haven Railroad caboose. The project corridor lies a considerable distance away. Probably eligible for the National Register despite its lack of original setting.

Elizabeth Mill, Milepost 176.70. 745 Jefferson Boulevard. Large 3-story brick mill built in 1875. The rail line is separated from the mill by a road and the mill's parking lot. Its cornice and dentils have been removed and it has modern windows. Although historically significant, these alterations have compromised its integrity, making its eligibility problematical; it should considered as only possibly eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the two preceding properties' settings will be minimal; therefore, no adverse effect is anticipated.

3.4.5.24 Cranston, RI

Providence U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS:

Park Avenue Bridge (RIDOT No. 922), Milepost 180.29. This simple plate girder single span, scheduled to be raised to achieve greater clearance for the catenary, was built in 1906. Although decreasing numbers may make earlier and larger examples of girder bridges eligible, this small bridge lacks any particular historical significance. Inventoried but not recommended as eligible by the RIDOT bridge survey. No effect is anticipated as a result of its raising.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Pawtuxet River Railroad Bridge, Milepost 179.16. Main line over Pawtuxet River and Wellington Street. This double-intersection Warren through truss with sub-struts is a massive structure carrying both lines of the Northeast Corridor. Of riveted construction, the 130'-long 1906 bridge represents a major work of early 20th century engineering. It is one of the few large trusses that remain on the main line. Probably eligible for the National Register.

As a through truss, the bridge will require some modifications to carry the catenary, thereby producing an adverse effect.

Maxwell Briscoe Motor Company/Universal Winding Co., Milepost 179.25. 1655 Elmwood Avenue. This large 3-story brick factory complex was built by the Atlantic Rubber Shoe Co. c. 1908 but acquired by Maxwell Briscoe soon thereafter for production of automobiles. Later, it was owned by Universal Winding Co., said to be the largest producer of winding machinery in the world. The rail line lies some distance away. The factory is probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

United Traction Depot & Repair Shop, Milepost 182.70. 833 Cranston Street. This large 2 1/2-story brick building was built in 1900 by the United Traction Company to house and repair its streetcars. Later, Narragansett Brewery used it as a warehouse. The rail line is immediately adjacent. Determined eligible for the National Register.

Because the tracks run along the rear elevation, the visual effect of introducing the catenary to the property's setting is relatively minor; therefore, the effect will not be adverse.

3.4.5.25 Providence, RI

Providence U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS:

Elmwood Paralleling Station, Milepost 181.70. The site of the station immediately adjoins two buildings that are part of the former **Gorham Silver Co. complex** (see below), determined eligible for the National Register. The station site is about 65' south of the **Gorham Company Carriage House** and an associated garage at the south end of the historic property. Because of the size of the factory and the fact that the site is at the perimeter of the historic property, behind two secondary buildings, the visual effect of the station on the factory complex will be minor (no adverse effect). The impact could be reduced even more if the site is shifted further to the south.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

General Electric Company, Milepost 180.35. This historic former General Electric plant is a 2-story brick building with segmental-arched windows. The rail line is immediately adjacent. The building is possibly eligible for the National Register, though window replacement and modern infills compromise its integrity.

Because the tracks run along the rear elevation, the visual effect of introducing the catenary to the property's setting is relatively minor; therefore, the effect will not be adverse.

Gorham Manufacturing Company, Milepost 181.70. 333 Adelaid Avenue. Built in 1890, this 3-story brick complex housed one of the largest foundries in the world for jewelry, statue, and tableware production. The huge E-shape factory faces the main line. Includes the **Gorham Company Carriage House**, a brick 1 1/2-story hip-roofed structure with a cupola, and an associated garage. Determined eligible for the National Register.

Union Railroad Company Car Barns and Stable, Milepost 181.90. 333 Bucklin Street. This enormous brick building was built in 1865. The roof is topped by a square cupola with slightly flared eaves. The rail line is adjacent and below this building. Probably eligible for the National Register.

Potters Avenue Historic District, Milepost 182.00-182.50. This potential historic district includes several historic structures, among them Queen Anne-style houses at 34 and 36 Carter Street; the John and Thomas Hope Company, 1 Mashpaug Street, a 3 1/2-story brick factory, built in 1882, that made calico-printing equipment; and the John Barbour House, 41 Madison Street, a Queen Anne style house. Probably eligible for the National Register.

Atlantic Coal Company Storage Elevators, Milepost 183.20. Off Troy Street near Route 10 and rail line, Olneyville. These nine concrete storage elevators were used to store coal for distribution in the Providence area. Adjacent to the coal towers are remnants of sidings and raised rail beds that are part of this facility and of the former Olneyville Freight Yards. An example of an important building technology, these elevators are probably eligible for the National Register.

Weybosset Mills, Milepost 183.55. Troy and Dike Streets. The first building of this historic textile mill complex, a stuccoed-stone mill 4 stories tall, was constructed in 1836, with numerous subsequent additions. The mill is immediately adjacent to the rail line. Probably eligible for the National Register.

Power Plant, Milepost 183.50. 7 Dike Street. This large brick building, built c.1910, has large arched windows and a corbelled cornice. It appears to have been a power plant or electrical sub-station. The building is immediately adjacent to the Amtrak line and is probably eligible for the National Register.

Commercial Building, Milepost 183.55. 1820 Westminster Street. This c.1880 mansard-roof building is 3 1/2-stories tall. It is directly adjacent to the rail line and should be considered as possibly eligible for the National Register.

Although the project area is immediately adjacent to the preceding seven historic buildings or districts, and a modern element in the form of the catenary will be introduced, the visual impact on the properties' settings will be relatively minor because the catenary has been designed to be as unobtrusive as possible; therefore, no adverse effect is anticipated.

City Machine Company, Milepost 184.50. Harris Avenue and Acorn Street. This complex began in 1868 but now covers more than an entire city block with 1- 2- and 3-story brick buildings. The company was an important supplier of machinery and equipment to textile manufacturers throughout the area. Located at some distance from the rail line across the street. It is probably eligible for the National Register.

Merchants Cold Storage And Warehouse Company, Milepost 184.90. 65 Harris Avenue. This building is significant as an impressive example of 19th century cold storage technology. The huge brick building with its recessed Gothic arches and corbelled belt courses still contains some of its historic equipment, though the last steam engine is scheduled for removal. The building was constructed in 1893 and enlarged in 1910 to become the largest cold storage plant in New England outside of Boston. The building is somewhat distant from the rail line, across Harris Avenue. Determined eligible for the National Register.

Brown & Sharp Manufacturing Company, Milepost 185.10. 235 Promenade Street. This famous machine tool company, one of America's most important, moved to this site in 1868. The site now covers over two city blocks and includes an assortment of 3- to 5-story structures built from 1876 to 1916, mostly constructed of brick. The complex is of a partly hollow square form and is considered one of the finest factory complexes of its period. The complex is now known as The Foundry and is a mixed use development. It is separated from the rail line by a parking lot and a raised modern highway (I-95). The complex is listed on the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the three preceding properties' settings will be minimal; therefore, no adverse effect is anticipated.

Downtown Providence Historic District, Milepost 184.90-185.78. Bounded by Pine, Empire, Fountain Streets, the railroad, and the Providence River. Listed on the National Register.

Although the project area is immediately adjacent to preceding historic district, and a modern element in the form of the catenary will be introduced, the visual impact on the district will be relatively minor because the catenary has been designed to be as unobtrusive as possible; therefore, no adverse effect is anticipated.

Old Union Station, Milepost 185.40. 4 Exchange Terrace. This complex of buildings, built between 1896 and 1898, is constructed of yellow brick with brownstone trim. The buildings are steel-framed with dentil cornices and hipped roofs. The rear of the complex faces the former rail line which has been moved further north and placed in a tunnel as it runs by this station. Listed on the National Register.

University Of Rhode Island Extension Building, Milepost 185.30. 199 Promenade Street. This large yellow brick building was built in 1926 as the Henry Barnard School of the Rhode Island College of Education. It is a relatively plain large, 3-story building. The rail line is adjacent to and below the eastern side of the building. The building should be considered as possibly eligible for the National Register.

Rhode Island State House, Milepost 185.70. 90 Smith Street. One of Rhode Island's most prominent buildings, the State House is situated at the crest of Smith Hill at the center of a large, balustraded, marble terrace. The 3-story Neo-Classical building is topped by a large dome. It was designed by McKim, Mead, & White and constructed between 1891 and 1904. The rail line runs along the bottom of Smith Hill, but it is in a tunnel as it runs south of the Capitol and is therefore not visible until it emerges at the new train station, to the east of the State House. Listed on the National Register.

Roger Williams National Memorial Park, Milepost 185.70. 150 North Main Street. This four acre park, built in 1981, is adjacent to the site of Roger William's original settlement of Providence in 1636. Within the park is the William Antram House (built in 1738 and enlarged in 1790). This 2 1/2-story brick and clapboard home now serves as the headquarters for the park. The rail line is visible across Canal Street and the Blackstone Canal. Listed on the National Register.

Cathedral Of St. John, Milepost 185.70. 271 North Main Street. This stone church was designed by John Holden Greene and built in 1810. The building looks at the mainline to the west and below, across Roger Williams National Park. The church is listed on the National Register.

Rhode Island State Office Building, Milepost 185.80. 133 Smith Street. This large 3-story brick Neoclassical building was built c.1930 of red brick trimmed with stone. Located atop Smith Hill above the rail line. The building is probably eligible for the National Register.

College Hill Historic District, Milepost 185.00-185.50. Bounded by Olney and Hope Streets, Route 195, and the Providence River. The College Hill Historic District lies above and to the east of the Northeast Corridor. The area is largely residential, but also includes Brown University, Rhode Island School of Design, and a few small areas of shops and commercial establishments. The Amtrak line is distant but visible from the northern high points of College Hill that overlook downtown to the west. Listed on the National Register.

Though the tracks are just barely visible, the distance and the location of the right-of-way below grade are such that the visual impact of the catenary on the preceding seven historic buildings or districts will be minimal; therefore, no adverse effect is anticipated.

Moshassuck Square Historic District, Milepost 186.00-186.20. Bounded by Stevens, Charles, Randall, Smith, North Main, and Hewes Streets. An area of brick industrial buildings afflicted by considerable demolition since it was first listed on the National Register.
The rail line lies in a depressed corridor across a street, and only modern office buildings within the district are visible from the tracks. Therefore, no adverse effect on the district is anticipated.

Oriental Mills, Milepost 186.20. 20 Admiral Street. Also known as J.P. Campbell & Company, this mill was built c. 1860. The company specialized in production of white cotton goods. The rail line is separated from the mill by a modern addition at the rear of the building and a highway. The mill is probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

Silver Spring Bleaching And Dying Company, Milepost 186.60. 387 Charles Street. This former bleaching, dying, and textile printing plant was built between 1850 and 1880; although several small structures and one of the power plants at the site have been destroyed, the complex still maintains substantial integrity. The plant is directly adjacent to the rail line. Probably eligible for the National Register.

Providence Tool Company, Milepost 186.70. 148 West River Street. This brick factory complex was built in 1861. The site is significant for the work completed there by Frederick Howe, his development of the milling machine, and his close relationship with Brown and Sharp. The Northeast Corridor runs directly behind this complex. It is probably eligible for the National Register.

Box Factory/Ginger Ale Plant, Milepost 186.85. Silver Spring Street adjacent to rail line. A brick box factory built c.1908, it has a tall yellow-brick stack topped with ornamental brick and painted with the words "Box Shop." Probably eligible for the National Register.

Because the tracks run along the rear of the preceding three factory complexes, the visual effect of introducing the catenary to the properties' settings is relatively minor; therefore, the impact will not be an adverse effect.

North Burial Ground, Milepost 187.00-187.50. 5 North Main Street. This park-like burial ground is Providence's oldest, established in 1700. Its 150 acres contain important graves from the 18th, 19th, and 20th centuries. The Amtrak line lies in the distance across Interstate 95 from the cemetery. Listed on the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

Northrup Yard, Milepost 187.70. This yard was created by the Boston & Providence and Providence & Worcester Railroads before 1915. The yard could at one time handle 1,000 cars each day. The yard was changed from a hump or gravity fed yard to its current flat configuration in the late 1960s. It should be considered as possibly eligible for the National Register.

Colfax Tower, Milepost 187.80. Located alongside the Northrup Yard, this brick tower once controlled its switches, but it is no longer in use. Built c.1940, it has a pyramidal roof and exposed rafter-ends. Probably eligible for the National Register.

Though the tracks run along the eastern side of the above two resources, the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

3.4.5.26 Pawtucket, RI

Providence and Pawtucket U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS:

Providence Paralleling Station, Milepost 187.55. Although located in a densely built urban area of historic residences, commercial buildings, and factories, the site of the switching station will be within the AMTRAK Providence maintenance facility immediately adjacent to the railroad right-of-way. No historic properties appear to be nearby. Therefore, there will be no effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

American Textile Company, Milepost 187.90. 250 Esten Avenue. Built c.1900, this mill was once the largest lace-making plant in the country. The 3-story brick mill has a hipped roof tower. The mill is separated from the rail line by I-95. Probably eligible for the National Register.

Hope Webbing Company, Milepost 188.00. 1005 Main Street. This large mill complex was built between 1889 and 1912 and was said to have been the largest narrow fabric production facility in the U.S. The mill has a distant view of the Northeast Corridor from its rear across Interstate 95. Probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the two preceding properties' settings will be minimal; therefore, no adverse effect is anticipated.

Blackstone Canal, Milepost 188.27. One section of this early 19th-century canal is immediately adjacent to the rail line, where the Moshassuck River passes under the tracks. The route of the historic Blackstone Canal is a National Heritage Corridor, now being developed for interpretive, educational, and recreational use, and the canal is also individually listed on the National Register.

Because the right-of-way is very wide at this point, and includes several parallel (currently unused) tracks, the installation of the catenary on the east side of the embankment will not have an adverse effect on the canal, an intact section of which lies on the west side of the embankment.

Woodlawn Signal Tower, Milepost 189.10. No longer in operation, this brick tower is located within the railroad right-of-way. Built in 1914, the 2-story tower has a tiled concave hipped roof with exposed rafters. The tower exemplifies one of the New Haven Railroad's standard plans and recalls a now-archaic switching and signalling technology. Probably eligible for the National Register.

Provided that the catenary uprights are placed as far away from this historic structure as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Mineral Spring Cemetery, Milepost 189.20. Mineral Spring Avenue and Conant Streets. This is one of Pawtucket's oldest cemeteries and is directly adjacent to the rail line. Although cemeteries are not ordinarily eligible for the National Register, its landscape qualities may make it an exception.

This property is already substantially affected by the existing right-of-way, which runs along its eastern edge at a depressed elevation. The additional visual impact of the modern catenary will therefore be minor and is not considered an adverse effect.

Mineral Spring Park, Milepost 189.20. Mineral Spring Avenue, North Main and Conant Streets. This small triangular park is adjacent to Mineral Spring Cemetery. The park includes an 1890 monument to Samuel Collyer, chief engineer of the fire department who died when a fire engine overturned on him. The monument has been determined eligible for the National Register, and the park as a whole is also recommended.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

Conant Thread Company, Milepost 189.20. Pine, Conant, and Carpenter Streets. Also known as the Coats and Clark Mills, this complex of brick mills was built on approximately fifty acres between 1870 and 1919. The site straddles the boundary between Pawtucket and Central Falls. The rail line is adjacent to the mill complex, which has been determined to be eligible for the National Register.

Pawtucket Freight Station, Milepost 189.40. Pine Street. This building was constructed in 1882 and was originally located just off Broad Street, near the city's first train station. It was moved and lengthened by 100 feet when the rail line was relocated in 1907. This long brick building is characterized by numerous arched doorways and windows and a clerestory monitor which has been covered with metal siding. A track ran through the building and sheltered freight cars during loading or unloading. The station is next to the Amtrak line and is probably eligible for the National Register.

Union Wadding Company, Milepost 189.50. 125 Goff Avenue. The rail line is directly behind this brick mill, which was built between 1847 and 1870. Probably eligible for the National Register.

Former School, Milepost 189.60. Cherry Street. Now attached to the rear of Garreau Furniture Company at 194 Barton Street and used for storage, this building appears to have once been a school. The 2 1/2-story brick building has a cross hip roof. It is immediately adjacent to the rail line. Despite its alterations, it should be considered as possibly eligible for the National Register.

Although secondary elevations of the preceding four properties face the rail line, and the project adds a modern element to their settings in the form of the catenary, the visual impact will be modest because the catenary has been designed to be as unobtrusive as possible; therefore, no adverse effect is anticipated.

Italianate-Style House, Milepost 189.80. 27 Miller Street. Built c.1865, this house has stuccoed walls and a low pitched bracketed hipped roof. It lies a considerable distance away from the tracks. The house should be considered as possibly eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

Pawtucket/Central Falls Station, Milepost 189.80. Broad Street. Built in 1916, this Beaux-Arts brick structure spans the tracks of the Northeast Corridor, which runs below the station. The 2-story station is on the Pawtucket Central Falls border. The station was vacated in 1959. The building has been determined eligible for the National Register.

Because the tracks run below the station, the visual impact of the catenary will be relatively slight; therefore, no adverse effect is anticipated.

Blackstone River Railroad Bridge, Milepost 190.55. This deep plate girder span was built in 1897. It spans 376 feet over the Blackstone River on 4 stone piers, 2 in the River. It is the largest beam railway bridge in the state. As an example of 19th-century bridge building, it is probably eligible for the National Register.

The bridge will require substantial modifications to carry the catenary, thereby producing an adverse effect.

Pumping Station No. 1, Milepost 190.65. Branch Street. This High-Victorian brick building was built in 1877 by the city of Pawtucket. It has a hipped roof and granite belt courses. It is immediately adjacent to the rail line. Probably eligible for the National Register.

Pumping Station No. 4, Milepost 190.65. Branch Street. This Neoclassical building was constructed in 1907. It has a hipped roof and granite belt courses, rectangular windows on the first floor and round-arch windows on the second floor. It is immediately adjacent to the rail line. Probably eligible for the National Register.

Although secondary elevations of the preceding two properties face the rail line, and the project adds a modern element to their settings in the form of the catenary, the visual impact will be modest because the catenary has been designed to be as unobtrusive as possible; therefore, no adverse effect is anticipated.

3.4.5.27 Central Falls, RI

Attleboro U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

South Central Falls Historic District, Milepost 189.80-190.10. Approximately bound by Broad, Rand, and Dexter Streets and the Central Falls/Pawtucket Border. This district of residential, commercial, and industrial structures lies at some distance from the tracks. Listed on the National Register.

Central Falls Congregational Church (now St. Joseph's Parish Hall), Milepost 189.90. 376 High Street. Shingle-Style church with a square tower at one corner, built in 1883. It lies some distance from the project corridor. Listed on the National Register.

St. Joseph's Church, Milepost 189.90. 391 High Street. Large Gothic brick church built in 1919 as a Catholic church with a largely Polish congregation. It lies a considerable distance away from the tracks. Probably eligible for the National Register.

Victorian-Period House, Milepost 189.90. 24 & 26 Jenks Street. This c. 1890 2-1/2-story duplex house is of the Queen Anne style with elaborate shingling. It lies some distance from the project corridor. Probably eligible for the National Register.

Norton House, Milepost 189.90. 78 Jenks Street. This 1850s Italianate cottage has a brackets along the door hood, bay window, and eaves. It is a 1 1/2-story end-gable house. It lies some distance from the project corridor. Probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the preceding five properties' settings will be minimal; therefore, no adverse effect is anticipated.

Italianate-Detailed House, Milepost 190.00. 69 Cross Street. This late 19th century, 2 1/2-story Italianate house has a bracketed door hood and eaves. It is immediately adjacent to the rail line. It should be considered as possibly eligible for the National Register.

Greene House, Milepost 190.00. 85 Cross Street. This large 1868, 2 1/2-story Second Empire Style house features a mansard roof, round arch windows, projecting pavilions, and elaborate brackets along the cornice. The home's original carriage house is extant adjacent to the Amtrak line. Determined eligible for the National Register.

Although secondary elevations of the preceding two properties face the rail line, and the project adds a modern element to their settings in the form of the catenary, the visual impact will be modest because the catenary has been designed to be as unobtrusive as possible; therefore, no adverse effect is anticipated.

Flagg House, Milepost 190.90. 86 Cross Street. This c.1865 1 1/2-story cross-gabled Italianate house has bracketed eaves, windows, and door hood. It lies some distance from the project corridor. It should be considered as possibly eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

Central Street Pedestrian Viaduct, Milepost 190.00. Now closed, this 1915 plate-girder span once provided pedestrian access across the rail line at Central Street. A remnant of its original decorative railing survives in one post. Although girder structures have not generally been identified as eligible resources in this report, the historic significance of this bridge as a pedestrian amenity makes it possibly eligible.

The installation of solid protective barriers on this bridge will obscure its original appearance, thereby producing an adverse effect

Grant House, Milepost 190.00. 143 Central Street. This c. 1880 2 1/2-story Italianate house has bracketed eaves, door hood, bay window, and side porch. The rail line is nearby just across Railroad Street. This house should be considered as possibly eligible for the National Register

Crocker House, Milepost 190.00. 144 Central Street. This simple c.1880 2 1/2-story Italianate home has bracketed eaves and one central circular arched window. The Amtrak line is visible from the front of the house. It should be considered as possibly eligible for the National Register.

Wood House, Milepost 190.00. 153 Central Street. This 3-story Queen Anne Style house, built in 1894, has an elaborate corner tower and a 2-story porch. The rail line lies to the east just across nearby Railroad Street. Probably eligible for the National Register.

Fales House, Milepost 190.20. 476 High Street. This house was built in 1858 and renovated in 1867 in the Second Empire style. It has a mansard roof with dormers and a square cupola. The rail line lies across Elm Street from this house. The home of D. G. Fales of Fales and Jenks, it has been determined eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the preceding four properties' settings will be minimal; therefore, no adverse effect is anticipated.

Boston Switch Tower, Milepost 190.30. This tower controlled the junction of the Northeast Corridor and the Providence and Worcester Railroad. The 2-story brick tower is topped with a tiled concave hipped roof. The tower is no longer in use but is next to the rail line and is probably eligible for the National Register.

Provided that the catenary uprights are placed as far away from this historic structure as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Fales and Jenks Mill, Milepost 190.30. 27 Foundry Street. This 3-story brick mill was built between 1861 and 1863. It has a castellated tower and modified trapdoor monitor. The mill housed a series of 19th century tenants involved in the production of both textile machinery and textiles themselves. It is immediately adjacent to the Amtrak line and the Boston Tower. It has been determined eligible for the National Register.

Because the tracks run along a secondary elevation of the factory, the visual effect of introducing the catenary to the property's setting is relatively minor; therefore, the impact will not be an adverse effect.

High Street Railroad Bridge, Milepost 190.49. Stone arch, built in 1887, carrying the rail line over High Street. Although lined with concrete, it remains significant as an example of masonry arch construction. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

3.4.5.28 Attleboro, MA

Attleboro U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS:

Attleboro Paralleling Station Milepost 193.40. Located on a large vacant lot within sight of, but substantially to the west of, the Hebronville Mill. The distance is such that there will be no effect on the historic district.

Norton Switching Station, Milepost 198.99. The switching station will be located adjacent to the railroad right-of-way in a sparsely built area; there appear to be no historic resources in this vicinity, and therefore no effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Howard Bullock Textile Machine Factory, Milepost 190.75. Turner Street, South Attleboro. Though technically in Massachusetts, this large four-story brick factory, built in 1893-1894 for a major machine builder, forms part of the historic industrial landscape of Pawtucket, R.I., an area dense with historic factories. Probably eligible for the National Register.

Because the tracks run along the rear of the mill, the visual effect of introducing the catenary to the property's setting is relatively minor; therefore, the effect will not be adverse.

Seven Mile River Railroad Bridge, Milepost 192.76. Brick and stone-arch bridge built in 1888. Significant as an example of masonry arch construction. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

Hebronville Mill Historic District, Milepost 193.75-193.85. District includes mill (now converted to rental space), worker housing (primarily across tracks on Knight Ave.), and the 1873 Hebronville Methodist Church. Listed on the National Register.

Provided that the placement of catenary uprights is such as to avoid obscuring historic buildings close to the tracks, the visual effect on the district will be relatively minor; therefore, no adverse effect is anticipated.

Dodgeville Mill Historic District, Milepost 195.55-196.00. Resource includes mill, superintendent's house, worker housing just to south, and church. The area has been determined eligible for National Register.

Provided that the placement of catenary uprights is such as to avoid obscuring historic buildings close to the tracks, the visual effect on the district will be relatively minor; therefore, no adverse effect is anticipated.

Dodgeville Mill Tailrace Railroad Culvert, Milepost 195.55. Built in 1880 to replace the last wooden bridge on the main line from Boston; massive stone construction with brick arches. Significant as an example of masonry arch construction. Probably eligible for the National Register.

Ten Mile River Railroad Culvert, Milepost 195.58. This effectively forms a single structure with the nearly identical tailrace culvert described above. Significant as an example of masonry arch construction. Probably eligible for the National Register.

Ten Mile River Railroad Bridge, Milepost 196.59. Brick and stone-arch bridge built in 1886. Significant as an example of masonry arch construction. Probably eligible for the National Register.

The size of the three preceding undergrade bridges makes it unnecessary to modify them in any way for the catenary; therefore, no adverse effect is anticipated.

First Parsonage For Second Parish Church, Milepost 197.00. 41 South Main St. This Federal-era house is located two blocks from the elevated tracks. Listed on the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

East Attleboro Academy, Milepost 197.10. 28 Sanford St. School, Greek Revival-style, c.1840, located several blocks from the tracks. Listed on the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

South Main Street Railroad Bridge (MHD No. RR0602009100), Milepost 197.13. Stone-arch bridge, part of 1905 railroad viaduct through Attleboro. Significant as an example of masonry arch construction and as part of early 20th-century railroad improvements in this vicinity. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

D. E. Makepeace Company, Milepost 197.20. 46 Pine Street. Small factory approximately two blocks from the tracks. Listed on the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

Mill Street Railroad Bridge (MHD No. RR0602010100), Milepost 197.21. Stone-arch bridge, part of 1905 railroad viaduct through Attleboro. Significant as an example of masonry arch construction and as part of early 20th-century railroad improvements in this vicinity. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

Attleboro Post Office, Milepost 197.35. 75 Park St. Neo-Classical post office, 1916, located some distance from the Park Street Bridge. Listed on the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

Park Street Railroad Bridge (MHD No. RR0602006100), Milepost 197.38. Stone-arch bridge, part of 1905 railroad viaduct through Attleboro. Significant as an example of masonry arch construction and as part of early 20th-century railroad improvements in this vicinity. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

Attleboro Stations, Milepost 197.50. 1-3 Mill Street. Tile-roofed brick stations built as separate southbound and northbound structures built in 1905. Listed on the National Register.

Provided that the catenary uprights are placed as far away from the historic stations as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Attleboro Tower, Milepost 197.55. Located at the northern edge of downtown Attleboro, this two-story wooden hip-roofed tower, built c.1900, contains a 68-lever Saxby and Farmer Mechanical Interlocking Machine, put in service in 1908. Probably eligible for the National Register.

Provided that the catenary uprights are placed as far away from this historic building as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Peck Street Railroad Bridge (MHD No. RR0602005100), Milepost 197.64. Stone-arch bridge, part of 1905 railroad viaduct through Attleboro. Significant as an example of masonry arch construction and as part of early 20th-century railroad improvements in this vicinity. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

3.4.5.29 Mansfield, MA

Attleboro, Taunton and Brockton U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Wading River Railroad Bridge, Milepost 200.66. Stone-arch bridge, 35' span, built in 1915. Significant as an example of masonry bridge construction. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

Chilson Iron Foundry, Milepost 204.35. Foundry Street. Immediately adjacent to north side of tracks, Mansfield. Two-story stone building with brick cornice; monitor roof; datestone of 1855. Significant as an early example of a kind of specialized industrial structure and for its association with stove manufacture, a notable local industry. Probably eligible for the National Register.

Provided that the catenary uprights are placed as far away from this historic building as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Lowney Chocolate Factory, Milepost 204.85. Oakland Street. Well-preserved five-story mill, 1903, still in use as a candy factory. Probably eligible for the National Register.

Because the tracks run along the rear of the mill, the visual effect of introducing the catenary to the property's setting is relatively minor; therefore, the effect will not be adverse.

3.4.5.30 Foxboro, MA

Brockton U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS:

East Foxboro Paralleling Station, Milepost 205.70. Located in a neighborhood of modern houses, on a site overgrown with woods and brush. No historic resources appear to be nearby; therefore, there will be no effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Victorian-Period House, Milepost 206.40. Cocasset Street, East Foxboro; in close proximity to tracks. Significant as an example of the Queen Anne style of architecture. Includes barn of similar age. Probably eligible for the National Register.

Although the tracks pass in front of the house, the introduction of the catenary represents only a marginal additional visual intrusion relative to the existing railroad right-of-way. Provided that the catenary uprights are placed as far away from this historic building as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Capt. Josiah Pratt House, Milepost 206.50. 141 East Street, East Foxboro; early 1800s Federal-style house located in close proximity to tracks. Listed on the National Register.

Because the tracks run along the rear of the property, the visual effect of introducing the catenary to the property's setting is relatively minor; therefore, the effect will not be adverse.

3.4.5.31 Sharon, MA

Brockton and Norwood U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS:

Canton Paralleling Station, Milepost 212.40. The paralleling station will be located within or immediately adjacent to the railroad right-of-way in a wooded area; there appear to be no historic resources in this vicinity, and therefore there will be no effect.

BRIDGE CLEARANCE PROJECTS:

Depot Street Bridge (MHD No. 900637048101), Milepost 211.04. Two-span concrete-slab bridge built in 1936. The bridge is scheduled to be demolished and replaced. Although more than 50 years old, it has been determined not eligible by the SHPO; therefore, there will be no effect.

Maskwonicut Street Bridge, Milepost 211.62. Small beam bridge, 1932, with associated stone arch culvert of unknown date. Although more than 50 years old, the beam bridge's late date and common, simple form make its eligibility doubtful. The smaller bridge appears to have some significance as an example of stone-arch construction and should be regarded as possibly eligible for the National Register.

The main bridge is scheduled for raising to achieve clearance for the catenary. Provided that the stone-arch culvert is retained intact, no adverse effect is anticipated.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

"The Homestead,", Milepost 210.00. 247 South Main St. Large pre-Revolutionary house some distance from tracks and surrounded by modern subdivision. Probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the property's setting will be minimal; therefore, no adverse effect is anticipated.

Sharon Station, Milepost 210.50. Brick Colonial Revival station, 1936 (misdated 1946 in MBTA Inventory), with interior and exterior relatively unaltered from original historic appearance. Probably eligible for the National Register.

Provided that the catenary uprights are placed as far away from this historic building as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

Sharon Historic District, Milepost 211.04-211.20. Small village center historic district located some distance east of the project corridor. A Local Historic District. Listed on the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the district will be minimal; therefore, no adverse effect is anticipated.

Sharon Water Works, Milepost 211.10. Brick pumping station, 1896, Depot Street, with steeply pitch hipped roof and cupola; small hip-roofed brick outbuilding. Probably eligible for the National Register.

Although located adjacent to the tracks, the pump station faces Depot Street, the raising of which (1936) substantially altered the property's historic setting; The visual effect of introducing the catenary to the property's setting is relatively minor; therefore, the effect will not be adverse.

John Savels House, Milepost 211.80. 178 North Main St. Large 18th-century center-chimney house located some distance east of railroad right-of-way. Probably eligible for the National Register.

Darius Lothrup House, Milepost 211.90. 184 North Main St. This granite-walled house, built in the mid-19th century, lies some distance east of the project corridor. Probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on these two properties' settings will be minimal; therefore, no adverse effects are anticipated.

3.4.5.32 Canton, MA

Norwood U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Neponset Cotton Mill, Milepost 213.70. This area, in the shadow of (and just west of) the Canton Viaduct, was previously determined eligible for the National Register. However, the worker housing associated with the mill appears to have been demolished, and the 1823 mill itself is altered almost beyond recognition. Such substantial loss of integrity may make it no longer eligible for the National Register.

Because the tracks run along the rear of the now highly altered mill, the visual effect of introducing the catenary is relatively minor; therefore, the effect will not be adverse.

Canton Viaduct, Milepost 213.74. Complete in 1835 by the Boston and Providence Railroad, this is one of the most significant railroad structures in the eastern United States. It was designed by noted engineers William Gibbs McNeill and George Washington Whistler. It was modified, c.1900, with trusswork along the top to help support the outer ends of the track. Listed on the National Register.

This bridge will require substantial modification associated with installation of the catenary, thereby producing an adverse effect. The effect would be minimal if modifications are confined to the trusswork, leaving the original stone viaduct intact.

Canton Junction Station, Milepost 214.10. This small, c.1885 station shows the influence of H. H. Richardson in its massive masonry construction and contrasting-colored masonry. Probably eligible for the National Register.

Provided that the catenary uprights are placed as far away from this historic building as is feasible, thereby minimizing their visual impact, no adverse effect will occur.

3.4.5.33 Westwood, MA

Norwood U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

No historic resources within the project area were identified in Westwood.

3.4.5.34 Dedham, MA

Norwood U.S.G.S. Quadrangle

SWITCHING, PARALLELING AND SUBSTATIONS: None.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Spragues Brook Railroad Bridge, Milepost 218.57. Stone-arch bridge, 13' long, built in 1887; significant as an example of masonry arch construction. Probably eligible for the National Register.

The size of this undergrade bridge makes it unnecessary to modify it in any way for the catenary; therefore, no adverse effect is anticipated.

3.4.5.35 Boston, MA

Norwood and Boston South U.S.G.S. Quadrangles

SWITCHING, PARALLELING AND SUBSTATIONS:

Readville Paralleling Station, Milepost 219.10. Located in the Readville rail yard at the junction of several rail lines, well south of the station and Franklin Branch Bridge and a similar 19th-century bridge carrying the branch over the road. No other historic resources appear to be nearby. Therefore, there is no effect.

Roxbury Crossing Substation, Milepost 226.02. Although located within an urban area, the neighborhood of this substation has been completely rebuilt; there are no buildings in the vicinity, and therefore no effect.

BRIDGE CLEARANCE PROJECTS: None.

INSTALLATION OF OVERHEAD CATENARY SYSTEM:

Franklin Branch Bridge, Milepost 219.41. Baltimore through-truss railroad bridge carrying a branch line over the corridor, built in 1898; significant as a large example of late 19th-century truss engineering and a relatively rare design. Included in the Massachusetts HAER Inventory. Probably eligible for the National Register.

Because it is a railroad overpass, with no public access, protective barriers will not be needed on this bridge. The effect will be limited to the minor visual impact of the catenary passing under the bridge; therefore, no adverse effect is anticipated.

Westinghouse Fan and Bearing Plant, Milepost 220.10. Huge complex of c.1910 industrial buildings with three-story office at one end, 1 Westinghouse Plaza, Readville; significant for the economic history of the area. Probably eligible for the National Register.

Because the tracks run along the side of the complex, the visual effect of introducing the catenary to the property's setting is relatively minor; therefore, the effect will not be adverse.

Hyde Park Pumping Station, Milepost 221.20. One-story brick pumping station, 753 Hyde Park Avenue, c.1910, Renaissance Revival style. Probably eligible for the National Register.

Because the tracks run along the rear of the building, the visual effect of introducing the catenary to the property's setting is relatively minor; therefore, the effect will not be adverse.

Mt. Hope Footbridge, Milepost 223.31. This undated (probably c.1910) through truss, 75' long, represents a relatively intact example of early 20th-century truss technology. Although modified with the addition of a chain-link "tunnel" within the trusses, its original appearance is still evident. Probably eligible for the National Register.

The installation of solid protective barriers on this bridge will obscure and possibly physically alter the trusses, thereby producing an adverse effect.

Arnold Arboretum, Milepost 223.65-223.75. Historic park of 265 acres; a National Historic Landmark. Listed on the National Register as part of the Olmsted Park System (includes Arborway).

Franklin Park, Milepost 223.70-224.00. This historic park designed by Frederick Law Olmsted in 1885 is located across a busy street and at a considerable distance from the tracks. A Local Landmark. Listed on the National Register as part of the Olmsted Park System (includes Arborway).

Armory Street Workers' Housing, Milepost 224.65. 200 block of Armory St., 100 block of Seaverns Ave. Late 19th-century factory-worker residential neighborhood. Probably eligible for the National Register.

Roxbury Highlands Historic District, Milepost 225.55-226.00. This residential neighborhood of architecturally interesting 19th-century buildings is separated from the tracks by a considerable distance, including a busy street and a linear park built during the mid-1980s rebuilding of the line. Listed on the National Register.

Dudley House, Milepost 225.65. 167 Centre St. Early 19th-century Federal-style house, separated from the tracks by a busy street and a wide area cleared of buildings in the mid-1980s rebuilding of the line. Determined eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the five preceding properties will be minimal; therefore, no adverse effect is anticipated.

Saint Botolph Street Historic District, Milepost 226.95-227.35. Tracks in this neighborhood of 19th-century brick rowhouses are now in a tunnel beneath a linear park. A Local Historic District. Determined eligible for the National Register.

South End Historic District, Milepost 226.80-227.65. Tracks in this area of Victorian-period rowhouses are now in a tunnel beneath a linear park. Area is similar in character to St. Botolph Street potential district, and adjoins it across the park. A Local Historic District. Listed on the National Register.

Because the right-of-way is not visible, there will be no effect on the two preceding potential historic districts.

Cahners Building, Milepost 227.60. 221 Columbus Avenue. Architecturally significant brick early 20th-century commercial building, separated from the Amtrak right-of-way by Interstate 90 (the Massachusetts Turnpike) and MBTA tracks. Probably eligible for the National Register.

Youth's Companion Building, Milepost 227.65. 197-217 Columbus Ave. Architecturally significant Richardsonian Romanesque building, 1881, separated from the Amtrak right-of-way by Interstate 90 (the Massachusetts Turnpike) and MBTA tracks. Listed on the National Register.

Armory Of The First Corps Of Cadets, Milepost 227.80. 130 Columbus Avenue. A Victorian armory located a considerable distance from the tracks. A Local Landmark. Listed on the National Register.

Bay Village Historic District, Milepost 227.80-227.90. Mid-19th century neighborhood of brick houses and narrow streets, separated from the tracks by a busy thoroughfare. A Local Historic District. Probably eligible for the National Register.

Though the tracks are visible, the distance is such that the visual impact of the catenary on the preceding four properties will be minimal; therefore, no adverse effect is anticipated.

Fort Point Channel Railroad Bridge, Milepost 228.70. A large multiple movable bridge, c.1910, consisting of three parallel bascules, carrying an adjacent railroad line not part of the corridor. Probably eligible for the National Register.

The bridge's setting is a mixture of both modern and historic buildi[illegible]nd engineering features. Therefore, the additional impact of the catenary system will be relatively minor. No adverse effect is anticipated.

South Station, Milepost 229.20. Built between 1897 and 1899 in a Beaux-Arts Classical style. Listed on the National Register.

Architectural detailing is mostly confined to the facade of the station, with substantial modern construction at the rear, where the catenary will end. Therefore, there will be no adverse effect on the significant features or setting of the station.

3.5 SUMMARY OF ANTICIPATED EFFECTS AND POTENTIAL MITIGATION

The survey identified a large number of historic resources on, adjacent to, or in clear sight of the project corridor and activity sites. Almost all of these can be considered as affected by the undertaking, if only because the visual qualities of their settings are changed by the introduction of a new element. Therefore, a finding of effect is reasonable for these historic resources.

Most new construction (Tables 3.1 through 3.3) will occur in areas that are either undeveloped or have no standing historic resources nearby and therefore, at these areas there are no effects expected from the proposed project. Four facilities (Leete's Island Paralleling Station, New London Substation, Exeter Paralleling Station, and Elmwood Paralleling

Station) have historic resources nearby, but the distance is such that the visual effects will be minimal; at these sites the project recommends a finding of No Adverse Effect.

In general, the project recommends a finding of No Adverse Effect for the visual effects of the catenary system itself on historic resources in the corridor (Tables 3.4 through 3.6). The following considerations led to this recommendation:

- The catenary has been designed to have a minimal visual impact on the surroundings. The width of the uprights has been kept to a minimum (8 to 10"), there will be no solid structural connection between the uprights (unlike the existing catenary supports at the western end of the project area), and the spacing of the uprights (approximately 200' apart) is as wide as possible.

- For many of the historic resources, the rail line itself represents an element that lies outside the period of significance for the resource. The 18th and early 19th-century houses, for example, were all built before the rail line; the incremental visual effect of adding electrification is therefore minor relative to the intrusion of the tracks themselves.

- In most cases, the rail corridor passes by the rear elevation of the resource, making the visual effect of the catenary less of an impact than if it partially obscured a principal elevation.

In the case of historic buildings that are close to the tracks and have a principal elevation facing the tracks, the recommendation of No Adverse Effect is conditional upon the placement of uprights so as to minimize their visual impact on the historic property. This can be accomplished by spacing the uprights so that adjacent sets are as far away from the historic property as possible. Similarly, careful spacing of the uprights can minimize their visual effects on historic districts. Sight lines along the streets in urban districts, for example, should be kept as clear as possible.

The catenary itself is also not expected to affect overhead highway bridges or most railroad bridges along the right-of-way, since the spacing of the uprights is sufficient so that no actual attachment of wires or supports will be necessary.

The following sections summarize the effects that were identified as potentially adverse, along with possible mitigation strategies. Mitigation refers to a set of actions that avoid, reduce or compensate for an undertaking's adverse effects on historic properties. Typical mitigation measures include limiting the magnitude of the undertaking, modifying the undertaking through redesign, and photographic and written documentation of historic properties prior to their alteration or demolition. It is not within the scope of this document to provide all the engineering studies of alternatives and other technical data that must be assembled as part of the consultative process. However, this document presents a general approach to mitigation that identifies the major issues and alternatives to be addressed for each of the categories of adverse effects identified in Section 3.4.4.

3.5.1 Historic Railroad Bridges

A number of long railroad bridges, movable railroad bridges, and one railroad tunnel will require physical alterations in order to accommodate the poles and/or wires necessary for electrification. The following measures may mitigate the adverse effect of these modifications:

1. Investigate feasibility of alternatives to the catenary that will require fewer modifications to the historic bridge.

2. Insure that minimal physical alteration of historic material occurs and that the alteration, wherever possible, is reversible.

3. Insure that new elements, such as brackets for the overhead or power feeds, are as visually unobtrusive as possible.

3.5.2 Alteration of Overhead Highway Bridges

The project anticipates raising one historic overhead highway bridge, a concrete bridges from the 1930s with distinctive railing detail (Main Street Bridge, South Kingston, RI). The following measures may mitigate the adverse effect of this action:

1. Investigate feasibility of alternatives to demolishing the bridge scheduled for raising, such as achieving clearance by lowering the track.

2. Insure that the parapets are retained intact or accurately reproduced.

3. In raising the bridge, modify piers and abutments as little as possible so as to minimize changes to its visual qualities.

4. Record photographically the appearance of the bridge according to HAER standards prior to altering it.

3.5.3 Protective Barriers on Overhead Highway Bridges

Most historic overhead highway bridges (see Tables 3.4 through 3.6) will be affected, both visually and physically, by the installation of protective barriers. In most cases, the barriers represent a large change in the visual qualities of the bridge and a significant departure from its historic appearance. The installation of the barriers may also require intrusion into the physical fabric of bridges that have historic railings or parapets, thus degrading their integrity. The following measures may mitigate the adverse effect of these actions:

1. Investigate feasibility of alternative protection methods.

2. Modify design of barriers to limit their visual effect. Investigate feasibility of reducing their height; using widely-spaced vertical bars rather than a solid panel; or using clear glass or polymer in place of opaque metal.

3. Insure that minimal physical alteration of historic material, including railings and parapets, occurs and that the alteration, wherever possible, is reversible.

3.5.4 Impacts on Visual Qualities of Historic Districts

Although in most cases the introduction of the catenary does not represent a major intrusion beyond that of the existing right-of-way, in two potential historic districts (Haley Farm, Groton, CT and Wilcox Road, Stonington, CT), the catenary will introduce a discordant modern element on an historic landscape. These effects could be mitigated by landscaping and other screening treatments consistent with the historic setting of the affected resource.

3.6 SUBSEQUENT STEPS IN SECTION 106 REVIEW PROCESS

As noted previously, this document will serve as a basis for initial Section 106 consultation with the state SHPOs. The SHPOs will review the recommendations contained herein regarding the identification of historic resources, the eligibility of resources not already listed on the National Register or determined eligible, and potential project effects, pursuant to the requirements of Section 106 as outlined in Section 3.3.1 of this report.

In conjunction with the SHPOs, FRA will identify specific mitigation measures for any potential adverse effects, which may be formalized in either a Memoranda of Agreement (MOA) among the agency, the SHPOs, and the Advisory Council on Historic Preservation, or a Programmatic Agreement (PA). The PA would allow some elements of the project to advance while providing a mechanism for resolving outstanding issues on other elements that may require further information or consultation.

TECHNICAL STUDY 4
NOISE AND VIBRATION

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4.1 INTRODUCTION AND PURPOSE

This technical study presents an assessment of the potential long-term and short-term noise and vibration impacts from the proposed Northeast Corridor North End Electrification Project. Such environmental impacts in the communities along the corridor may result from proposed changes in train operations and from construction activities associated with the corridor electrification. The purposes of this study are to identify these impacts and to recommend appropriate mitigation measures.

This study evaluates the potential environmental impacts of the project due to the following: (1) noise from train operations, (2) noise from traffic near railroad stations, (3) noise from fixed facilities (e.g. electric substations), (4) noise from construction activity, (5) ground-borne vibration from train operations and (6) ground-borne vibration from construction activity. An outline of the study contents is provided below.

Section 4.2 summarizes the regulatory setting by describing the Federal, state and local regulations or standards that govern noise and vibration along the project corridor. This review forms the basis for the selection of the noise and vibration criteria used to assess adverse impact.

Section 4.3 describes the affected environment, including an overview of the existing noise and vibration sensitive land use and the existing sources of noise and vibration along the project corridor. This section also defines the units of noise and vibration that are used in the study, and describes the measurement survey carried out to document existing noise and vibration levels at representative locations along the corridor.

Section 4.4 summarizes the potential environmental consequences of the project with regard to noise and vibration impact. For each category of impact, this section defines the evaluation criteria, describes the prediction methods and assumptions, and summarizes the extent of noise and vibration impact anticipated. This section also describes the measurements made to define train noise and vibration source levels and propagation.

Section 4.5 presents potential measures to mitigate the adverse noise and vibration impacts identified in Section 4.4. Noise and vibration control measures related to the source, transmission path and receiver are discussed, and estimates of the extent of mitigation are provided.

Finally, Section 4.6 summarizes the conclusions of the study, followed by references and data tables in Appendix 4.A.

4.2 REGULATORY SETTING

Federal, state and local regulations provide standards and guidelines for acceptable levels of noise and vibration that are applicable to both construction and operation of the proposed action.

Federal, Connecticut and Massachusetts standards and guidelines are presented below; Rhode Island has no statewide noise standards or guidelines.

4.2.1 Federal Regulations

4.2.1.1 Noise Control Act of 1972 (42 USC 4910). Pursuant to the Noise Control Act, the U.S. Environmental Protection Agency (EPA) defined acceptable levels of noise which would protect public health and welfare with an adequate margin of safety. These levels, as summarized in Table 4-1 (EPA, 1974), are presented in terms of either L_{dn} or $L_{eq}(24)$, which represent a 24-hour dose of noise energy based on the A-weighted sound level (dBA). L_{dn}, which contains a penalty for nighttime noise, is recommended for residences, whereas $L_{eq}(24)$ is recommended for areas where people spend more limited amounts of time. Since the protective noise levels were derived without concern for technical or economic feasibility and contain a margin of safety, EPA stresses that they must not be viewed as standards, criteria, regulations or goals, but rather as guidelines.

4.2.1.2 EPA Railroad Noise Emission Standards (40 CFR Part 201) and FRA Railroad Noise Emission Compliance Regulations (49 CFR Part 210). Pursuant to the Noise Control Act, EPA has issued noise emission standards for specific types of railroad equipment. FRA has adopted these regulations for the purpose of enforcement. The standards provide specific noise limits for stationary and moving locomotives, moving railroad cars, active retarders, car coupling and locomotive load cell test stands in terms of A-weighted sound level at a specified measurement location. Table 4-2 summarizes these standards for locomotives and rail cars that are subject to the regulation. This regulation is preemptive, and thus states and local governments cannot set more stringent limits for railroad equipment than these Federal regulations require.

4.2.1.3 FHWA Noise Abatement Procedures (23 CFR Part 772). These U.S. Federal Highway Administration (FHWA) procedures provide noise abatement criteria and procedures for Federally-sponsored highway projects, and can be applied to project-generated traffic. The criteria, summarized in Table 4-3, are based on either hourly L_{10} (the A-weighted sound level that is exceeded during 10 percent of the hour) or hourly L_{eq} (equivalent or energy-average sound level), evaluated for the noisiest traffic hour of the day.

The regulations require that noise abatement be considered when the noise abatement criteria are approached or exceeded based on land use, or when the predicted traffic noise levels "substantially" exceed existing noise levels. The definition of "substantially" varies among the state highway departments, with the predicted noise levels being allowed to exceed the existing noise levels by as much as 5 to 15 dBA.

4.2.1.4 HUD Environmental Standards (24 CFR Part 51). The U.S. Department of Housing and Urban Development (HUD) has developed noise standards for the acceptability of sites for projects they fund. The purpose of these standards is to encourage the development of land uses which are compatible with the surrounding noise environment. The criteria, expressed in terms

TABLE 4-1. SUMMARY OF ACCEPTABLE NOISE LEVELS BY EPA

EFFECT	LEVEL	AREA
Hearing Loss	$L_{eq}(24) \leq 70$ dBA	All areas.
Outdoor activity interference and annoyance	$L_{dn} \leq 55$ dBA	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq}(24) \leq 55$ dBA	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	$L_{dn} \leq 45$ dBA	Indoor residential areas.
	$L_{eq}(24) \leq 45$ dBA	Other indoor areas with human activities such as schools, etc.

Source: EPA, 1974

of L_{dn}, define levels not exceeding 65 dBA as "acceptable," levels above 65 dBA but not above 75 dBA as "normally unacceptable," and levels above 75 dBA as "unacceptable" for residential areas.

4.2.1.5 Federal Transit Administration Guidelines. Noise impact criteria for transit projects are included in UMTA Circular C 5620.1 (UMTA, 1979) by the U.S. Federal Transit Administration (FTA, formerly UMTA). These criteria are based on noise increase in terms of either L_{eq} or L_{dn}. The criteria consider noise increases of 3 dBA or less to be "generally not significant," noise increases of 4 or 5 dBA to be "possibly significant," and noise increases of more than 5 dBA to be "generally significant."

FTA is currently developing a "Guidance Manual for Transit Noise and Vibration Impact Assessment" which includes new criteria for noise and vibration impact evaluation (FTA, 1990). The proposed criteria for adverse impacts are summarized in Table 4-4 for noise and in Table 4-5 for vibration.

TABLE 4-2. SUMMARY OF EPA RAILROAD NOISE STANDARDS

NOISE SOURCE	OPERATING CONDITION	NOISE METRIC	MEAS. DIST. (ft)	STANDARD (dBA)
Non-Switcher Locomotives built on or before 12/31/79	Stationary, Idle	L_{max} (Slow)	100	73
	Stationary, Non-Idle	L_{max} (Slow)	100	93
	Moving	L_{max} (Fast)	100	96
Switcher Locomotives plus Non-Switcher Locomotives built after 12/31/79	Stationary, Idle	L_{max} (Slow)	100	70
	Stationary, Non-Idle	L_{max} (Slow)	100	87
	Moving	L_{max} (Fast)	100	90
Railroad Cars	Speed $\leq$ 45 mph	L_{max} (Fast)	100	88
	Speed > 45 mph	L_{max} (Fast)	100	93

Source: U.S. EPA Railroad Noise Emission Standards (40 CFR Part 201)

For noise, the criteria limit the noise increase due to the project based on the existing ambient noise level, in terms of L_{eq} or L_{dn}. These criteria reflect an equivalent increase in noise annoyance depending on the existing noise, allowing less of an increase at locations where existing noise levels are higher (Table 4-4). As is also indicated in Table 4-4, the allowable increases in L_{eq}(24) are greater than the allowable increases in L_{dn}. This is to account for the lower noise sensitivity at sites with daytime use only, where L_{eq}(24) would be applied as a measure of noise impact.

As shown in Table 4-5, the proposed FTA vibration criteria include impact thresholds based on land use and event frequency, in terms of the rms ground vibration velocity level (V_{dB}, in dB re 1 micro-in./sec). Rms is a measure of how humans react to vibration.

4.2.1.6 Bureau of Mines Guidelines. Researchers at the U.S. Bureau of Mines (BOM) have identified a ground vibration peak particle velocity of 2.0 in./sec as a safe blasting limit to avoid major damage to residential structures, but recommend lower levels to minimize complaints (Nicholls, 1971). They have also identified a ground vibration peak particle velocity of 0.5 in./sec as the approximate threshold for minor cosmetic damage to buildings (Siskind, 1980).

TABLE 4-3. FHWA NOISE ABATEMENT CRITERIA

ACTIVITY CATEGORY	$L_{eq}(h)$	$L_{10}(h)$	DESCRIPTION OF ACTIVITY CATEGORY
A (Exterior)	57	60	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B (Exterior)	67	70	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries and hospitals.
C (Exterior)	72	75	Developed lands, properties or activities not included in Categories A or B above.
D			Undeveloped lands.
E (Interior)	52	55	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums.

Source: FHWA Noise Abatement Procedures (23 CFR Part 772)

4.2.2 Connecticut Regulations

The State of Connecticut Noise Control Regulations contain specific noise limits based on source and receiver land use category as well as time of day of exposure to the noise. Although noise generators such as safety devices, mobile sources and construction equipment are excluded or exempt from the regulations, the regulations would generally apply to fixed sources such as electric substation facilities.

With regard to substation noise, the most stringent, relevant limits govern noise transmitted from industrial land to residential property. For this case, the applicable limits at the residential property line are 61 dBA during the daytime (7 A.M. to 10 P.M.) and 51 dBA at night (10 P.M. to 7 A.M.). These levels are to be reduced by 5 dBA if the intruding noise has audible, discrete tones (e.g. transformer noise).

TABLE 4-4. PROPOSED FTA SIGNIFICANT NOISE IMPACT CRITERIA

EXISTING NOISE LEVEL (dBA) [L_{dn} or $L_{eq}(24)$]	LIMIT FOR NOISE LEVEL INCREASE (dBA)	
	L_{dn}	$L_{eq}(24)$
<45	15	20
45	14	19
46	13	18
47-48	12	17
49	11	16
50	10	15
51	10	14
52	9	14
53-54	8	13
55	7	12
56	7	11
57-58	6	11
59	6	10
60-61	5	10
62	5	9
63	4	9
64-66	4	8
67-69	3	7
70-73	3	6
74-77	2	5
78-79	2	4
>79	1	3

Source: FTA, 1990

TABLE 4-5. PROPOSED FTA CRITERIA FOR VIBRATION IMPACT

LAND USE CATEGORY	GROUND-BORNE VIBRATION LIMITS (rms Vibration Velocity Level in dB re 1 micro-inch/second)	
	Frequent Events[1]	Infrequent Events[2]
Category 1: Buildings where low ambient vibration is essential for interior operations.	65 dB	65 dB
Category 2: Residences and buildings where people normally sleep.	72 dB	80 dB
Category 3: Institutional land uses with primarily daytime use.	75 dB	83 dB

Source: FTA, 1990

The regulations also specify that if the background noise is measured to exceed the standards, then the noise limit shall be set at a level 5 dBA above the background level. Background noise is defined in statistical terms as the noise level exceeded 90% of the time (L_{90}).

Connecticut has no vibration control regulations.

4.2.3 Massachusetts Regulations

Specific guidelines for enforcing the Massachusetts Noise Regulation (310 CMR 7.10) have been developed by the Departmen of Environmental Protection (DEP) Division of Air Quality Control (DAQC). The guidelines, contained in DAQC Policy 90-001, state that a source of sound will be considered to be violating the Department's noise regulation if the source (1) increases the broadband sound level by more than 10 dBA above ambient (L_{90}), or (2) produces a "pure tone" condition (e.g. from transformers).

[1] "Frequent Events" is defined as more than 70 vibration events per day. Most transit systems fall into this category.

[2] "Infrequent Events" is defined as less than 70 vibration events per day. This category includes most commuter and inter-city rail systems.

With regard to ground vibration, blasting limits are included in Board of Fire Prevention Regulations (527 CMR 13.11). These limits are essentially equivalent to a peak particle velocity of 1.9 in./sec, which is slightly more conservative than the U.S. Bureau of Mines criterion of 2.0 in./sec for structural damage.

4.2.4 Local Regulations

Only about one-third of the 36 municipalities along the corridor have quantitative noise regulations. The applicable regulations of these communities are summarized below. There are no local vibration regulations in the communities along the corridor.

4.2.4.1 New Haven, CT. Noise regulations are contained in Section 18-19 of the Code of Ordinance of the City of New Haven. Included are noise limits for mechanical equipment which could apply to electrical substations. For equipment located in industrial zones, the applicable limit is 80 dBA measured at the property line nearest to the source or at a distance of 15 feet from the equipment.

4.2.4.2 Branford, Westbrook, Old Saybrook, and Old Lyme, CT. Noise regulations are included in Chapter 189 of the Branford Code, Chapter 12 of the Westbrook Code, Old Saybrook Ordinance No. 56 and Section 4 of the Old Lyme Noise Control Ordinance. The noise level limits in each of these codes are identical to the Connecticut state regulations. However, the codes also limit construction, demolition and blasting operations to daytime hours, and apply no penalty to tonal noise sources.

4.2.4.3 Westerly, Richmond, and North Kingstown, RI. Permissible sound levels are specified in Chapter 19, Article 967 of the Westerly Code of Ordinances, the Richmond Noise Control Ordinance and Section 8-87 of the North Kingstown revised ordinances. These levels are given according to receiving land use and time of day of exposure to the noise and are the same in each community.

In each community, the most stringent limits are for residential land use, with a limit of 60 dBA during the day and 50 dBA at night. These limits are to be reduced by 5 dBA for pure-tone sound sources. Construction activities are exempt from these regulations during daytime hours only. The North Kingstown also effectively prohibits noisy nighttime construction that affects residential zones.

4.2.4.4 Warwick, RI. Applicable noise regulations are included in Section 604.1 of the Warwick Code, specifying maximum permitted sound levels from any non-residential use measured at neighboring property lines. For residential land zones, the limits are 60 dBA during the day and 50 dBA at night. The permissible levels are reduced by 5 dBA for impact noises in residential areas during nighttime hours. Furthermore, construction or demolition activities are exempt from the regulation during daytime hours.

4.2.4.5 Providence, RI. Applicable noise regulations are included in Providence Ordinance No. 32. Section 7 of this ordinance limits the noise from machinery, equipment, fans and air conditioning to 55 dBA during the day and 50 dBA at night at residential property lines. In addition, Section 8 of the code effectively prohibits noisy construction work during nighttime hours.

4.2.4.6 Pawtucket, RI. Section 20.1-10 of the Pawtucket Revised Ordinances limits the increase in ambient noise level due to operation of machinery, equipment, fans and air conditioning to 5 dBA at any property line. In addition, Section 20.1-11 effectively prohibits noisy construction work during nighttime hours.

4.2.4.7 Boston, MA. The City of Boston Code, Ordinances, Title 7, Section 50 includes zoning district noise standards. The most stringent limits are 60 dBA during the day and 50 dBA at night for residential land use, along with corresponding octave-band sound pressure level limits.

The noise ordinance also includes specific construction noise limits, which exclude impact devices. For residential or institutional land use, construction noise at the property line is limited to a maximum level of 86 dBA, with a limit of 75 dBA for the L_{10} (the construction noise level exceeded 10 percent of the time).

In addition to the above, the City of Boston Code, Ordinances, Title 14, Chapter 11, Section 354 (titled "Unreasonable Noise") also applies. This ordinance establishes a noise limit of 50 dBA for construction noise measured at residential lot lines between 6 pm and 7 am. This ordinance effectively prohibits nighttime construction near residential areas.

4.3 AFFECTED ENVIRONMENT

The existing noise and vibration environment along the Northeast Corridor between New Haven and Boston is dominated by diesel locomotive-hauled railroad train operations. These operations primarily consist of inter-city and commuter passenger train traffic, but also include a limited number of freight operations. Secondary sources of noise along the corridor include motor vehicle traffic on nearby roadways, aircraft overflights in some areas and general community activities. Other than train operations, there are no significant sources of ground-borne vibration along the corridor.

The major sources of existing train noise along the corridor are (1) the diesel locomotive engines, (2) the rolling interaction of the train wheels on the track rails and (3) the locomotive horns that are sounded near the few remaining at-grade road crossings. The major source of existing ground-borne vibration from trains is the rolling interaction of the rail vehicle wheels on the rails. Although the track includes continuous welded rail (CWR) along most of the corridor, there is increased noise and vibration from wheel/rail impacts at a limited number of locations where there are gaps in the rails. These locations are primarily where there is special trackwork associated with track switches and crossovers.

The predominant noise and vibration-sensitive land use along the corridor is residential. Additional sensitive receptors include schools, churches and other institutional buildings. To document the existing noise and vibration environment in these areas, field measurements were carried out at representative locations along the corridor. The measurement methods and results are described below in Section 4.3.2 following a discussion of noise and vibration measures in Section 4.3.1.

4.3.1 Measures of Noise and Vibration

4.3.1.1 Noise Descriptors. The most commonly used measure of noise is the A-weighted sound level, expressed in decibels (dBA). The A-weighted sound level is a single-number measure of sound intensity with weighted frequency characteristics that correspond to human subjective response to noise. It is widely accepted by acousticians as a proper unit for describing environmental noise. To indicate what various noise levels represent, Figure 4-1 provides a comparison of representative noise levels for common sources of outdoor and indoor noise.

An understanding of the following is helpful in providing a subjective impression of changes in the A-weighted sound level:

- Except in carefully controlled laboratory experiments, an increase of only 1 decibel in A-weighted sound level cannot be perceived;
- Outside the laboratory, a 3-decibel increase in A-weighted sound level is considered a barely-noticeable difference;
- A change in A-weighted sound level of at least 5 decibels is required before any significant change in a community would be perceived;
- A 10-decibel increase in A-weighted sound level is subjectively heard as approximately a doubling in loudness.

Because environmental noise fluctuates from moment to moment, it is common practice to condense all this information into a single number, called the "equivalent" or "energy-average" sound level (L_{eq}). Because many surveys show that the L_{eq} properly predicts annoyance, this descriptor is commonly used for noise impact assessment. L_{eq} can be thought of as the steady sound level that represents the same sound energy as the varying sound levels over a specified time period. Commonly used equivalent noise descriptors are the L_{eq}(h), measured over a one-hour period, and the L_{eq}(24), measured over a 24-hour period.

One of the most widely accepted measures of cumulative noise exposure in residential areas is the Day-Night Sound Level, abbreviated as L_{dn}. The L_{dn} is the A-weighted equivalent sound level for a 24-hour period with an additional 10-decibel weighting imposed on noise that occurs during the nighttime hours (between 10 p.m. and 7 a.m.).

To indicate what various values of L_{dn} represent, Figure 4-2 provides examples of typical noise environments and criteria. Except for extreme situations, L_{dn} is generally found to range between 55 dBA and 75 dBA in populated areas. As shown in Figure 4-2, this spans the range between an "ideal" and an "unacceptable" residential environment according to Federal agency criteria.

Environmental noise can also be viewed on a statistical basis using percentile sound levels, L_n, which refer to the sound level exceeded "n" percent of the time. For example, the sound level exceeded 90 percent of the time (L_{90}) is often considered to represent the "background" noise in a community. Similarly, the sound level exceeded 33 percent of the time (L_{33}) is often used to approximate the L_{eq} from traffic in the absence of sporadic events such as aircraft overflights and train passages.

4.3.1.2 Vibration Descriptors. Vibration is an oscillatory motion of an object about some equilibrium position which can be described in terms of displacement, velocity or acceleration. Although displacement is easier to understand then velocity or acceleration, it is rarely used for describing ground-borne vibration. One reason for this is that most vibration sensors are designed to provide output signals proportional to either velocity or acceleration. Even more important, the response of humans, buildings and equipment to vibration is more accurately described using velocity or acceleration. Because sensitivity to vibration has typically been found to correspond to a constant level of vibration velocity amplitude within the low frequency range of most concern for environmental vibration (roughly 5-100 Hz), vibration velocity is used in this analysis to describe ground-borne vibration from train operations.

There are several different descriptors that are used to quantify vibration amplitude. One of the most common is the peak particle velocity (PPV), defined as the maximum instantaneous positive or negative peak of the vibratory motion. PPV is often used in monitoring blasting vibration since it is related to the stresses experienced by building components. Although PPV is appropriate for evaluating the potential for building damage, it is less suitable for evaluating human response which is better related to an average vibration amplitude. Because the net average of a vibration signal about its equilibrium position is zero, the root mean square (rms) amplitude is often used to describe the "smoothed" vibration amplitude. The rms amplitude is defined as the average of the squared amplitude of the signal, and is typically evaluated over a one-second period of time.

Based on the above discussion, rms vibration velocity has been selected as the basic descriptor of ground-borne vibration for the present analysis. Although velocity is normally described in units of inches per second in the USA, the decibel notation, which acts to compress the range of numbers required to describe vibration, can also be used. In this notation, the vibration magnitude is expressed in terms of velocity level, in decibels, defined as follows:

$$V_{dB} = 20\log_{10}(v/v_{ref})$$

where: v = rms velocity, in./sec
v_{ref} = 1×10^{-6} in./sec

Thus, the descriptor used in this analysis for the assessment of ground-borne vibration is the rms vibration velocity level, V_{dB}, expressed in decibels relative to one micro-inch per second.

Figure 4-3 illustrates typical ground-borne vibration levels for common sources as well as criteria for human and structural response to ground-borne vibration. As shown, the range of interest is from approximately 50 dB to 100 dB, from imperceptible background vibration to the threshold of damage. Although the threshold of human perception to vibration is approximately 65 dB, annoyance is not usually significant unless the vibration exceeds the 70 to 75 dB range.

4.3.2 Existing Noise and Vibration Measurement Survey

A measurement survey was carried out between 27 October 1992 and 5 November 1992 to document existing levels of noise and ground-borne vibration at representative locations along the corridor. These measurements were performed at 11 noise and vibration-sensitive sites distributed along the corridor between New Haven and Boston as shown in Figure 4-4. The sites were chosen to be representative of a range of community environments with different types of train operations. For security reasons, all of the sites were selected at residential property.

A Larson Davis Model 870 portable noise monitor was set up and programmed to continuously sample the A-weighted sound level (with fast response) for a full 24-hour period at each measurement site, except at site A-3A where the measurement period was about 2.5 hours. The measurement instrumentation conforms to ANSI Standard S1.4 for Type 1 sound level meters. Calibrations, traceable to the U.S. Institute of Standards and Technology (formerly the U.S. NBS), were performed for each set of measurements in the field using acoustical calibrators.

The noise monitors were programmed to record hourly results, including the L_{eq} and statistical percentile levels, as well as data on individual train events. To obtain train event data, noise level thresholds and event durations were prescribed to obtain the maximum noise level (L_{max}), Sound Exposure Level[3] (SEL) and time-history information. Data-base computer software was then used to discriminate between train and non-train events. The L_{dn} and $L_{eq}(24)$ were also computed from the data at all sites except for site A-3A. A summary of the existing noise measurement results is provided in Table 4-6.

The noise measurement results indicate L_{dn} ranging from 68 to 77 dBA at the monitoring sites, located 25 to 105 feet from the near track. The $L_{eq}(24)$ were 4 to 7 decibels lower than the L_{dn},

[3] The SEL is a time-integrated, A-weighed sound level for a single event that is equivalent in magnitude to a reference signal with a duration of one second. SEL provides a measure that accounts for both the magnitude and duration of a single noise event and that can be used to calculate the contribution of such events to the overall noise environment.

TABLE 4-6. SUMMARY OF EXISTING NOISE MEASUREMENT RESULTS

SITE	ADDRESS	START DATE AND TIME	DIST. TO NEAR TRACK CENTER (ft)	L_{dn} (dBA)	24-HOUR L_{eq} (dBA)	MAX. HOURLY L_{eq} (dBA)	MIN. HOURLY L_{90} (dBA)	RANGE OF L_{max} FOR TRAINS (dBA)
A-1	135 First Ave. New Haven, CT	11/04/92 12:00 PM	88	69	64	73	39	79-103
A-2	176 Westbrook Heights Rd. Westbrook, CT	11/03/92 04:00 PM	105	68	63	69	44	75-94
A-3	21 Gunshot Rd. Waterford, CT	11/02/92 02:00 PM	80	68	62	67	37	79-97
A-3a	500 Noank Rd. W. Mystic, CT	11/05/92 02:35 PM	35	–	–	–	–	90-114
A-4	8 Wilford Ct. Pawcatuck, CT	11/02/92 06:00 PM	73	77	73	79	41	83-112
A-5	36 Railroad St. Charleston, RI	10/29/92 04:00 PM	57	68	61	70	25	78-103
A-6	88 Alger St. Warwick, RI	10/29/92 06:00 PM	63	72	65	74	35	76-107
A-7	11 Foundry St. Central Falls, RI	10/28/92 04:00 PM	25	74	68	74	47	81-100
A-8	38 Otis St. W. Mansfield, MA	10/29/92 01:00 PM	50	72	66	71	30	72-100
A-9	20 Hartwell Pl. Canton, MA	10/27/92 01:00 PM	60	73	67	72	44	78-99
A-10	2 Westminster St. Hyde Park, MA	10/27/92 11:00 AM	70	74	68	73	36	74-98

and the maximum L_{eq}(h) ranged from 67 to 74 dBA. These levels were dominated by trains, with maximum noise levels ranging from 72 to 112 dBA, with the highest levels caused by train horns. Minimum background noise levels (L_{90}) ranged from 25 to 47 dBA.

Train vibration measurements were performed using a PCB Model 393C seismic accelerometer, installed on the ground next to the residence at each site. The accelerometer was mounted with putty in a vertical orientation on top of a steel stake driven into the soil at each site. The electrical signal from the accelerometer was amplified with an EPAC Model 60/10 LN amplifier, and recorded on a TEAC R-61 FM tape recorder. Calibration of the recorded data was accomplished based on the published sensitivity of the accelerometer, using the tape recorder's internal 1 volt peak sinusoidal reference signal.

For laboratory analysis of the tape-recorded vibration data, the integrator of a Bruel & Kjaer (B&K) Model 2635 charge amplifier was first used to convert the acceleration signals to velocity signals. A Rion Model LR-04 graphic level recorder was then used to plot time histories of the overall (1 Hz to 1000 Hz) rms vertical vibration velocity level with a slow (1 second) averaging time. The resulting ranges of maximum ground-borne vibration level measured for 5 to 21 trains during periods of 2.5 to 4 hours at the 11 sites are summarized in Table 4-7.

The train vibration measurement results indicate maximum vertical ground vibration velocity levels (V_{dB}) of 60 to 95 dB at the monitoring sites, located 25 to 119 feet from the near track. These levels range from just below the approximate threshold for human perception of vibration to the approximate threshold for cosmetic damage to historic or fragile buildings.

Descriptions of the existing noise and vibration measurement sites and discussions of the survey results at these locations are provided below in Sections 4.3.2.1 through 4.3.2.11.

4.3.2.1 Site A-1: 135 First Avenue - New Haven, CT. Site A-1 (See Figure 4-5) was selected to be representative of single-family urban residences adjacent to the rail corridor and far from busy roadways or other major community noise sources. Noise and vibration were measured next to the rear corner of the home, at distances of 88 feet and 100 feet from the near and far track center lines, respectively. Both tracks at this location are of wood tie and ballast construction, and are slightly above grade. Although the tracksprimarily consist of continuous welded rail, gaps of 1/2-inch to 3/4-inch were observed in the westbound (far track) rails near this measurement location.

Daily train traffic along this area of the corridor currently includes 22 Amtrak inter-city passenger trains, 18 Shore Line East commuter trains plus miscellaneous freight trains. Based on the noise monitor event data, it is estimated that 53 trains went by this location during the 24-hour measurement period. Ten trains were actually observed at this site, including 5 Amtrak trains, 3 commuter trains and 2 freight trains. Amtrak train speeds were observed to be in the range of 56 to 67 mph.

The noise monitor data indicated an L_{dn} of 69 dBA during the 24-hour measurement period at this site. Without trains, it is estimated that the L_{dn} would be about 57 dBA. As shown in Figure 4-6, the hourly maximum and equivalent noise levels vary widely depending on train traffic, and the background noise levels (L_{90}) range between approximately 40 dBA and 50 dBA. Maximum ground-borne vibration levels ranged between 65 dB and 86 dB, with Amtrak trains generating the highest levels.

4.3.2.2 Site A-2: 176 Westbrook Heights Rd. - Westbrook, CT. Site A-2 (See Figure 4-7) was selected to be representative of suburban homes adjacent to the rail corridor in the vicinity of highway I-95. Noise and vibration were measured next to the front corner of the home, at

TABLE 4-7. EXISTING GROUND VIBRATION MEASUREMENT SUMMARY

SITE	ADDRESS	START DATE AND TIME	END DATE AND TIME	DIST. TO NEAR TRACK CENTER (ft)	NUMBER OF TRAINS MEAS.	RANGE OF MAXIMUM VIBRATION VELOCITY LEVEL FOR TRAINS (dB re 1 μ-in/sec)
A-1	135 First Ave. New Haven, CT	11/05/92 08:15 AM	11/05/92 11:59 AM	88	10	65-86
A-2	176 Westbrook Heights Rd. Westbrook, CT	11/04/92 01:27 PM	11/04/92 04:46 PM	105	8	65-76
A-3	21 Gunshot Rd. Waterford, CT	11/02/92 01:56 PM	11/02/92 05:17 PM	80	6	82-86
A-3a	500 Noank Rd. W. Mystic, CT	11/05/92 02:35 PM	11/05/92 05:01 PM	35	5	76-82
A-4	8 Wilford Ct. Pawcatuck, CT	11/03/92 10:10 AM	11/03/92 12:47 PM	73	5	81-87
A-5	36 Railroad St. Charleston, RI	10/30/92 02:37 PM	10/30/92 05:07 PM	57	5	88-92
A-6	88 Alger St. Warwick, RI	10/30/92 09:05 AM	10/30/92 12:26 PM	63	7	86-94
A-7	11 Foundry St. Central Falls, RI	10/29/92 02:09 PM	10/29/92 05:21 PM	25	10	86-95
A-8	38 Otis St. W. Mansfield, MA	10/29/92 08:16 AM	10/29/92 11:50 AM	119	11	68-74
A-9	20 Hartwell Pl. Canton, MA	10/27/92 01:48 PM	10/27/92 05:09 PM	60	10	60-70
A-10	2 Westminster St. Hyde Park, MA	10/28/92 08:00 AM	10/28/92 11:00 AM	70	21	78-87

distances of 105 feet and 117 feet from the near and far track center lines, respectively. Both tracks at this location are of at-grade tie and ballast construction, with wood ties on the eastbound (near) track and concrete ties on the westbound (far) track.

Daily train traffic along this area of the corridor currently includes 22 Amtrak inter-city passenger trains, 18 Shore Line East commuter trains plus miscellaneous freight trains. Based on the noise monitor event data, it is estimated that 52 trains went by this location during the

24-hour measurement period. Eight trains were actually observed at this site, including 5 Amtrak trains, 2 commuter trains and 1 freight train. Amtrak train speeds were generally in the range of 68 to 75 mph.

The noise monitor data indicated an L_{dn} of 68 dBA during the 24-hour measurement period at this site. Without trains, it is estimated that the L_{dn} would be about 63 dBA. As shown in Figure 4-8, the hourly maximum noise levels vary widely depending on train traffic, and the hourly equivalent levels follow a similar pattern with somewhat less variation. Background noise levels (L_{90}) range between roughly 45 dBA and 55 dBA, dominated by traffic noise from I-95. Maximum ground-borne vibration levels ranged between 65 dB and 76 dB, with Amtrak trains generating the highest levels.

4.3.2.3 Site A-3: 21 Gunshot Road - Waterford, CT. Site A-3 (see Figure 4-9) was selected to be representative of suburban homes adjacent to the rail corridor and far from busy roadways or other major community noise sources. Noise and vibration were measured next to the rear corner of the home, at distances of 80 feet and 92 feet from the near and far track center lines, respectively. Both tracks at this location are constructed of wood ties and ballast on a 6-ft high embankment.

Daily train traffic along this area of the corridor currently includes 22 Amtrak inter-city passenger trains plus various freight trains. Based on the noise monitor event data, it is estimated that 23 trains went by this location during the 24-hour measurement period. Six trains were actually observed at this site, including 5 Amtrak trains and 1 work train.
Amtrak train speeds were observed to be in the range of 51 to 63 mph.

The noise monitor data indicated an L_{dn} of 68 dBA during the 24-hour measurement period at this site. Without trains, it is estimated that the L_{dn} would be about 60 dBA. As shown in Figure 4-10, the hourly maximum and equivalent noise levels vary widely depending on train traffic, and the background noise levels (L_{90}) range between roughly 40 dBA and 50 dBA. Maximum ground-borne vibration levels ranged between 82 dB and 86 dB.

4.3.2.4 Site A-3a: 500 Noank Road - West Mystic, CT. Site A-3a (See Figure 4-11) was selected to be representative of suburban, waterfront residences near the rail corridor. Noise and vibration were measured at 35 feet and 48 feet from the near and far track center lines respectively. Both tracks are of at-grade tie and ballast construction, with wood ties on the near (westbound) track and concrete ties on the far track.

Daily scheduled train traffic currently includes 20 Amtrak trains that sound their horns for a nearby grade crossing. Five Amtrak trains were observed at this location, causing maximum ground-borne vibration levels ranging between 76 dB and 82 dB. Train speeds were observed to be in the range of 52 to 70 mph.

4.3.2.5 Site A-4: 8 Wilford Court - Pawcatuck, CT. Site A-4 (See Figure 4-12) was selected to be representative of suburban homes adjacent to a rail corridor near a grade crossing. Noise and vibration were measured next to the rear corner of the home, at 73 feet and 85 feet from the near and far track center lines, respectively. Both tracks at this location are of at-grade tie and ballast construction, with concrete ties on the near (westbound) track and wood ties on the far track.

Daily train traffic along this area of the corridor currently includes 20 Amtrak inter-city passenger trains plus freight trains. Based on the noise monitor event data, it is estimated that 22 trains went by this site during the 24-hour measurement period. Five Amtrak trains were actually observed at this site, with speeds in the range of 60 to 79 mph.

The noise monitor data indicated an L_{dn} of 77 dBA during the 24-hour measurement period at this site. Without trains, it is estimated that the L_{dn} would be about 65 dBA. As shown in Figure 4-13, the hourly maximum and equivalent noise levels vary widely depending on train traffic, and the background noise levels (L_{90}) range between roughly 40 dBA and 55 dBA. Maximum ground-borne vibration levels ranged between 81 dB and 87 dB.

4.3.2.6 Site A-5: 36 Railroad Street - Charleston, RI. Site A-5 (See Figure 4-14) was selected to be representative of rural homes adjacent to the rail corridor and far from busy roadways or other major community noise sources. Noise and vibration were measured next to the front corner of the home, at 53 feet and 66 feet from the near and far track center lines, respectively. Both tracks at this location are of at-grade tie and ballast construction, with concrete ties on the near (westbound) track and wood ties on the far (eastbound) track.

Daily train traffic along this area of the corridor currently includes 20 Amtrak inter-city passenger trains plus freight trains. Based on the noise monitor event data, it is estimated that 26 trains went by this site during the 24-hour measurement period. Five Amtrak trains were actually observed at this site, with speeds in the range of 74 to 83 mph.

The noise monitor data indicated an L_{dn} of 68 dBA during the 24-hour measurement period at this site. Without trains, it is estimated that the L_{dn} would be about 52 dBA. As shown in Figure 4-15, the hourly maximum and equivalent noise levels vary widely depending on train traffic, and the background noise levels (L_{90}) range between roughly 25 dBA and 40 dBA. Maximum ground-borne vibration levels ranged between 88 dB and 92 dB.

4.3.2.7 Site A-6: 88 Alger Street - Warwick, RI. Site A-6 (See Figure 4-16) was selected to be representative of suburban, residential locations with multi-family land use. Noise and vibration were measured near the rear corner of the end unit of this housing complex, at distances of 63 feet and 88 feet from the center lines of the near and far tracks, respectively. Both tracks at this location are of at-grade tie and ballast construction, with concrete ties on the near (westbound) track and wood ties on the far (eastbound) track.

Daily train traffic along this area of the corridor currently includes 20 Amtrak inter-city passenger trains plus various freight trains. Based on the noise monitor event data, it is estimated that 24 trains went by this location during the 24-hour measurement period. Six trains were actually observed at this site, including 4 Amtrak trains and 2 freight trains. Due to track construction work in the vicinity, all observed trains were on the near track. Amtrak train speeds were observed to be in the range of 74 to 86 mph.

The noise monitor data indicated an L_{dn} of 72 dBA during the 24-hour measurement period at this site. Without trains, it is estimated that the L_{dn} would be about 64 dBA. As shown in Figure 4-17, the hourly maximum and equivalent noise levels vary widely depending on train traffic, and the background noise levels (L_{90}) range between roughly 35 dBA and 50 dBA. Maximum ground-borne vibration levels ranged between 86 dB and 94 dB, with Amtrak trains generating the highest levels.

4.3.2.8 Site A-7: 11 Foundry Street - Central Falls, RI. Site A-7 (See Figure 4-18) was selected to be representative of homes adjacent to the rail corridor in urban areas with mixed residential and industrial land use. Noise and vibration were measured near the rear corner of this home, at distances of 25 feet, 38 feet and 51 feet from the center lines of the near, middle and far tracks, respectively. All tracks at this location are of wood tie and ballast construction.

Daily train traffic along this area of the corridor currently includes 20 Amtrak inter-city passenger trains, 10 Massachusetts Bay Transportation Authority (MBTA) commuter trains plus miscellaneous freight trains. Based on the noise monitor event data, it is estimated that 41 trains went by this location during the 24-hour measurement period. Ten trains were actually observed at this site, including 5 Amtrak trains, 2 MBTA commuter trains and 3 freight trains. Amtrak train speeds were observed to be in the range of 48 to 54 mph.

The noise monitor data indicated an L_{dn} of 74 dBA during the 24-hour measurement period at this site. Without trains, it is estimated that the L_{dn} would be about 63 dBA. As shown in Figure 4-19, the hourly maximum and equivalent noise levels vary widely depending on train traffic, and the background noise levels (L_{90}) are close to 50 dBA during most of the day. Maximum ground-borne vibration levels ranged between 86 dB and 95 dB, with Amtrak trains generating the highest levels.

4.3.2.9 Site A-8: 38 Otis Street - West Mansfield, MA. Site A-8 (See Figure 4-20) was selected to be representative of homes adjacent to the rail corridor in rural communities along secondary roadways. Noise was measured near the swimming pool and hammock in the back yard of the home, at distances of 50 feet and 65 feet from the center lines of the near and far tracks, respectively. Vibration was measured near the rear corner of the home, at distances of 119 feet and 134 feet from the near and far track center lines, respectively. Both tracks at this location are of concrete tie and ballast construction.

Daily train traffic along this area of the corridor currently includes 20 Amtrak inter-city passenger trains, 32 MBTA commuter trains plus miscellaneous freight trains. Based on the noise monitor event data, it is estimated that 56 trains went by this location during the 24-hour measurement period. Eleven trains were actually observed at this site, including 4 Amtrak trains and 7 MBTA commuter trains. Speeds were observed to be in the range of 53 to 101 mph for Amtrak trains and 61 to 77 mph for MBTA commuter trains.

The noise monitor data indicated an L_{dn} of 72 dBA during the 24-hour measurement period at this site. Without trains, it is estimated that the L_{dn} would be about 55 dBA. As shown in Figure 4-21, the hourly maximum and equivalent noise levels vary widely depending on train traffic, and the background noise levels (L_{90}) range between roughly 30 dBA and 45 dBA. Maximum ground-borne vibration levels ranged between 68 dB and 74 dB, with Amtrak trains generating the highest levels.

4.3.2.10 Site A-9: 20 Hartwell Place - Canton, MA. Site A-9 (See Figure 4-22) was selected to be representative of homes adjacent to the rail corridor in major suburban areas. Noise and vibration were measured near the rear corner of the home, at distances of 60 feet and 75 feet from the near and far track center lines, respectively. Both tracks at this location are of concrete tie and ballast construction.

Daily train traffic along this area of the corridor currently includes 20 Amtrak inter-city passenger trains, 32 MBTA commuter trains plus miscellaneous freight trains. Based on the noise monitor event data, it is estimated that 57 trains went by this location during the 24-hour measurement period. Ten trains were actually observed at this site, including 5 Amtrak trains, 4 MBTA commuter trains and 1 freight train. Speeds were observed to be in the range of 67 to 82 mph for Amtrak trains and 31 to 74 mph for MBTA commuter trains.

The noise monitor data indicated an L_{dn} of 73 dBA during the 24-hour measurement period at this site. Without trains, it is estimated that the L_{dn} would be about 62 dBA. As shown in Figure 4-23, the hourly maximum and equivalent noise levels vary widely depending on train traffic, and the background noise levels (L_{90}) range between roughly 45 dBA and 50 dBA. Maximum ground-borne vibration levels ranged between 60 dB and 70 dB, with Amtrak and MBTA trains generating the highest levels.

4.3.2.11 Site A-10: 2 Westminster Street - Hyde Park, MA. Site A-10 (See Figure 4-24) was selected to be representative of homes adjacent to the rail corridor in urban areas with mixed residential and commercial land use. Noise and vibration were measured near the rear corner of the home, at distances of 70 feet, 85 feet and 100 feet from the center lines of the near, middle and far track center lines, respectively. All tracks at this location are of tie and ballast construction, with concrete ties on the near and middle tracks and wood ties on the far track.

Daily train traffic along this area of the corridor currently includes 20 Amtrak inter-city passenger trains, 96 MBTA commuter trains plus miscellaneous freight trains. Based on the noise monitor event data, it is estimated that 121 trains went by this location during the 24-hour measurement period. Twenty-one trains were actually observed at this site, including 3 Amtrak trains and 18 MBTA commuter trains. Speeds were observed to be in the range of 83 to 88 mph for Amtrak trains and 42 to 72 mph for MBTA commuter trains.

The noise monitor data indicated an L_{dn} of 74 dBA during the 24-hour measurement period at this site. Without trains, it is estimated that the L_{dn} would be about 58 dBA. As shown in Figure 4-25, the hourly maximum and equivalent noise levels vary widely depending on train traffic, and the background noise levels (L_{90}) range between roughly 35 dBA and 50 dBA. Maximum ground-borne vibration levels ranged between 78 dB and 87 dB, with Amtrak trains generating the highest levels.

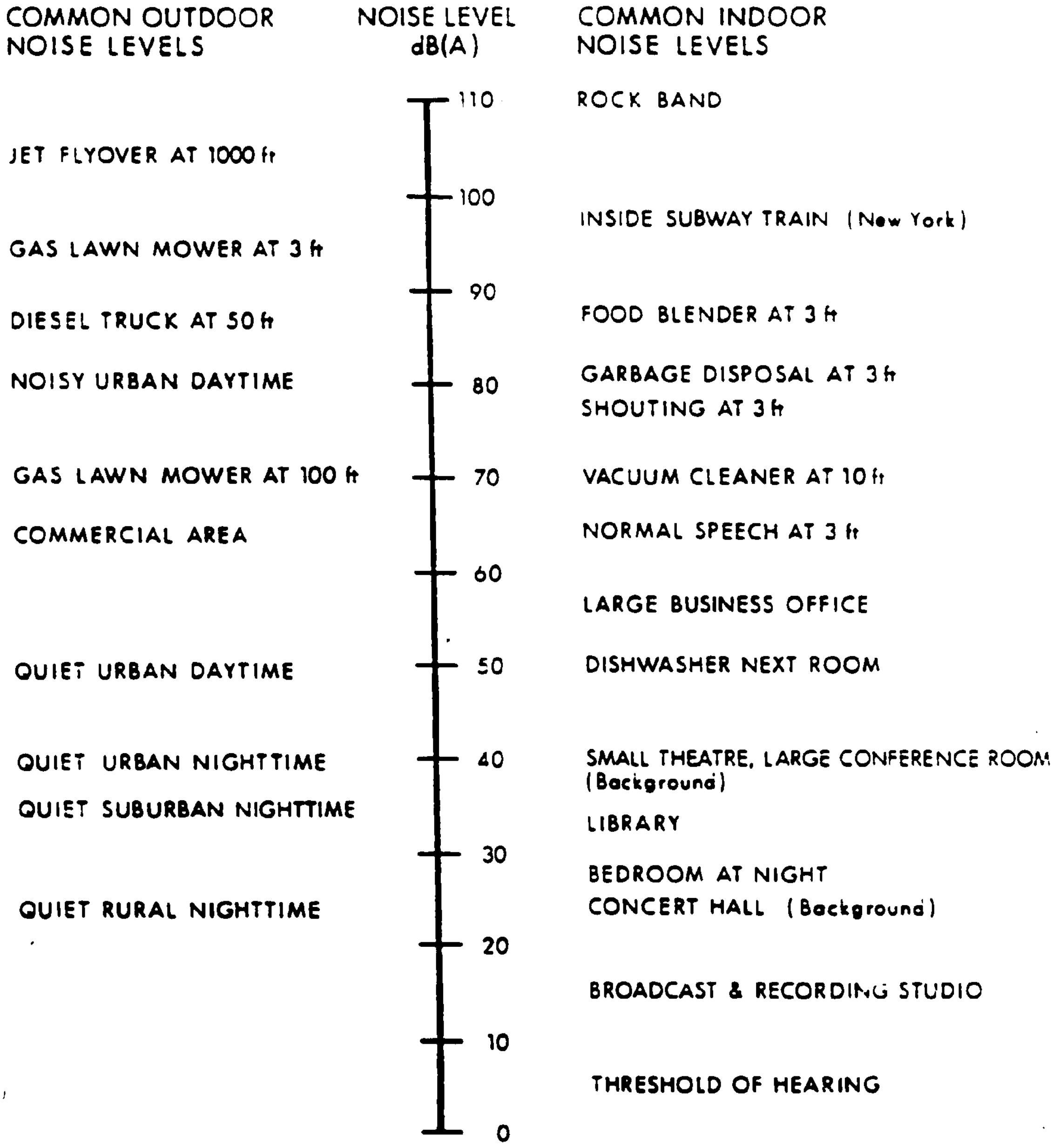

FIGURE 4-1. TYPICAL A-WEIGHTED SOUN › LEVELS

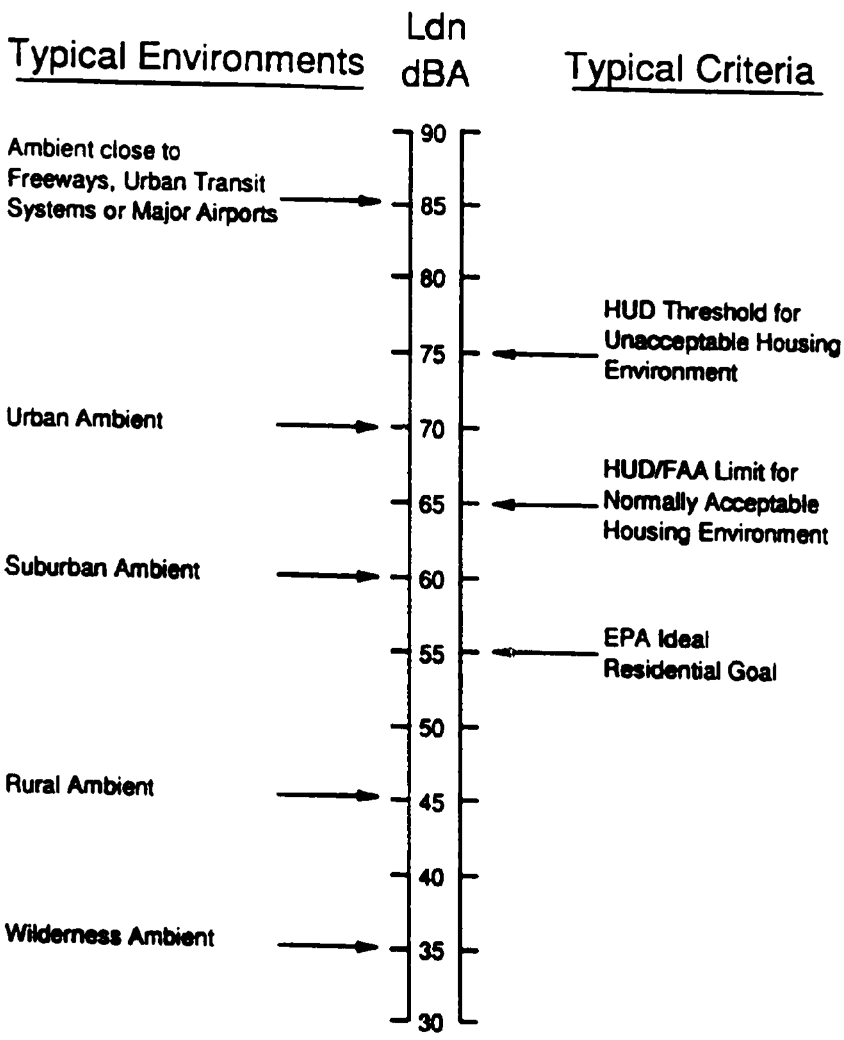

FIGURE 4-2. EXAMPLES OF TYPICAL OUTDOOR NOISE EXPOSURE

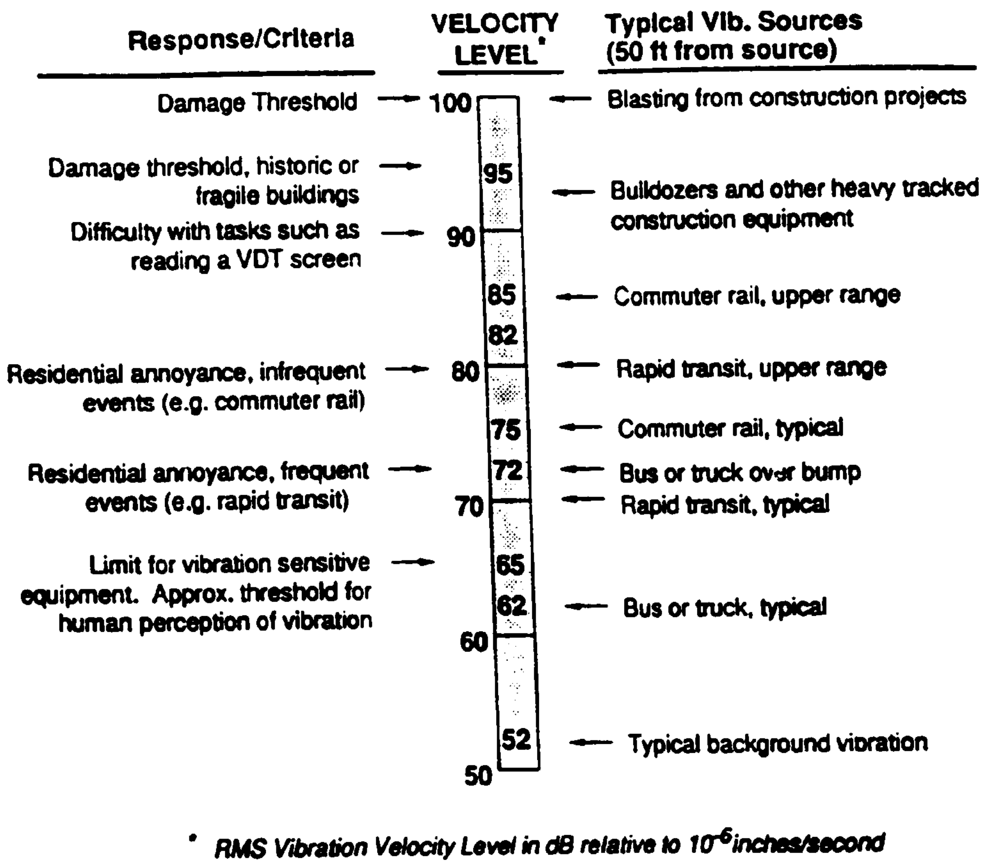

FIGURE 4-3. TYPICAL GROUND-BORNE VIBRATION LEVELS

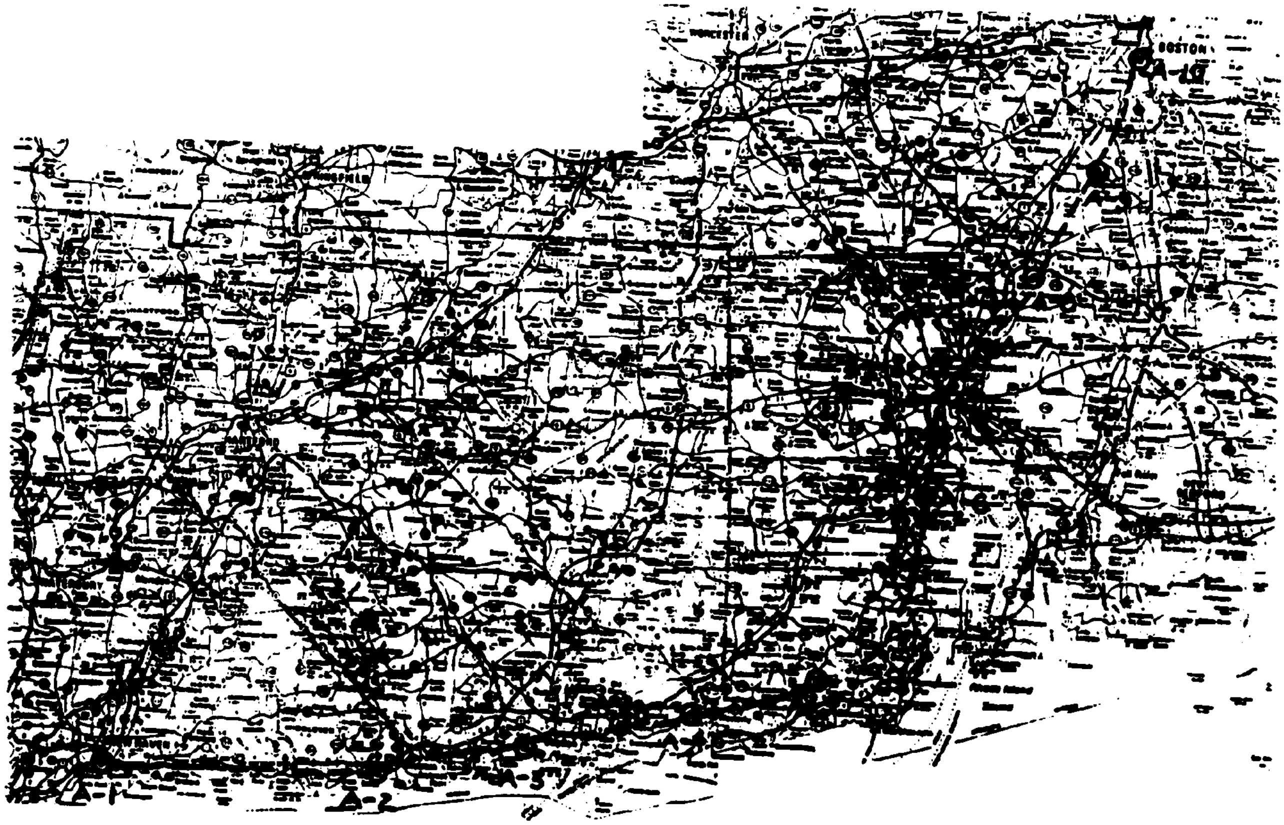

FIGURE 4-4. EXISTING NOISE AND VIBRATION MEASUREMENT SITES

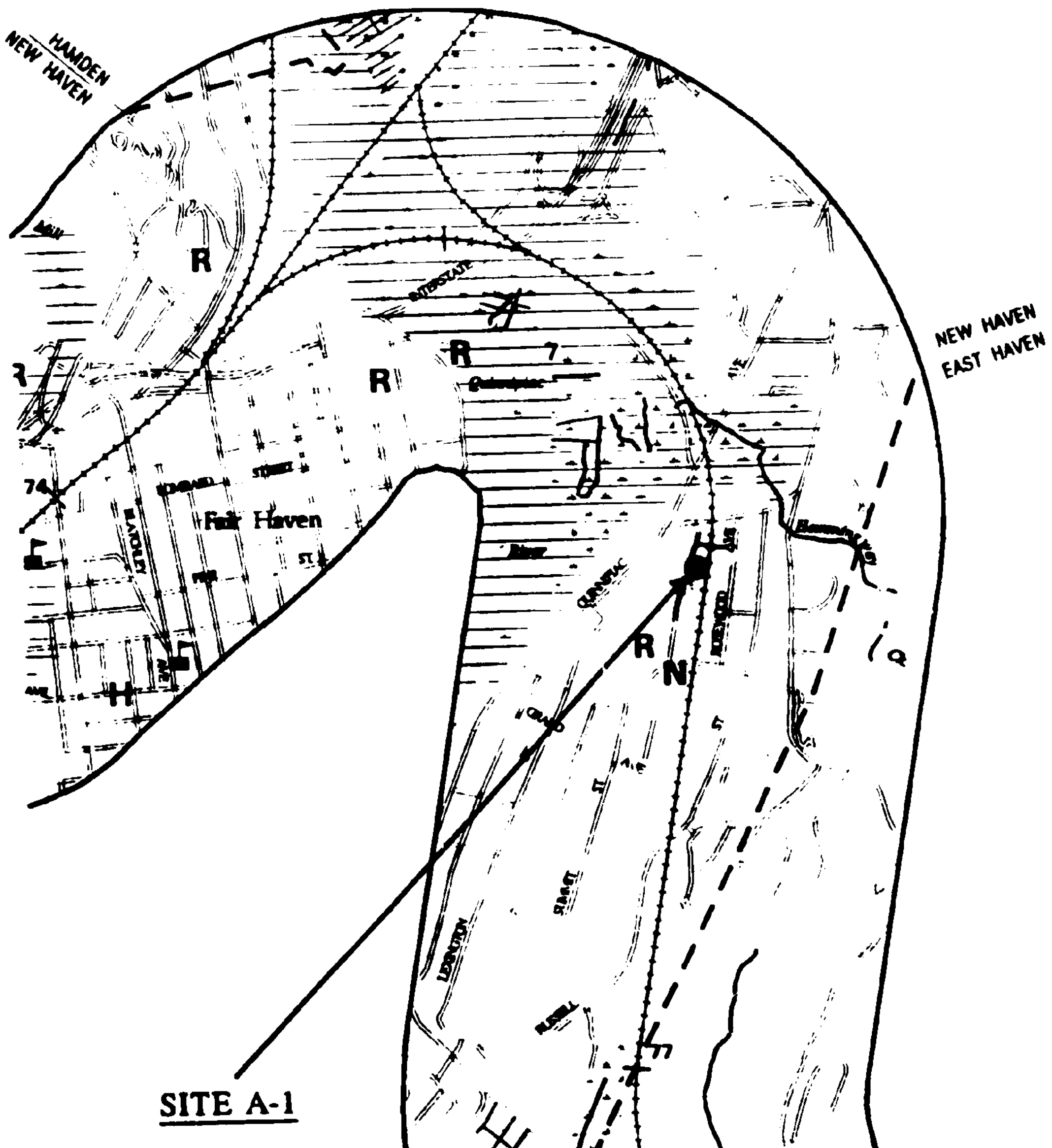

FIGURE 4-5. SITE A-1: 135 FIRST AVE. - NEW HAVEN, CT

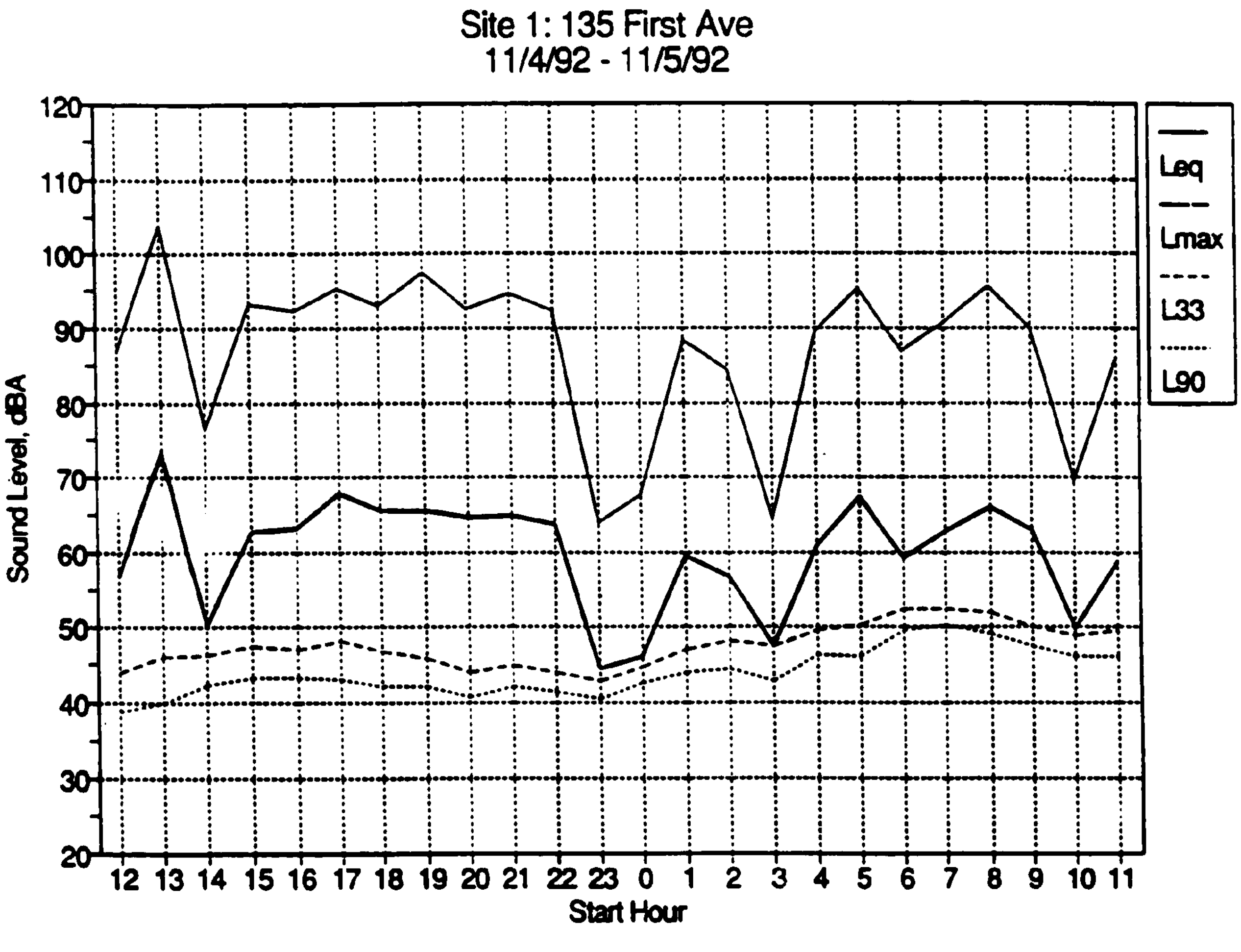

FIGURE 4-6. HOURLY SOUND LEVELS AT SITE A-1

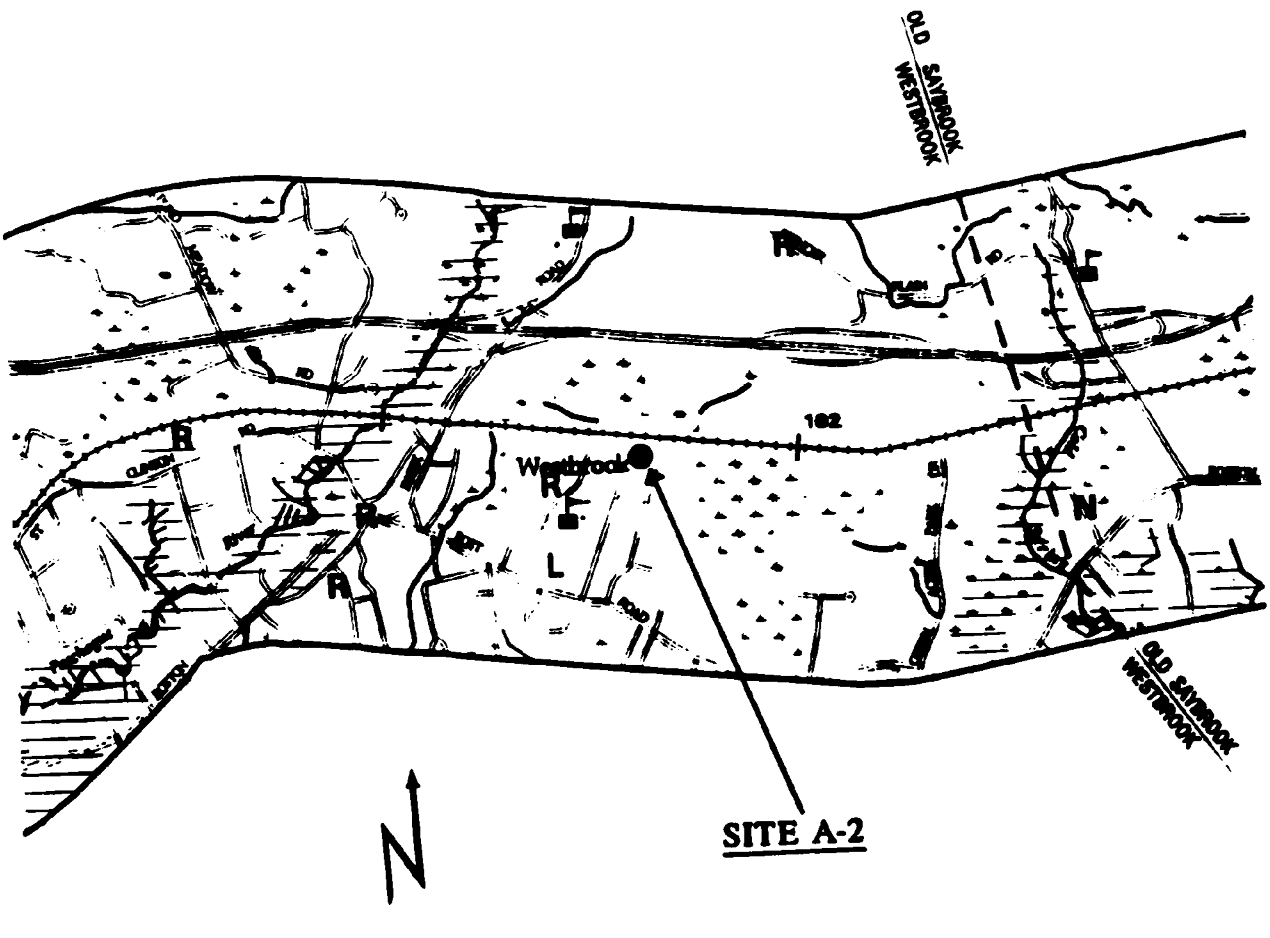

FIGURE 4-7. SITE A-2: 176 WESTBROOK HTS. RD.- WESTBROOK, CT

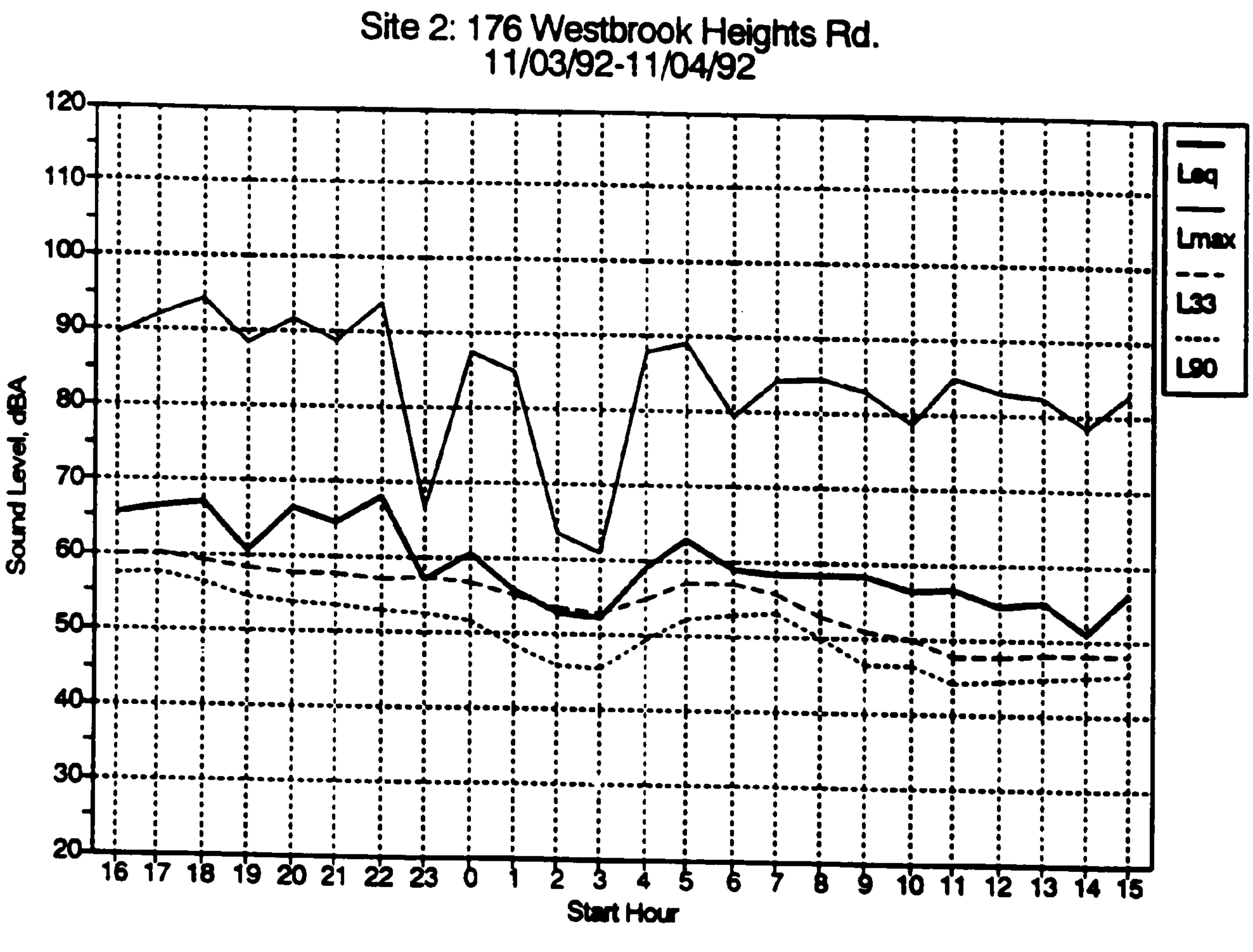

FIGURE 4-8. HOURLY SOUND LEVELS AT SITE A-2

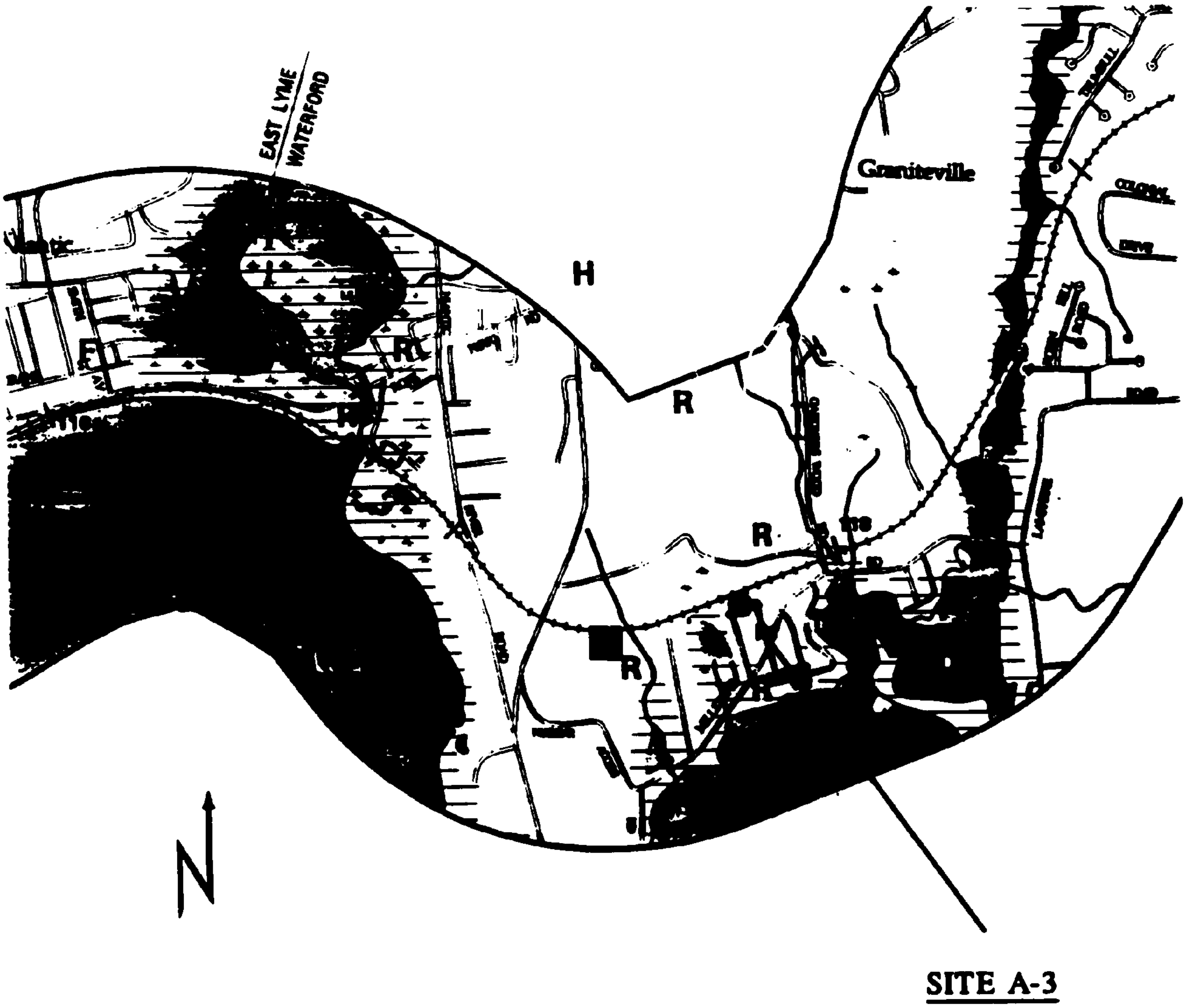

FIGURE 4-9. SITE A-3: 21 GUNSHOT RD. - WATERFORD, CT

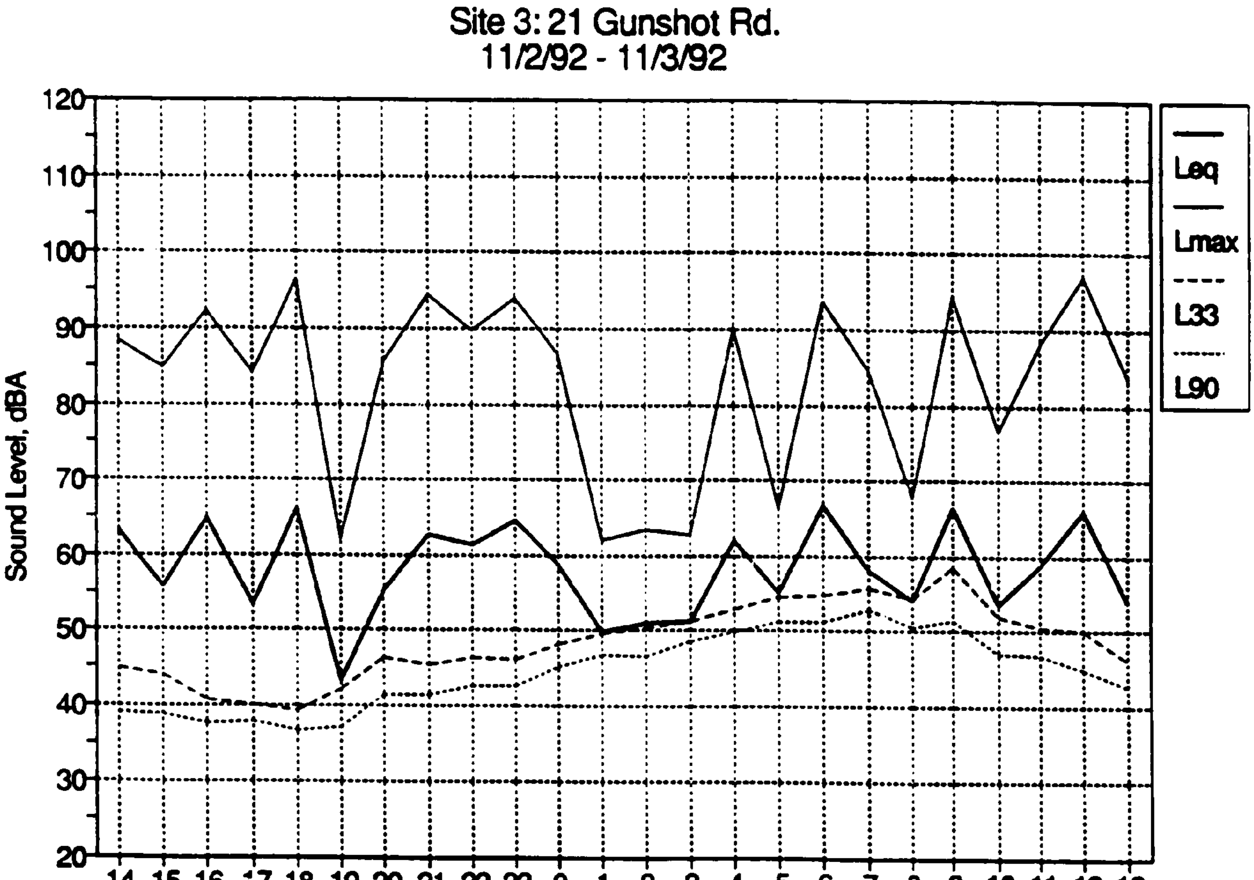

FIGURE 4-10. HOURLY SOUND LEVELS AT SITE A-3

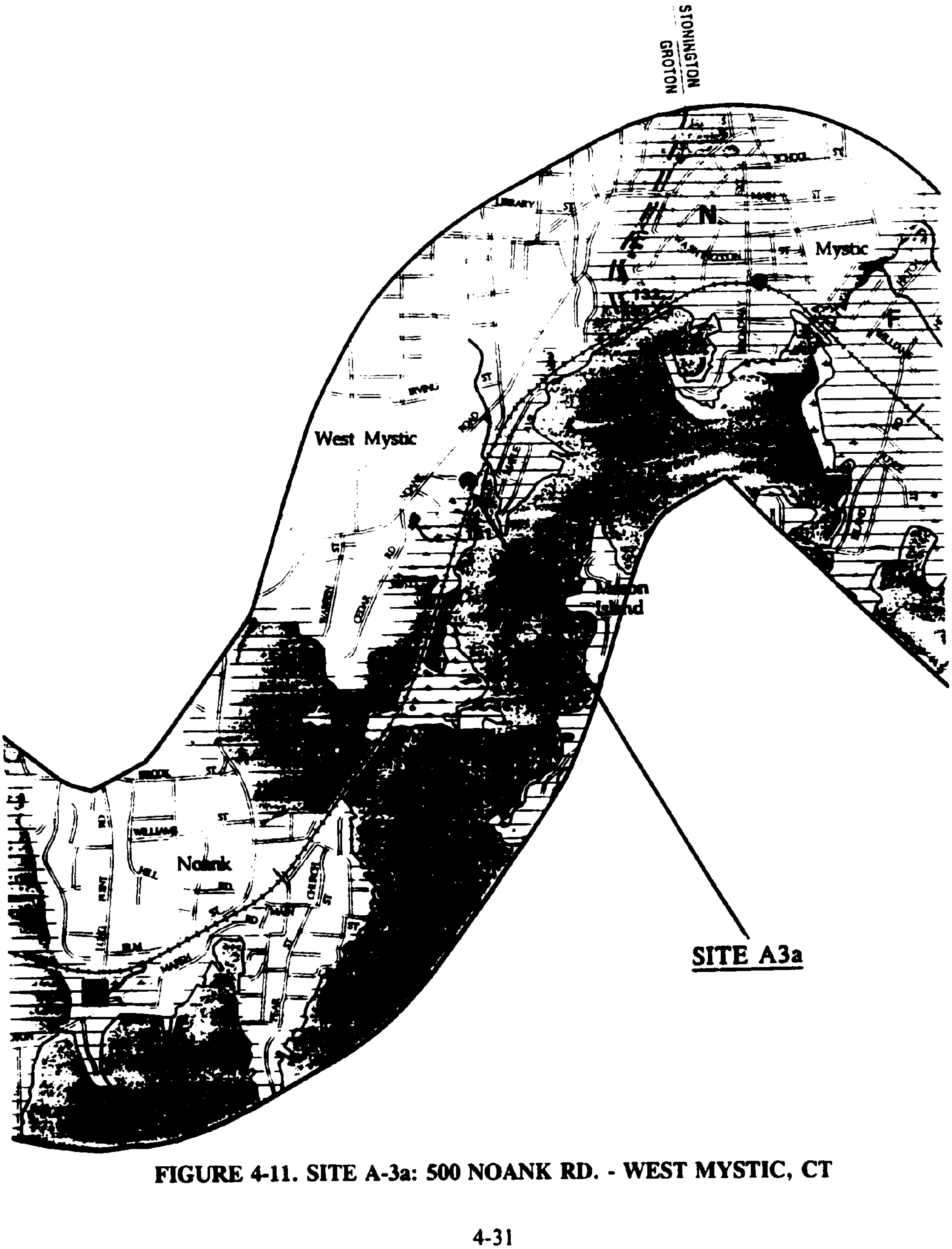

FIGURE 4-11. SITE A-3a: 500 NOANK RD. - WEST MYSTIC, CT

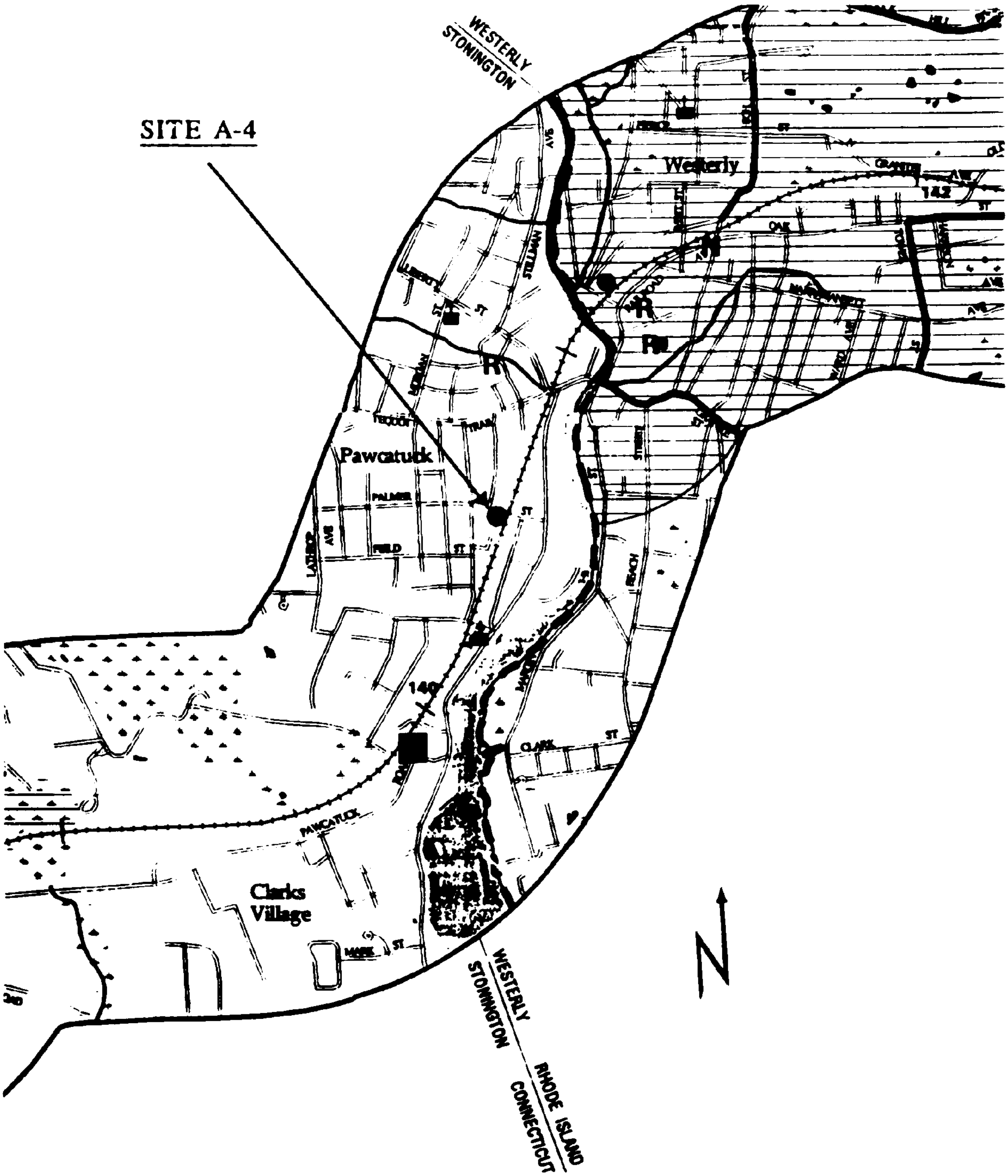

FIGURE 4-12. SITE A-4: 8 WILFORD CT.- PAWCATUCK, CT

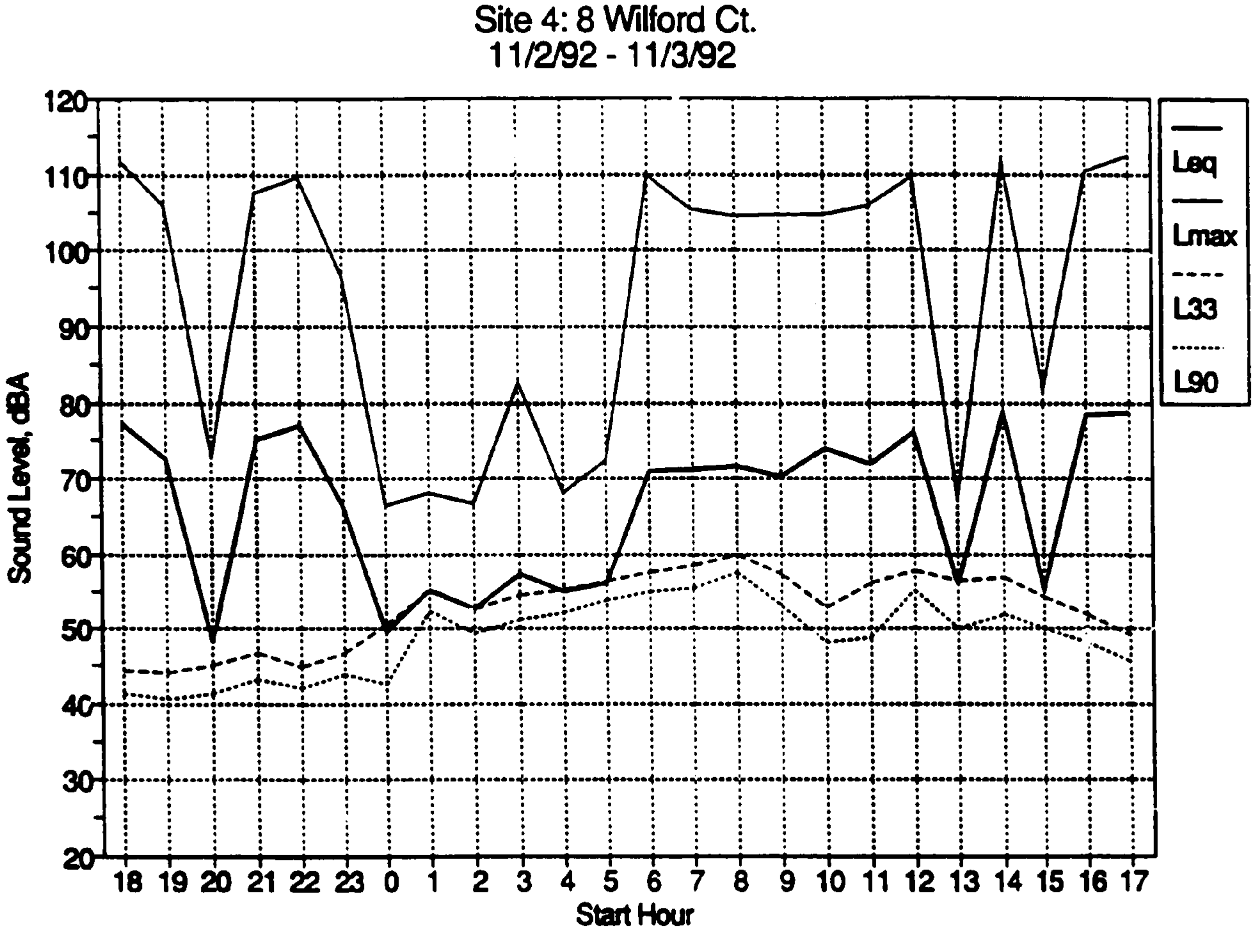

FIGURE 4-13. HOURLY SOUND LEVELS AT SITE A-4

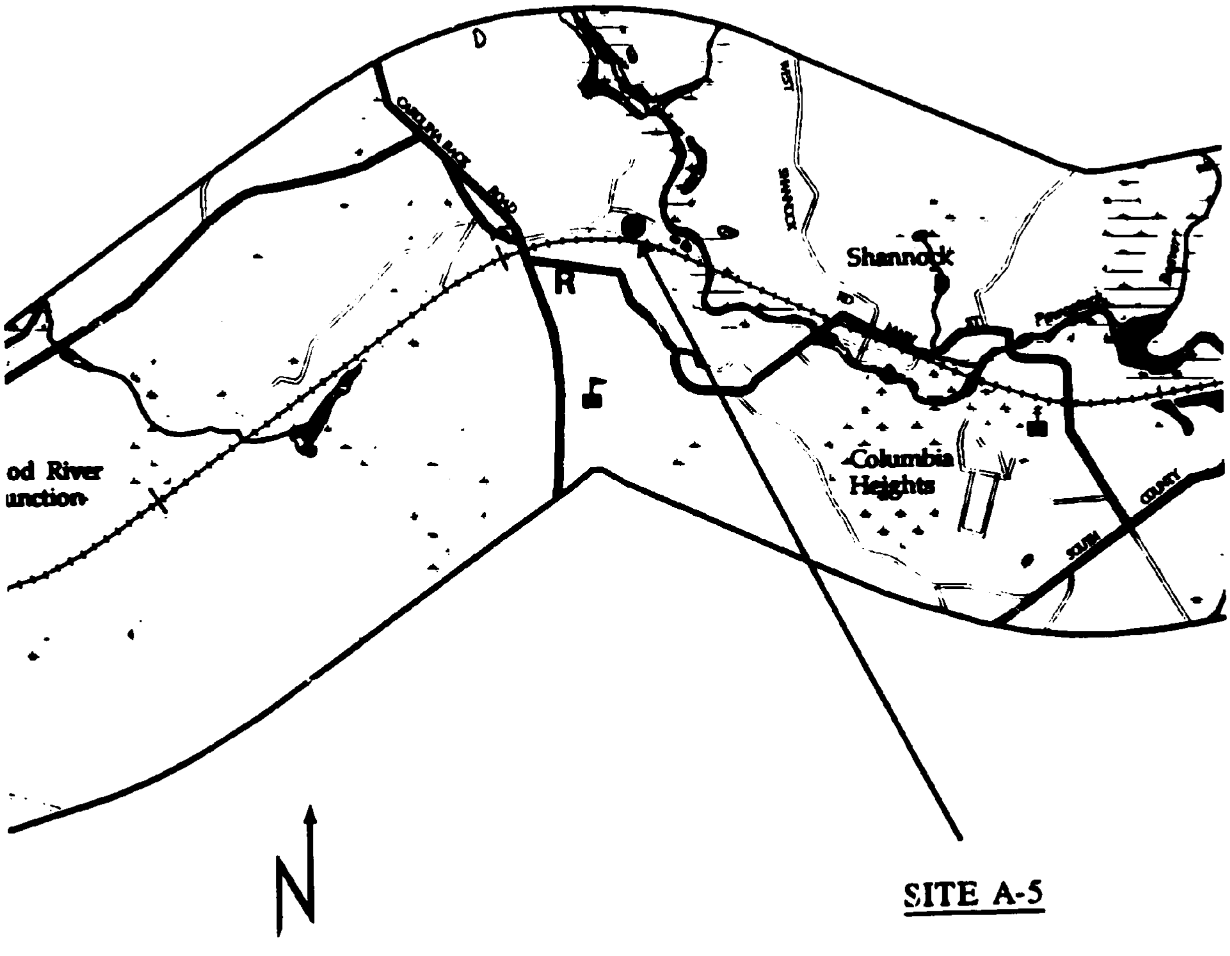

FIGURE 4-14. SITE A-5: 36 RAILROAD ST. - CHARLESTOWN, RI

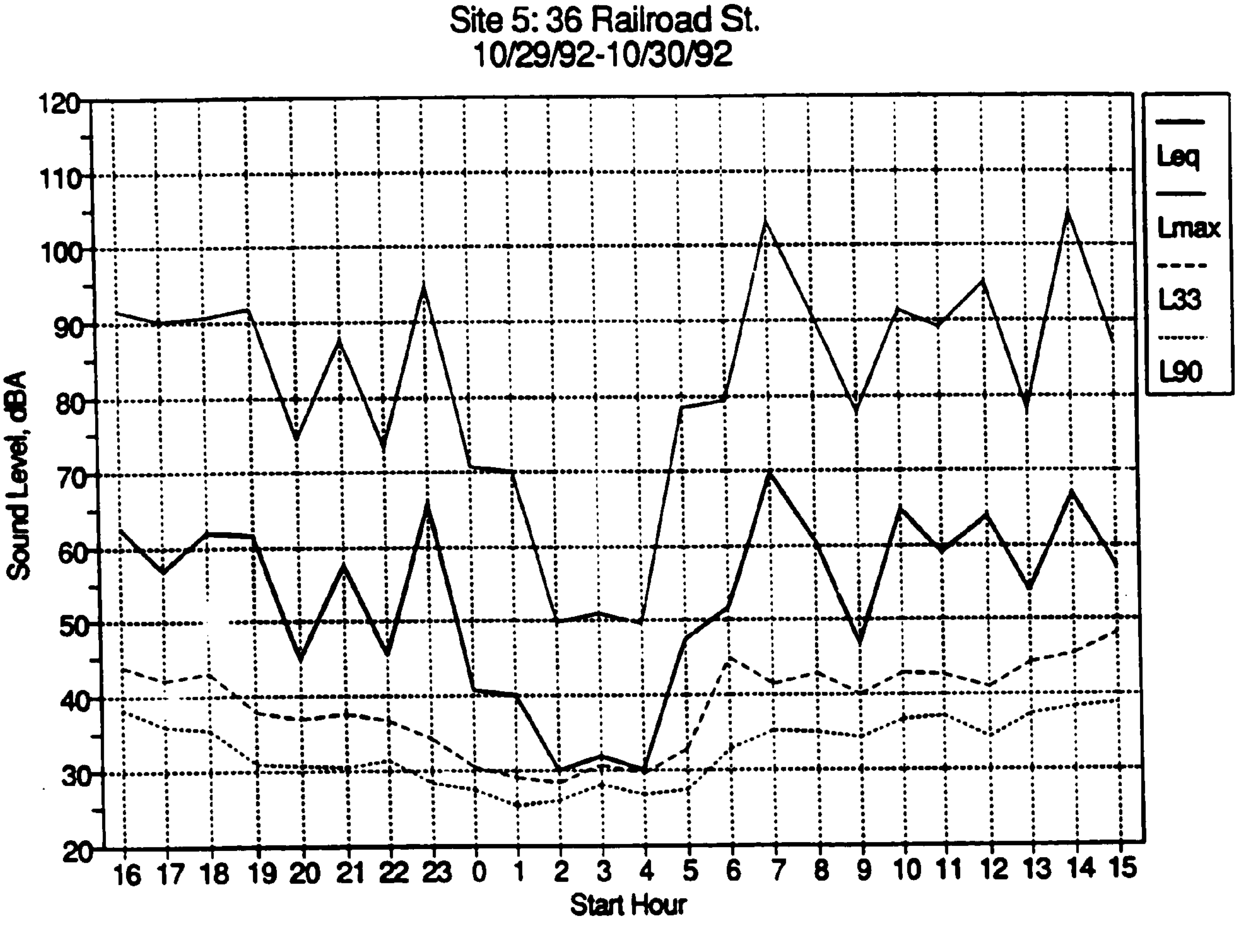

FIGURE 4-15. HOURLY SOUND LEVELS AT SITE A-5

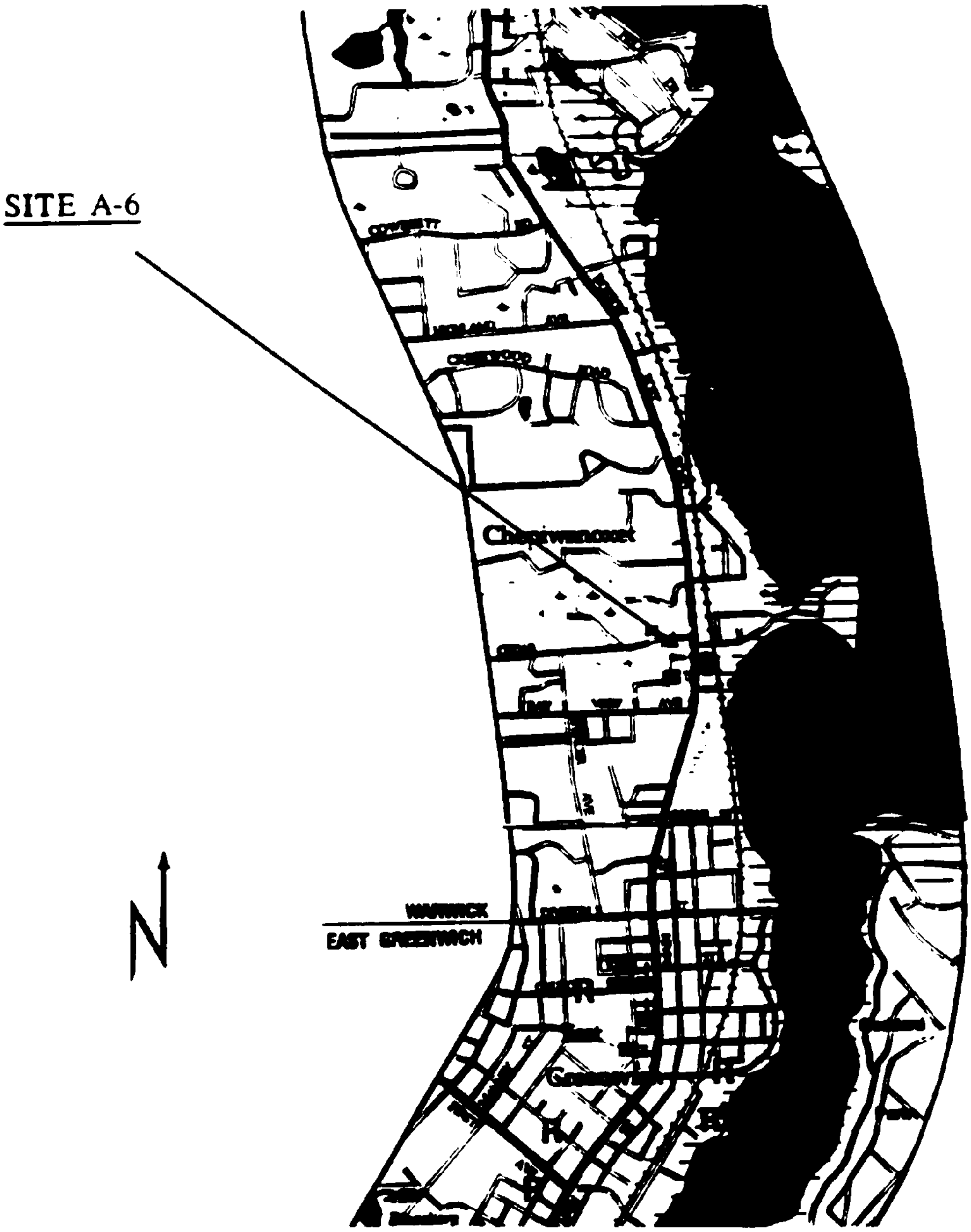

FIGURE 4-16. SITE A-6: 88 ALGER ST. - WARWICK, RI

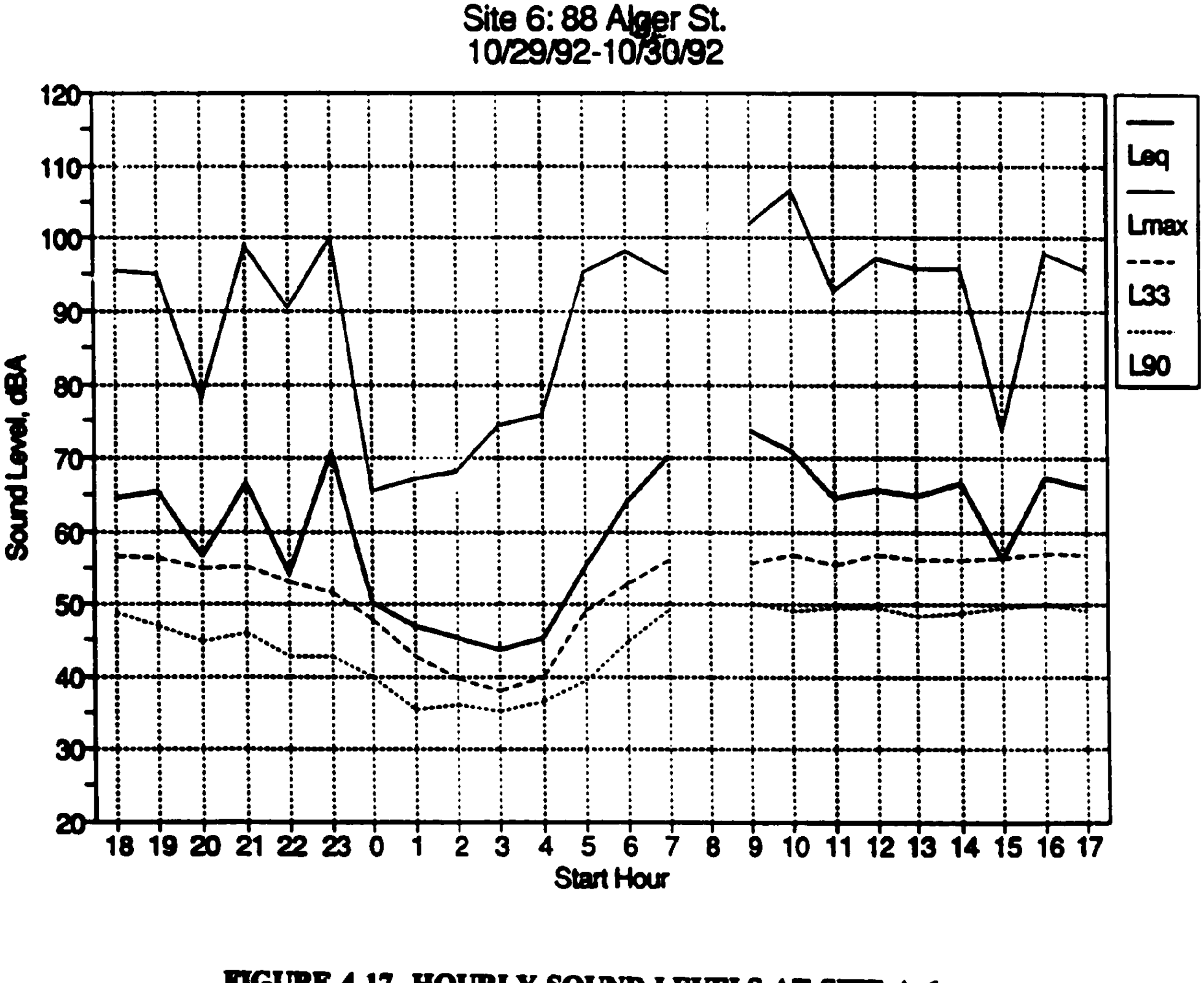

FIGURE 4-17. HOURLY SOUND LEVELS AT SITE A-6

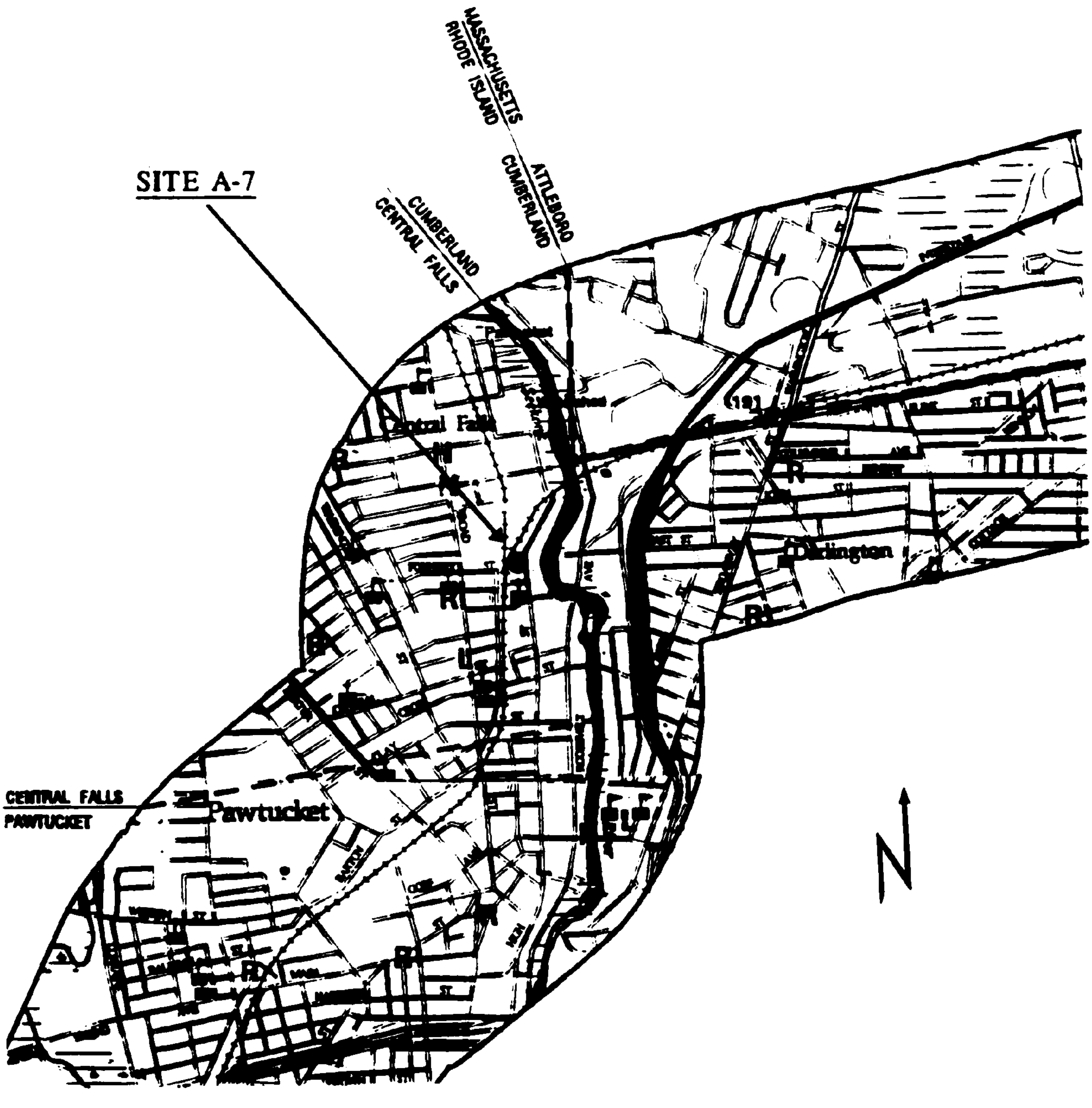

FIGURE 4-18. SITE A-7: 11 FOUNDRY ST. - CENTRAL FALLS, RI

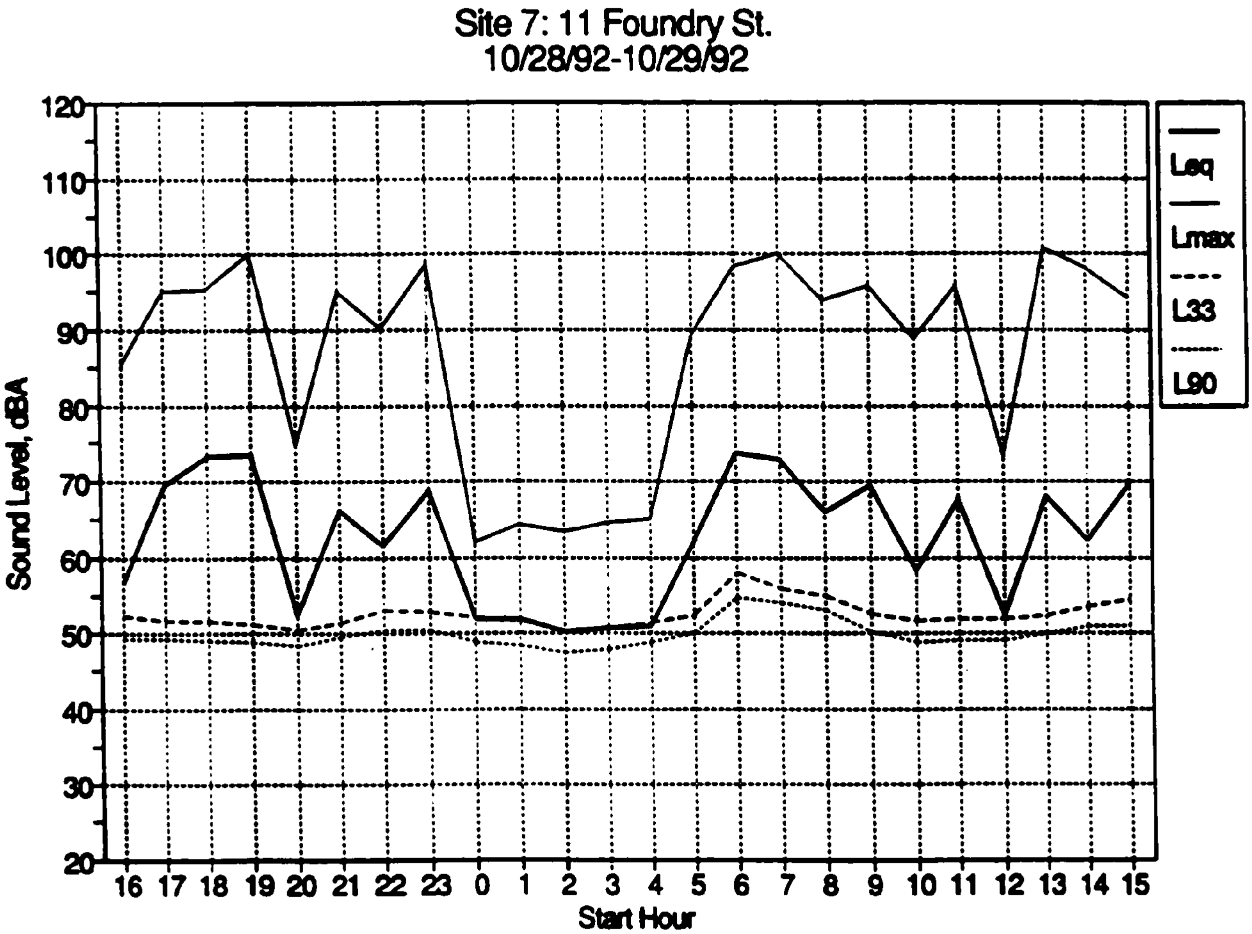

FIGURE 4-19. HOURLY SOUND LEVELS AT SITE A-7

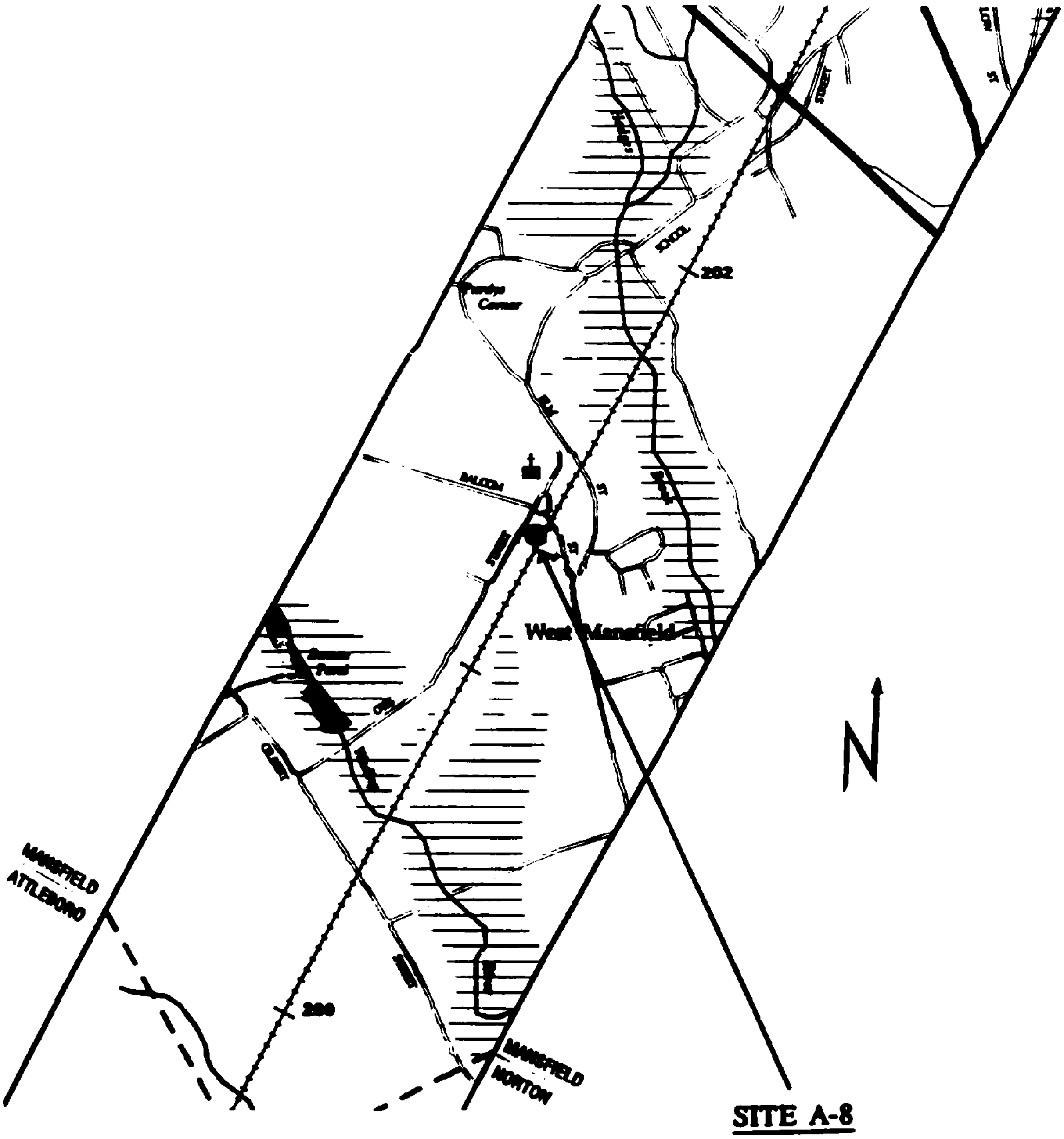

FIGURE 4-20. SITE A-8: 38 OTIS ST. - WEST MANSFIELD, MA

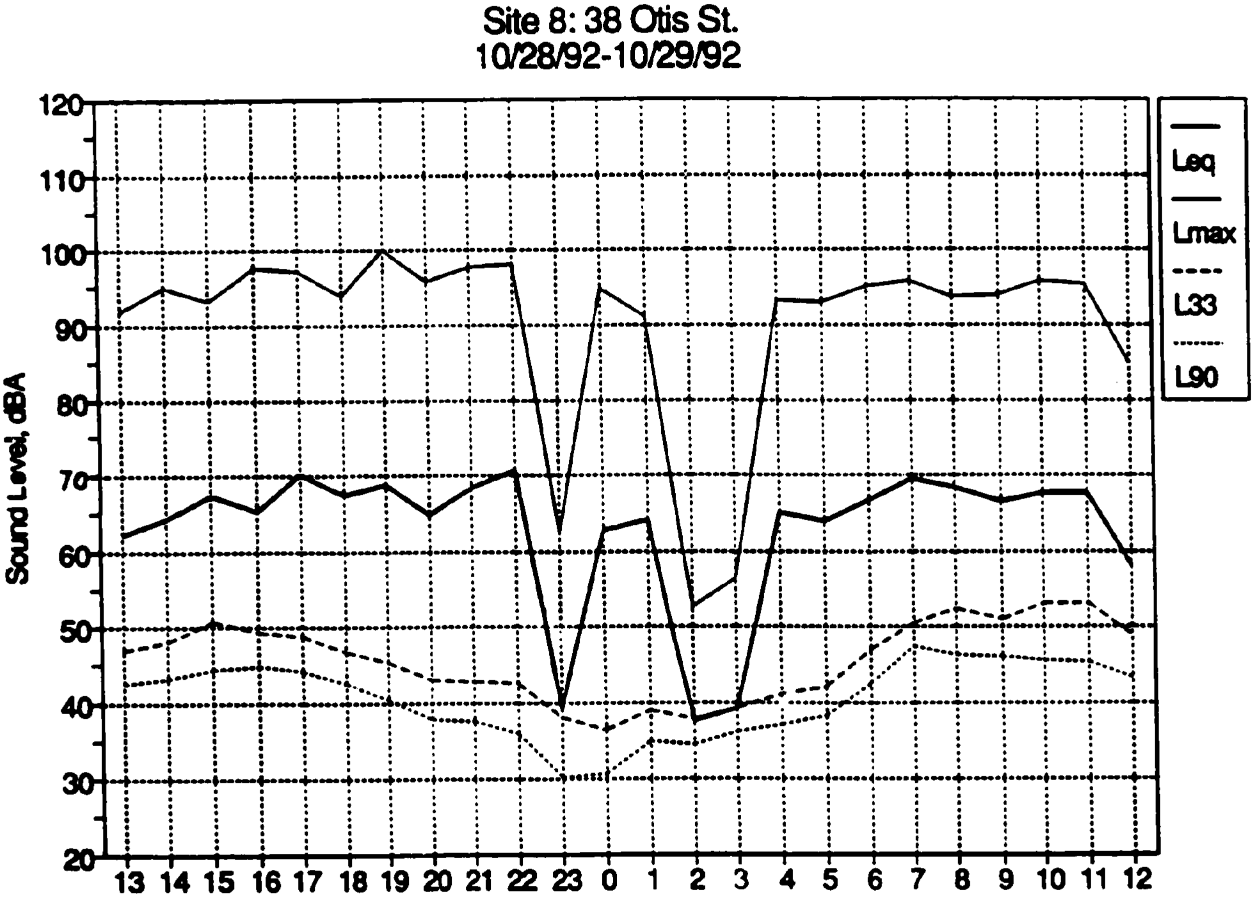

FIGURE 4-21. HOURLY SOUND LEVELS AT SITE A-8

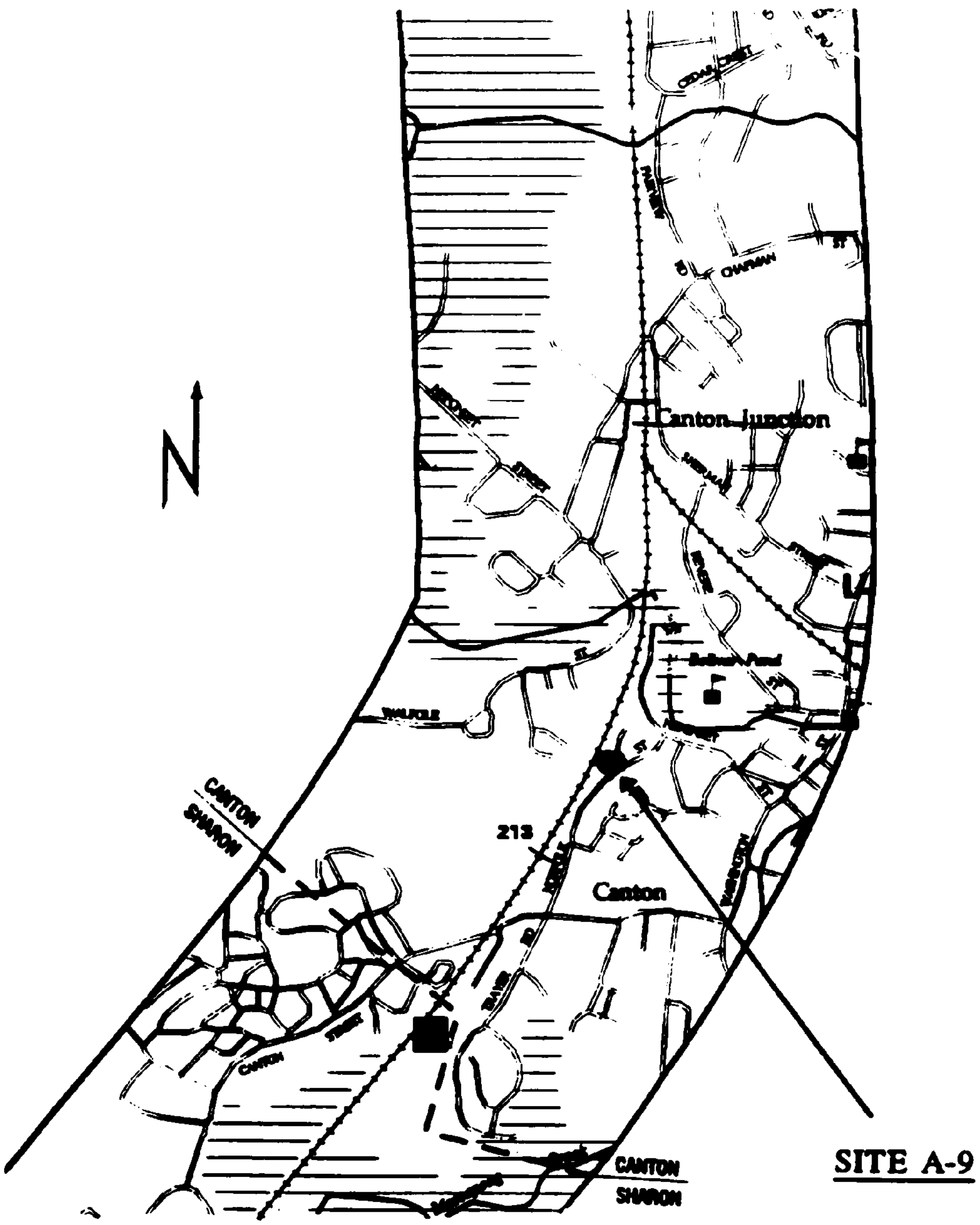

FIGURE 4-22. SITE A-9: 20 HARTWELL PL. - CANTON, MA

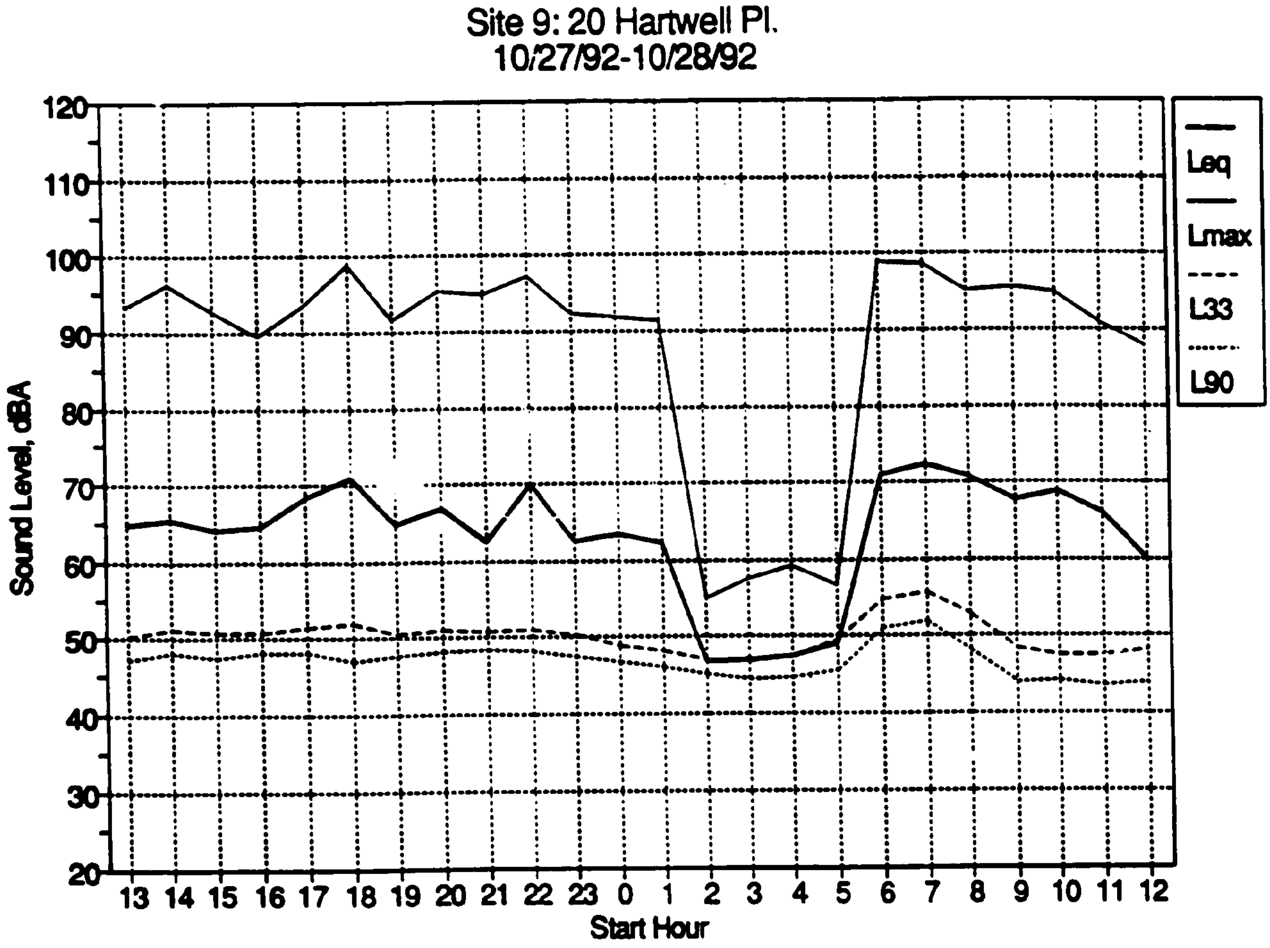

FIGURE 4-23. HOURLY SOUND LEVELS AT SITE A-9

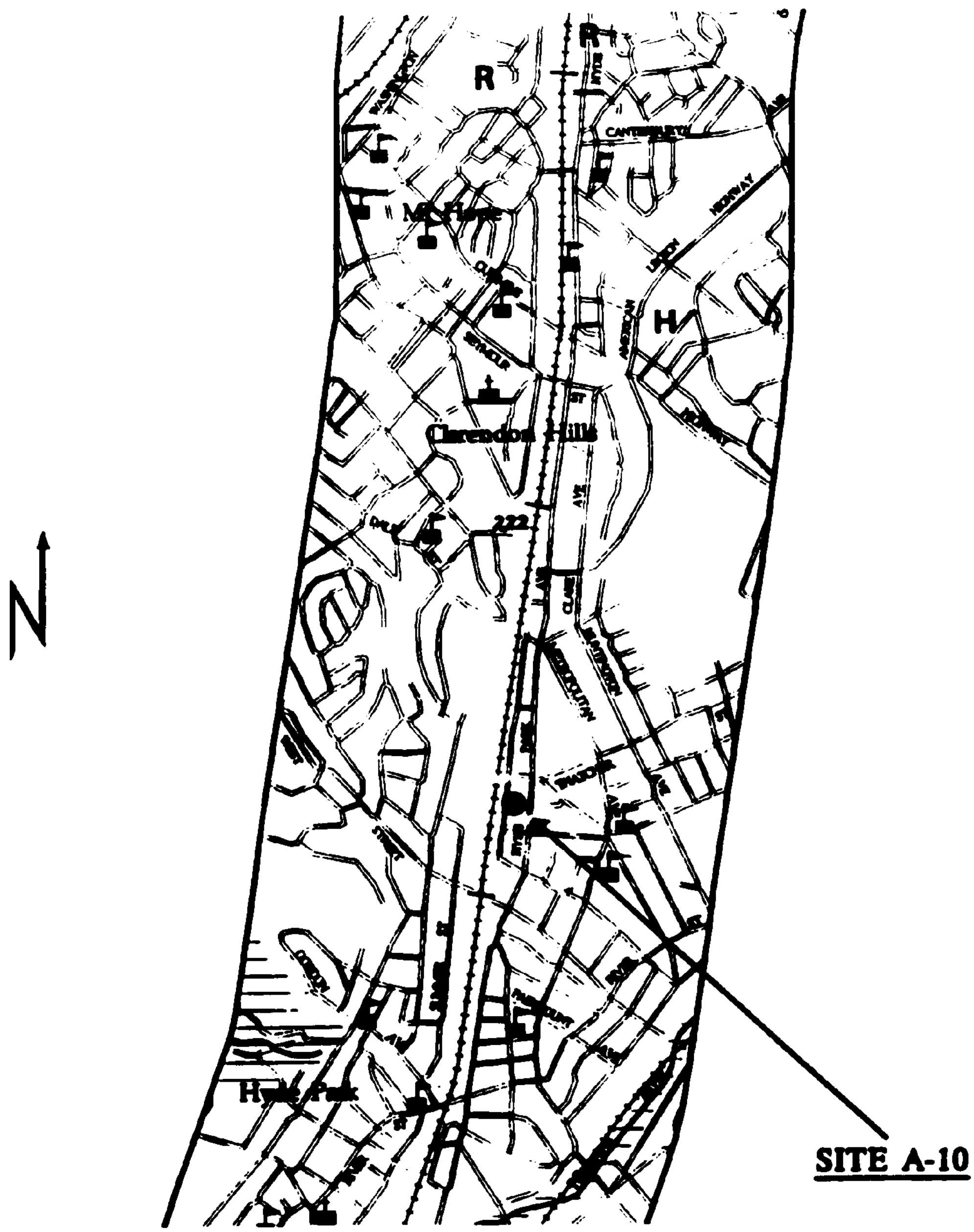

FIGURE 4-24. SITE A-10: 2 WESTMINSTER ST. - HYDE PARK, MA

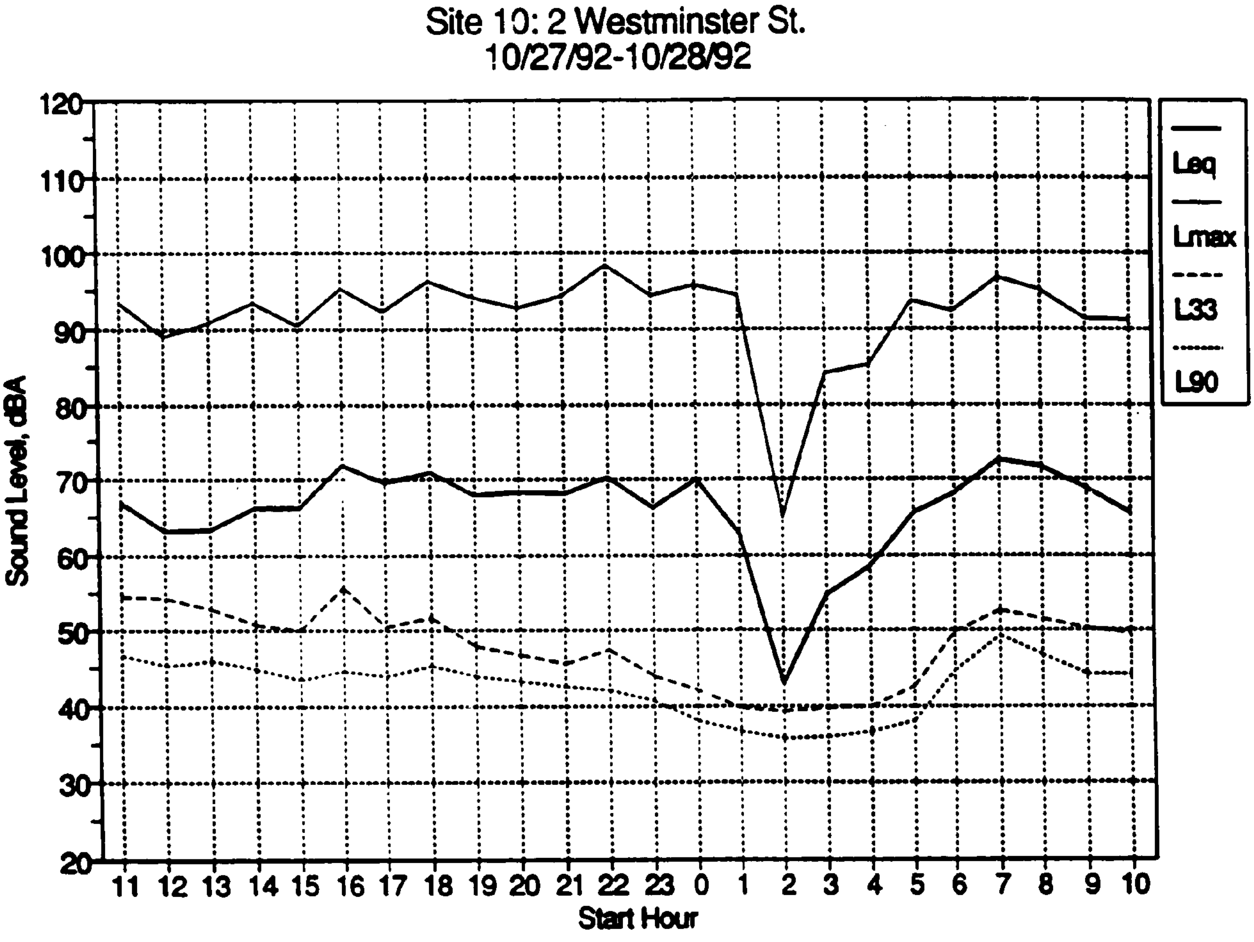

FIGURE 4-25. HOURLY SOUND LEVELS AT SITE A-10

4.4 ENVIRONMENTAL CONSEQUENCES

This section describes the analysis and assessment of potential environmental consequences of the Northeast Corridor North End Electrification Project that may result from the following:

- Noise from train operations
- Noise from traffic near railroad stations
- Noise from fixed facilities
- Noise from construction activity
- Vibration from train operations
- Vibration from construction activity

Each of the above impacts is described in detail in sections 4.4.1 through 4.4.6, respectively. The evaluation criteria, projection methods and impact assessment for each type of impact are contained in these sections, and a summary of the impacts is presented in Section 4.4.7.

4.4.1 Noise Impact from Train Operations

Although the Northeast Corridor has been actively carrying inter-city rail traffic for many years, the proposed changes in train operations may affect the noise environment along the corridor. These changes relate primarily to train schedules, lengths (consists) and speeds. Noise impact criteria, projections and assessment for the proposed changes in train operations are described below.

4.4.1.1 Train Noise Impact Criteria. The significance of noise impacts from train operations on the NEC for the "no-build" and "build" alternatives will be assessed based on the projected noise increase relative to existing conditions at noise-sensitive locations. Depending on land use, this increase will be measured in terms of either the 24-hour equivalent sound level, $L_{eq}(24)$, or the day-night sound level, L_{dn}. These descriptors correlate well with the effects of noise on people and are the environmental noise measures recommended by the U.S. Environmental Protection Agency (EPA, 1974). Both of these measures represent the total dose of noise energy at a given outdoor location over a 24-hour period in terms of the A-weighted sound level (dBA). A detailed description of these measures is provided in Section 4.3.1 of this report. Their definitions and applications are as follows:

- $L_{eq}(24)$ is a single value of sound level which includes all of the time-varying sound energy received over a 24-hour period. This descriptor will be applied for noise-sensitive land use where noise sensitivity does not depend on the time of occurrence (e.g. at schools, places of worship, recreational areas, etc.).

- L_{dn} is the A-weighted equivalent sound level for a 24-hour period, with an added 10-decibel weighting imposed on the equivalent sound levels occurring during the nighttime hours (10 P.M. to 7 A.M.). This descriptor will be applied for residences and other buildings where people normally sleep.

Significance criteria for train noise impact are based on those currently being proposed for adoption by the U.S. Federal Transit Administration (FTA, 1990). These criteria, presented in Table 4-8, are based on the increase in cumulative noise due to a project. They have been developed based on federal noise standards, and on well-documented criteria and research into human response to community noise.

As indicated in Table 4-8, the proposed criteria allow less of a noise increase in already noisy areas than in areas where the existing noise levels are lower. For example, at residential locations where the existing L_{dn} is 50 dBA, the proposed criteria would allow a noise increase of up to 10 dBA before adverse noise impact would occur. However, the allowable increase would be reduced to 5 dBA at residences where the existing L_{dn} is 60 dBA, and to 3 dBA where the existing L_{dn} is 70 dBA. At extremely noisy residential locations where the existing L_{dn} is 80 dBA, the noise increase would be limited to 1 dBA to avoid adverse impact.

As is also indicated in Table 4-8, the allowable increases in $L_{eq}(24)$ are greater than the allowable increases in L_{dn}. This is to account for the lower noise sensitivity at sites with daytime use only, where $L_{eq}(24)$ would be applied as a measure of noise impact.

The justification for the proposed criteria is that people already exposed to high levels of noise will notice and be annoyed by even a small increase in the cumulative noise in their community. In contrast, if the existing noise levels are quite low, a greater change in the community noise will be required for the equivalent degree of annoyance. Finally, because the project involves potential changes in train noise rather than the introduction of a new noise source in the communities along the corridor, it is appropriate to base the significance criteria for train noise impact on the noise increase relative to existing conditions.

4.4.1.2 Train Noise Source Measurements. To aid in the development of a train noise projection model, source measurements were carried out to document train noise levels for specific measurement distances, train consists and train speeds. In addition to each of the 11 sites described in the existing noise and vibration measurement survey (see Section 4.3.2), train noise source measurements were performed at nine other locations adjacent to the NEC tracks.

The nine supplementary source noise measurement sites were selected to represent a variety of train equipment types and track configurations. Six of these locations were distributed geographically between Boston and New Haven to document source noise levels for existing diesel-powered train equipment along the project corridor. The three remaining sites were located west of New Haven (in Connecticut and New Jersey) to document source noise levels for electric-powered equipment currently operating on the Northeast Corridor.

TABLE 4-8. PROPOSED FTA CRITERIA FOR NOISE IMPACT

EXISTING NOISE LEVEL (dBA) [L_{dn} or $L_{eq}(24)$]	LIMIT FOR NOISE LEVEL INCREASE (dBA)	
	L_{dn}	$L_{eq}(24)$
<45	15	20
45	14	19
46	13	18
47-48	12	17
49	11	16
50	10	15
51	10	14
52	9	14
53-54	8	13
55	7	12
56	7	11
57-58	6	11
59	6	10
60-61	5	10
62	5	9
63	4	9
64-66	4	8
67-69	3	7
70-73	3	6
74-77	2	5
78-79	2	4
>79	1	3

The supplementary source measurement sites have been designated by a B-prefix east of New Haven and by a C-prefix west of New Haven. The site locations and tests performed at these sites are described below.

- Site B-1 was selected on the westbound side of the corridor in the Stony Creek neighborhood of Branford, Connecticut. The measurement location was 100 feet from the westbound track near Milepost 84.60. Five diesel-locomotive hauled Amtrak trains were monitored at this site between 11:00 A.M. and 2:00 P.M. on 5 November 1992.

- Site B-2 was selected on the eastbound side of the corridor at Breen Avenue in Old Lyme, Connecticut. The measurement location was 75 feet from the eastbound track near Milepost 110.70. The tracks are on a 12 to 15-ft high embankment at this location. Five diesel-locomotive hauled Amtrak trains and one freight train were monitored at this site between 11:00 A.M. and 3:00 P.M. on 2 November 1992.

- Site B-3 was selected on the eastbound side of the corridor in the Wickford Junction area of North Kingstown, Rhode Island. The measurement location was on the eastbound side of the Route 102 bridge, near Milepost 110.80. Two diesel-locomotive hauled Amtrak trains were monitored at a position located 100 feet from the eastbound track during the afternoon of 30 October 1992. Two additional Amtrak trains were subsequently monitored at a position located 73 feet from the eastbound track on the morning of 6 November 1992.

- Site B-4 was selected on the westbound side of the corridor in Warwick, Rhode Island. The measurement location was 100 feet from the westbound track near Milepost 176.90. Four diesel-locomotive hauled Amtrak trains and one freight train were monitored at this site between 10:00 A.M. and 1:00 P.M. on 30 October 1992.

- Site B-5 was selected on the westbound side of the corridor in West Mansfield, Massachusetts. The measurement location was 100 feet from the westbound track near Milepost 201.50. Three diesel-locomotive hauled Amtrak trains, three MBTA commuter trains and two freight trains were monitored at this site on the afternoon of 29 October 1992.

- Site B-6 was selected on the eastbound side of the corridor at Glenwood Avenue in the Hyde Park neighborhood of Boston, Massachusetts. The measurement location was 75 feet from the eastbound track near Milepost 219.90. Four diesel-locomotive hauled Amtrak trains and six MBTA commuter trains were monitored at this site during the morning of 29 October 1992.

- Site C-1 was selected on the eastbound side of the corridor at Phipps Road in West Haven, Connecticut. The measurement location was 100 feet from the eastbound track near Milepost 69.30, and was partially shielded from the tracks which are on a 5-ft high embankment. Four AEM7 electric-locomotive hauled Amtrak trains were monitored at this site between 7:00 A.M. and 9:00 A.M. on 5 November 1992.

- Site C-2 was selected on the eastbound side of the corridor at Merrill Park in Iselin, New Jersey. The measurement location was 50 feet from the nearest of the four tracks at

Milepost 21.95. Eleven AEM7 electric-locomotive hauled Amtrak trains were monitored at this site on the morning of 22 October 1992, and 10 additional trains were monitored at this site during the afternoon of 3 March 1993. During the latter measurement period, two passages of the X2000 train were also monitored. The X2000, which employs "tilt-train" technology, was being tested in revenue service along the Northeast Corridor at this time.

- Site C-3 was selected on the westbound side of the corridor in Plainsboro, New Jersey. The measurement location was 50 feet from the nearest of the four tracks at Milepost 45.45. Nine AEM7 electric-locomotive hauled Amtrak trains were monitored at this site during the afternoon of 5 March 1993. Two passages of the X2000 train were also monitored during this test period.

Train noise was measured at each of the above sites using a Bruel & Kjaer (B&K) Type 2230 sound level meter, conforming to ANSI Standard S1.4 for precision (Type 1) sound level meters. The noise data were recorded on magnetic tape using digital-audio tape recorders (either Teac Model RD-130TE or Sony Model TCD-D10PRO). For each event recorded in the field, the train consist and track location were noted and the train speed was clocked using a stopwatch. During subsequent laboratory analysis, the tape-recorded data were played back into the sound level meter to determine the maximum noise level (L_{max}) and Sound Exposure Level (SEL) for each train event.

The results of the train noise measurements are provided in Table A-1 of Appendix 4.A, including operational as well as noise data. In addition to the tape recorded data at the B-sites and C-sites discussed above, this table also provides the results for trains observed at the A-sites, taken from the noise monitor data collected during the existing noise measurement survey. The data in Table A-1 were used to calibrate the train noise projection model, as described below.

4.4.1.3 Train Noise Projection Model. This section summarizes the mathematical model used to develop a general model of train noise that is based on available measurements. The same basic model can be used for all types of trains including the diesel-locomotive hauled Amtrak, commuter and freight trains, and the electric locomotive-hauled Amtrak trains. Given the L_{max} of a train passby under a specific set of reference conditions, the model allows estimating L_{max}, SEL and other noise metrics for varying distance from the track, train speeds, train consists, and schedules. The standard approach is to model rail cars as moving, incoherent, dipole, line sources (Rathe, 1977; Saurenman, 1982). This model is described by the following equations:

$$L_{max} = K + 10 \log \{\alpha + [\sin(2\alpha)]/2\} - 10 \log(y) + K_s \log (s/s_{ref}) - c_g - c_a - c_s$$

$$K = L_{max\text{-}ref} - 10 \log \{(1/y_{ref})*[\alpha_{ref} + \sin (2\alpha_{ref})/2]\}$$

$$SEL = L_{max} + 10 \log (len/v) - 10 \log [2\alpha + \sin(2\alpha)] + 3.3$$

For locomotives, which can be modelled as moving monopole point sources, the corresponding equations are as follows:

$$L_{max} = K + 10 \log(2\alpha) - 10 \log(y) + K_s \log(s/s_{ref}) - c_g - c_a - c_s$$

$$K = L_{max\text{-}ref} - 10 \log[(1/y_{ref})^*(2\alpha_{ref})]$$

$$SEL = L_{max} + 10 \log(len/v) - 10 \log(2\alpha) + 3.3$$

The parameters which apply to the equations above are:

y	=	observer distance from track centerline, feet
y_{ref}	=	reference observer distance from track centerline, feet
len	=	train length, feet
len_{ref}	=	reference train length, feet
α	=	$\tan^{-1}(len/2/y)$
α_{ref}	=	$\tan^{-1}(len_{ref}/2/y_{ref})$
s	=	train speed, feet/second
s_{ref}	=	reference train speed, feet/second
v	=	train velocity, mph
L_{max}	=	maximum sound level during train passby, dBA
$L_{max\text{-}ref}$	=	L_{max} during train passby with reference conditions, dBA
K_s	=	speed-dependence coefficient (dimensionless)
c_g	=	excess ground attenuation, dBA
c_a	=	excess air absorption, dBA
c_s	=	excess shielding attenuation, dBA

Standard reference source levels were developed for locomotives and rail cars based on the source noise measurements summarized in Table A-1. The above model was first used to predict the L_{max} and SEL for the observed trains, using available reference level data from the literature (Hanson, 1979; FTA, 1990). The reference levels were then adjusted to minimize the discrepancies between energy-average predicted and measured noise levels. The results of this procedure yielded the source reference levels given in Table 4-9 below.

TABLE 4-9. SOURCE REFERENCE LEVELS FOR TRAIN NOISE MODEL

TYPE OF TRAIN	TYPE OF VEHICLE	TRAIN NOISE SOURCE REFERENCE QUANTITIES				
		Distance y_{ref} (ft)	Length len_{ref} (ft)	Speed s_{ref} (ft/sec)	Noise $L_{max\text{-}ref}$ (dBA)	Speed Coeff. (K_s)
Amtrak (Diesel)	Locomotive	50	56	73.3	91	10
	Rail Car	50	85	73.3	81	30
Commuter (Diesel)	Locomotive	50	60	73.3	91	10
	Rail Car	50	85	73.3	84	30
Amtrak (Electric)	Locomotive	50	51	73.3	85	35
	Rail Car	50	85	73.3	81	30
X2000 (Electric)	Locomotive	50	58	73.3	82	35
	Rail Car	50	80	73.3	80	30
Freight (Diesel)	Locomotive	50	60	73.3	86	10
	Rail Car	50	70	73.3	81	30

The noise measurements indicated that the X2000 train was slightly quieter, about 2 dBA on average, than the Amtrak trains with AEM7 locomotives. However, it is important to note that the X2000 equipment had only been in revenue service for about one month, compared to many years for the Amtrak equipment. Furthermore, the X2000 power unit is rated at about 4400 horsepower, compared to 7000 horsepower for the AEM7 locomotive. Because Amtrak has specified an 8600 horsepower locomotive for future high-speed service on the Northeast Corridor, it is likely that two power units would be needed if the X2000 train is used. Based on the above noise model, the resulting train noise levels would be comparable to those produced by the current Amtrak equipment. Therefore, the reference source levels for the existing Amtrak trains with AEM7 locomotives have been selected to characterize future noise levels from Amtrak trains on the corridor for the purposes of this study.

To provide an understanding of the train noise model, Figures 4-26 and 4-27 indicate projected train noise levels at 100 feet for representative train consists operating within their appropriate speed limits. At this distance, excess sound attenuation from ground effects, atmospheric absorption and shielding can be ignored.

Figure 4-26 shows a graph of L_{max} versus train speed for typical passenger trains (with one locomotive and eight cars) and freight trains (with one locomotive and 30 cars). These results suggest that at lower speeds, locomotive noise is dominant for diesel trains and the electric trains are much quieter. The Amtrak and commuter diesel trains, which have similar locomotives and operating conditions, are projected to have similar maximum noise levels at these speeds. The projected freight train noise levels are about 5 dBA lower, most likely due to differences in equipment and operating conditions (e.g. lower acceleration and throttle settings). At high speeds, where wheel/rail noise becomes dominant, the Amtrak electric trains are projected to be as noisy as the Amtrak diesel trains, and the commuter trains are projected to be noisier.

Although the L_{max} is useful for characterizing the noise of train equipment and is easy to relate to, the SEL is more relevant to the assessment of impact since the impact criteria are based on sound energy exposure. Thus, it is instructive to examine Figure 4-27, which provides a graph of SEL versus speed.

The projections in Figure 4-27 indicate that the future Amtrak electric trains are expected to generate less sound energy than the current diesel trains for speeds below about 80 mph. However, the diesel-powered commuter trains are expected to continue to generate SELs that are up to 3 dBA greater than generated by the current Amtrak diesel trains. For typical operating conditions, freight trains are projected to generate SELs that are comparable to the diesel-powered passenger trains on the corridor.

The above discussion has concentrated on noise levels for single train passages. However, to project the overall daily noise exposure, the noise from all train operations that occur over a 24-hour period must be combined. The SEL, which is a measure of the total sound energy received from a single event such as a train passage, is used as the basis for computing the L_{dn} and $L_{eq}(24)$. These are given by the following equations:

$$L_{dn} = SEL + 10 \log (N_d + 10N_n) - 49.4$$

$$L_{eq}(24) = SEL + 10 \log (N_d + N_n) - 49.4$$

where: N_d = number of daytime trains per day

N_n = number of nighttime trains per day

The basic train noise model described above provides a means for projecting train noise at close range under standard conditions. However, it does not take into account the excess sound attenuation at greater distances due to ground effects, atmospheric absorption or shielding. Furthermore, it does not account for the additional noise generated by trains in the vicinity of grade crossings or special trackwork (e.g. switches and crossovers). The extent to which these effects have been incorporated into the train noise model is described below.

- Excess Sound Attenuation

Ground attenuation over flat ground depends on such factors as the height of the source and receiver above the ground, the type and condition of the soil, and the presence of any temperature or wind gradients. *Air absorption* of sound energy depends upon temperature and humidity, as well as on sound frequency and distance. Conservative assumptions were used to calculate the ground attenuation (c_g) and atmospheric absorption (c_a), based on simplified models in the literature (Kurzweil, 1979).

Shielding attenuation (c_s) depends primarily on geometrical factors relating the noise source, receiver and intervening terrain or structures. Information with regard to these factors was obtained from visual surveys and aerial photographs of the project corridor. Generalized assumptions for shielding attenuation were made based on typical track configurations using standard sound diffraction modelling techniques (Beranek, 1992). These assumptions are as follows:

- Deep Cut: Where the tracks are deep cut (15 to 20 feet), shielding attenuations of 11 dBA and 6 dBA were assumed for rail car and locomotive noise, respectively.

- Sloped Trench: Where the tracks are in sloped trenches (typically about 5-ft deep), a shielding attenuation of 8 dBA was assumed for rail car noise only.

- Transitions: In areas of transition between at-grade and cut sections, a shielding attenuation of 4 dBA was assumed for rail car noise.

- Embankment: Where the tracks are on embankment, a small (1 dBA) attenuation was assumed to account for the shielding of rail car noise by the edge of the embankment.

Finally, the shielding attenuation due to intervening buildings was estimated based on the method outlined in the FHWA Traffic Noise Prediction Model (FHWA, 1978).

- Grade Crossings

Noise exposure near at-grade crossings is typically dominated by horns that are sounded by trains as they approach the crossing. Therefore, the noise from grade-crossing signal bells was neglected for the purpose of the noise projections. Based on the measurements for this study, a reference source noise level of 108 dBA at 50 feet was determined for locomotive horns. Furthermore, the observations made during the measurements suggested that the train horn noise occurred along a track segment about 1/4-mile long prior to the crossing. These conditions are consistent with the assumptions made during the noise study for the Northeast Corridor Programmatic EIS (FRA, 1978).

Based on the above assumptions, the train horn SEL was calculated for representative locations, taken to be along a line perpendicular to the tracks, 100 feet prior to each grade crossing. The SEL was calculated by modelling the horns as moving, monopole point sources as follows:

$$SEL = L_{max\text{-}ref} + 10\log\{[(y_{ref})^2*(\alpha_1-\alpha_1)]/(s*y)\} - c_g - c_a - c_s$$

where:		
	$L_{max\text{-}ref}$	= 108 dBA at y_{ref}
	y_{ref}	= 50 feet
	α_1	= $\tan^{-1}(-1220/y)$
	α_2	= $\tan^{-1}(100/y)$

- Special Trackwork

Special trackwork, associated with switches and crossovers, generates additional noise due to wheel impacts when trains pass over discontinuities in these track sections. Although the noise increase near special trackwork can be significant, on the order of 5 to 10 dBA at 50 feet, the noise effect becomes less pronounced at greater distances. This is because the impacts are point sources, with a sound attenuation rate twice that of the train's wheel/rail interaction, which acts as a line source.

As suggested by the above discussion, the noise effects of special trackwork are highly localized. Because special trackwork will only affect noise levels in localized areas, and because the project will not alter their locations, a detailed analysis of special trackwork would not significantly change the overall results of the train noise assessment. Therefore, a detailed assessment of the noise effects at each special trackwork location is not required for a reasonable assessment of overall noise impact.

4.4.1.4 Train Noise Projections. Projections of train noise, in terms of L_{max}, L_{dn} and $L_{eq}(24)$, were carried out for the existing conditions and for the future no-build and build alternatives. These projections were based on existing and projected train schedules, consists and speeds along the project corridor, using the above prediction model. A general summary of the basic operating assumptions is provided below for Amtrak, commuter and freight trains. Although the MBTA operates Orange Line rapid transit trains along a small segment of the corridor, these trains were not included in the analysis since it is assumed that the level of train service will not change, and since the noise from these trains would not add significantly to the total projected noise exposures.

- Amtrak Service

A summary of existing and projected future Amtrak schedules and train consists is provided in Table 4-10. Included are the number of daily train operations during the daytime (7 A.M. to 10 P.M.) and nighttime (10 P.M. to 7 A.M.), as well as the average number of locomotives and cars in each case. In terms of equipment, F40PH diesel locomotives are assumed for the existing and future no-build cases and AEM7 locomotives are assumed for the future build case for the noise projections.

The existing train frequencies are based on the current Amtrak schedule (Winter 1992-1993). The future no-build schedule is assumed to be similar to the existing schedule, with a slight

TABLE 4-10. AMTRAK TRAIN SCHEDULES AND CONSISTS

CORRIDOR TRACK SEGMENT	TYPE OF TRAIN SERVICE	EXISTING CONDITIONS				NO-BUILD ALTERNATIVE				BUILD ALTERNATIVE			
		# Trains		Consist		# Trains		Consist		# Trains		Consist	
		Day	Night	#Loc	#Cars	Day	Night	#Loc	#Cars	Day	Night	#Loc	#Cars
New Haven-New London	Express	4	0	1	6	6	2	1	6	30	2	1	8
	Conv	15	3	1	6	15	3	1	6	16	4	2	18
New London-Back Bay	Express	3	1	1	6	6	2	1	6	29	3	1	8
	Conv	14	2	1	6	14	2	1	6	14	4	2	18
Back Bay-South Sta	Express	3	1	1	6	6	2	1	6	27	5	1	8
	Conv	18	5	1	6	18	5	1	6	17	7	2	18

increase in train frequency as projected by Amtrak. The future build schedules are based on the Amtrak Power Systems Specifications and train graph (Amtrak, 1991). This data indicates an approximate doubling in the number of daily trains and their consists relative to existing conditions.

Existing and future no-build train speeds were estimated from the speed limits and restrictions in the current Amtrak Employee Timetable. Future build train speeds were taken from Amtrak train performance calculations (Amtrak, 1992). Express train speeds were based on a consist of two X2000 power units and five cars with a maximum speed of 150 mph. Speeds for conventional trains were based on a consist of one AEM7 locomotive and eight cars, with a maximum speed of 120 mph.

- Commuter Rail Service

A summary of existing and projected future commuter rail schedules and train consists is provided in Table 4-11. Included are data for MBTA operations between Boston and Providence, for Shore Line East trains currently operated by Connecticut D.O.T. between New Haven and Old Saybrook with a proposed extension to New London, and for proposed Rhode Island D.O.T. trains between Providence and Kingston, RI. Diesel locomotives are conservatively assumed for all cases, since future electric commuter rail service is uncertain.

The existing train frequencies are based on the current commuter rail schedules (Winter 1992-1993) for the MBTA and Shore Line East. The future no-build and build schedules are based on information provided by MBTA, Connecticut D.O.T. and Rhode Island D.O.T. In the case of the MBTA, the future schedules reflect an anticipated increase of 37 percent in daytime train operations relative to the existing schedule, with roughly the same consists. For the Shore Line East, the future schedules indicate four added nighttime trains between New Haven and Old Saybrook plus new service consisting of 10 daily trains toNew London, all with similar consists.

TABLE 4-11. COMMUTER RAIL SCHEDULES AND CONSISTS

RAIL CARRIER	CORRIDOR TRACK SEGMENT	EXISTING CONDITIONS					FUTURE ALTERNATIVES				
		# Trains		Train Consist			# Trains		Train Consist		
					Avg # Cars					Avg # Cars	
		Day	Night	#Loc	Day	Night	Day	Night	#Loc	Day	Night
MBTA	South Sta.-Back Bay Sta.	132	32	1	7.1	6.4	181	32	1	7.1	6.4
	Back Bay Sta.-Forest Hills	106	25	1	7.1	6.6	138	25	1	7.1	6.6
	Forest Hills-Readville	76	21	1	7.4	6.7	112	21	1	7.4	6.7
	Readville-Canton Jct.	55	12	1	7.3	7.0	6[illegible]	12	1	7.3	7.0
	Canton Jct-Attleboro	24	7	1	7.1	8.6	26	7	2	7.1	8.6
	Attleboro-S. Attleboro	20	7	1	7.3	8.6	22	7	2	7.3	8.6
	S. Attleboro-Providence	8	2	1	7.9	9.0	20	4	2	7.9	9.0
RI DOT	Providence-Kingston	0	0	--	--	--	20	4	1	3.5	3.5
Shore Line East	New London-Old Saybrook	0	0	--	--	--	7	3	1	3.5	3.5
	Old Saybrook-New Haven	21	7	1	3.5	3.5	21	11	1	3.5	3.5

In addition, Rhode Island D.O.T. plans 24 daily trains, extending the MBTA service from Providence to Kingston.

For MBTA service, train speeds were estimated from train performance calculations, with maximum speeds of 80 mph for existing and future no-build operations and 100 mph for future build operations. The calculations used were for a train with one F40PH diesel locomotive and six fully-loaded cars, making all stops between Boston and Providence (T. K. Dyer, 1992). Speeds for future Rhode Island D.O.T. trains were estimated based on the MBTA speed characteristics, and on the commuter train speed limits shown in the 1991 Amtrak track chart. For the Shore Line East, existing and future train speeds were estimated to average 55 mph, based on observations during the measurement survey, except where restricted to lower speed according to the Amtrak track chart.

- Freight Operations

A summary of existing and projected future freight train schedules is provided in Table 4-12. Included are data for Conrail trains, operating along segments of the corridor between Boston and Attleboro, and for Providence and Worcester (P&W) trains, operating along segments of the corridor between Providence and New Haven. The range of train consists includes 1-3 locomotives plus 30-100 cars for Conrail and 1-2 locomotives plus 6-53 cars for P&W. In all cases, diesel locomotives and a speed of 30 mph are assumed.

Projections of total noise along the project corridor were made by combining the train noise, predicted using the above model and assumptions, and the "background" noise. As used here,

TABLE 4-12. FREIGHT TRAIN SCHEDULES AND CONSISTS

FREIGHT CARRIER	CORRIDOR TRACK SEGMENT IN SERVICE	RANGE OF DAILY TRAIN FREQUENCY ALONG LINE					
		EXISTING		NO-BUILD ALT.		BUILD ALT.	
		Day	Night	Day	Night	Day	Night
Conrail	Boston - Attleboro	0-6	0-2	0-6	0-2	0	2-6
P & W	Providence - New Haven	0-4	0	0-4	2-4	0-4	2-4

background noise refers to the L_{dn} or $L_{eq}(24)$ that would exist without the trains. The background levels along the corridor were estimated by generalizing the results at the existing noise measurement sites (see Section 4.3.2). Based on the range of levels indicated by the measurements, the background L_{dn} were estimated to be either 55 dBA, 60 dBA or

65 dBA, depending on location. As suggested by the measurement data, the background $L_{eq}(24)$ were estimated to be 5 dBA less than the background L_{dn}.

Table 4-13 indicates the generalized background noise levels that were applied for the areas where existing noise measurement sites were located. This table also provides a comparison of the noise levels measured at each site and the noise levels predicted using the train noise model and assumptions described above. The results indicate that on average, the model under-predicted the measured L_{dn} by 3 dBA and under-predicted the measured $L_{eq}(24)$ by 1 dBA. The fact that the model tended to under-predict the measured data suggests that noise sources other than trains may have influenced the 24-hour results. Furthermore, the fact that the agreement between predicted and measured values was better for $L_{eq}(24)$ than for L_{dn} suggests that there was more nighttime activity than assumed.

Given the variables involved, the model predictions agree reasonably well with the measured noise levels. For example, the predicted and measured $L_{eq}(24)$ agree within 2 dBA for all locations except at Site A-4, where variable train horn noise is a factor, and at Site A-6 which was located near a rail joint with a wide gap. Furthermore, because the predictions are based on a standard set of operating characteristics, variations in schedules and speeds during the measurements may have affected the agreement between projected and measured noise levels. In view of these variables, the most reliable data are for trains that were actually observed during the measurements. It is these data, along with the supplementary source noise data at other sites, that were used to calibrate the noise model.

Based on the above discussion, the train noise model is considered to be valid for the purpose of noise prediction and impact assessment. It is important to note that although the impact criteria depend on the existing noise level to some degree, the noise level increase is more significant in determining impact. Thus, a comparison of projected future noise levels with

TABLE 4-13. COMPARISON OF PREDICTED AND MEASURED NOISE LEVELS

SITE NO.	SITE LOCATION	DIST. TO CORRIDOR C.L. (ft)	EXISTING Ldn (dBA)				EXISTING 24-HOUR Leq (dBA)			
			Est. Bkgd	Meas. Exist	Pred. Exist	Pred-Meas	Est. Bkgd	Meas. Exist	Pred. Exist	Pred-Meas
A-1	New Haven, CT	94	60	69	67	-2	55	64	62	-2
A-2	Westbrook, CT	111	60	68	67	-1	55	63	62	-1
A-3	Waterford, CT	86	60	68	65	-3	55	62	60	-2
A-4	Pawcatuck, CT	79	65	77	72	-5	60	73	68	-5
A-5	Charlestown, RI	59	55	68	64	-4	50	61	61	0
A-6	Warwick, RI	69	60	72	65	-7	55	65	61	-4
A-7	Central Falls, RI	32	65	74	70	-4	60	68	66	-2
A-8	W. Mansfield, MA	50	55	72	72	0	50	66	67	+1
A-9	Canton, MA	68	60	73	69	-4	55	67	65	-2
A-10	Hyde Park, MA	78	60	74	72	-2	55	68	67	-1

projected existing noise levels provides a consistent method to evaluate the effects of rail system changes on the community noise levels along the project corridor.

4.4.1.5 Train Noise Impact Assessment. Tables 4-14 and 4-15 provide an overview of train noise impact along the project corridor, based on the results at the representative measurement sites. Table 4-14 compares the maximum train noise levels projected for the build alternative with those projected for the existing and no-build conditions. This table also includes the measured maximum existing train noise levels, demonstrating that the projections are within the range of the measured levels at all sites. Although the results in Table 4-14 are useful in indicating how much louder the noisiest future trains will be than the existing trains, they do not account for the train schedules, consists and frequencies, and thus do not provide a complete picture of noise impact.

To assess impact better, Table 4-15 provides the projected L_{dn} at each of the measurement sites for the existing, no-build and build alternatives. This table also indicates the predicted noise increases for the no-build and build alternatives, along with the site-specific impact criteria and assessment. Furthermore, Figures 4-28 through 4-38 indicate the predicted L_{dn} as a function of distance for the existing, no-build and build alternatives in the vicinity of each measurement site. It should be noted that these graphs assume no shielding from terrain features or buildings along the rail corridor. A discussion of the results at each site is provided below.

Site A-1: New Haven, CT. For the no-build alternative, the L_{dn} at this site is expected to increase by 2 dBA from an existing level of 67 dBA to a future level of 69 dBA, due to small increases in Amtrak, commuter rail and freight traffic. For the build alternative, the L_{max} for

TABLE 4-14. MAXIMUM TRAIN NOISE LEVELS AT MEASUREMENT SITES

SITE NO.	SITE LOCATION	DIST. TO CORRIDOR C.L. (ft)	EXISTING AND NO-BUILD CONDITIONS				FUTURE PROJECT BUILD ALTERNATIVE			
			Loudest Source	Max Speed (mph)	Lmax (dBA)		Loudest Source	Max Speed (mph)	Lmax (dBA)	
					Meas	Proj			Proj	Incr
A-1	New Haven, CT	94	Amtk/Diesel	70	79-103	87	Amtk/Elect	75	88	1
A-2	Westbrook, CT	111	Amtk/Diesel	80	75-94	86	Amtk/Elect	100	90	4
A-3	Waterford, CT	86	Amtk/Diesel	60	79-97	87	Amtk/Elect	80	90	3
A-3a	West Mystic, CT	42	Train Horn	60	90-114	110	Train Horn	85	110	0
A-4	Pawcatuck, CT	79	Train Horn	80	83-112	104	Train Horn	100	104	0
A-5	Charlestown, RI	59	Amtk/Diesel	75	78-103	91	Amtk/Elect	100	95	4
A-6	Warwick, RI	69	Amtk/Diesel	85	76-107	91	Amtk/Elect	125	96	5
A-7	Central Falls, RI	32	Amtk/Diesel	80	81-100	96	Cmtr/Diesel	65	96	0
A-8	W. Mansfield, MA	50	Amtk/Diesel	100	72-100	94	Amtk/Elect	150	102	8
A-9	Canton, MA	68	Amtk/Diesel	80	78-99	90	Amtk/Elect	128	97	7
A-10	Hyde Park, MA	78	Amtk/Diesel	100	74-98	90	Amtk/Elect	135	96	6

TABLE 4-15. TRAIN NOISE IMPACT ASSESSMENT AT MEASUREMENT SITES

SITE NO.	SITE LOCATION	DIST. TO CORRIDOR CENTER LINE (feet)	DAY-NIGHT EQUIVALENT SOUND LEVEL (dBA)						ADVERSE NOISE IMPACT	
			Total Predicted Noise			Total Noise Increase				
			Exist	No-Bld	Build	Crit.	No-Bld	Build	No-Bld	Build
A-1	New Haven, CT	94	67	69	70	3	2	3	No	No
A-2	Westbrook, CT	111	67	68	71	3	1	4	No	Yes
A-3	Waterford, CT	86	65	67	70	4	2	5	No	Yes
A-3a	West Mystic, CT	42	75	76	79	2	1	4	No	Yes
A-4	Pawcatuck, CT	79	72	74	76	3	2	4	No	Yes
A-5	Charlestown, RI	59	64	66	72	4	2	8	No	Yes
A-6	Warwick, RI	69	65	68	73	4	3	8	No	Yes
A-7	Central Falls, RI	32	70	72	74	3	2	4	No	Yes
A-8	W. Mansfield, MA	50	72	73	77	3	1	5	No	Yes
A-9	Canton, MA	68	69	69	74	3	0	5	No	Yes
A-10	Hyde Park, MA	78	72	72	76	3	0	4	No	Yes

the noisiest trains is expected to increase by 1 dBA from 87 to 88 dBA, and the L_{dn} is expected to increase by 3 dBA to a future level of 70 dBA. These projected noise increases are due to a slight increase in Amtrak train speed (from 70 to 75 mph) and a more significant increase in Amtrak service. Since the increases in L_{dn} do not exceed the 3 dBA criterion at this site, adverse noise impact is not projected for either of the future alternatives.

Site A-2: Westbrook, CT. For the no-build alternative, the L_{dn} at this site is expected to increase by 1 dBA from an existing level of 67 dBA to a future level of 68 dBA, due to small increases in Amtrak, commuter rail and freight traffic. For the build alternative, the L_{max} for the noisiest trains is expected to increase by 4 dBA from 86 to 90 dBA, and the L_{dn} is expected to increase by 4 dBA to a future level of 71 dBA. These projected noise increases are due to the proposed increases in Amtrak train frequency and speed (from 80 to 100 mph). Based on the 3 dBA criterion for L_{dn} increase at this site, adverse noise impact is projected for the build alternative only.

Site A-3: Waterford, CT. For the no-build alternative, the L_{dn} at this site is expected to increase by 2 dBA from an existing level of 65 dBA to a future level of 67 dBA, due to small increases in Amtrak and freight traffic, plus the addition of commuter rail service. For the build alternative, the L_{max} for the noisiest trains is expected to increase by 3 dBA from 87 to 90 dBA, and the L_{dn} is expected to increase by 5 dBA to a future level of 70 dBA. These projected noise increases are due to the proposed increases in Amtrak train frequency and speed (from 60 to 80 mph). Based on the 4 dBA criterion for L_{dn} increase at this site, adverse noise impact is projected for the build alternative only.

Site A-3a: West Mystic, CT. At this site, the highest noise levels are caused by train horns, with a projected L_{max} of 110 dBA in all cases. For the no-build alternative, the L_{dn} is expected to increase by 1 dBA from an existing level of 75 dBA to a future level of 76 dBA, due to small increases in Amtrak and freight traffic. For the build alternative, the L_{dn} is expected to increase by 4 dBA to a future level of 79 dBA, due to a more significant increase in Amtrak service and an increase in Amtrak train speed (from 60 to 85 mph). Based on the 2 dBA criterion for L_{dn} increase at this site, adverse noise impact is projected for the build alternative only.

Site A-4: Pawcatuck, CT. At this site, the highest noise levels are caused by train horns, with a projected L_{max} of 104 dBA in all cases. For the no-build alternative, the L_{dn} is expected to increase by 2 dBA from an existing level of 72 dBA to a future level of 74 dBA, due to small increases in Amtrak and freight traffic. For the build alternative, the L_{dn} is expected to increase by 4 dBA to a future level of 76 dBA, due to a more significant increase in Amtrak service and an increase in Amtrak train speed (from 80 to 100 mph). Based on the 3 dBA criterion for L_{dn} increase at this site, adverse noise impact is projected for the build alternative only.

Site A-5: Charlestown, RI. For the no-build alternative, the L_{dn} at this site is expected to increase by 2 dBA from an existing level of 64 dBA to a future level of 66 dBA, due to small increases in Amtrak and freight traffic. For the build alternative, the L_{max} for the noisiest trains is expected to increase by 4 dBA from 91 to 95 dBA, and the L_{dn} is expected to increase by 8 dBA to a future level of 72 dBA. These projected noise increases are due to the proposed increases in Amtrak train frequency and speed (from 75 to 100 mph). Based on the 4 dBA criterion for L_{dn} increase at this site, adverse noise impact is projected for the build alternative only.

Site A-6: Warwick, RI. For the no-build alternative, the L_{dn} at this site is expected to increase by 3 dBA from an existing level of 65 dBA to a future level of 68 dBA, due to small increases in Amtrak and freight traffic plus the addition of new commuter rail service. For the build alternative, the L_{max} for the noisiest trains is expected to increase by 5 dBA from 91 to 96 dBA, and the L_{dn} is expected to increase by 8 dBA to a future level of 73 dBA. These projected noise increases are due to the proposed increases in Amtrak train frequency and speed (from 85 to 125 mph). Based on the 4 dBA criterion for L_{dn} increase at this site, adverse noise impact is projected for the build alternative only.

Site A-7: Central Falls, RI. For the no-build alternative, the L_{dn} at this site is expected to increase by 2 dBA from an existing level of 70 dBA to a future level of 72 dBA, due to small increases in Amtrak and commuter rail traffic. For the build alternative, the L_{max} for the noisiest trains is expected to be about the same as for the existing and no-build scenarios, and the L_{dn} is expected to increase by 4 dBA to a future level of 74 dBA. This projected noise increase is due to proposed increase in Amtrak train frequency. Based on the 3 dBA criterion for L_{dn} increase at this site, adverse noise impact is projected for the build alternative only.

Site A-8: West Mansfield, MA. For the no-build alternative, the L_{dn} at this site is expected to increase by 1 dBA from an existing level of 72 dBA to a future level of 73 dBA, due to small increases in Amtrak and commuter rail service. For the build alternative, the L_{max} for the noisiest trains is expected to increase by 8 dBA from 94 to 102 dBA, and the L_{dn} is expected to increase by 5 dBA to a future level of 77 dBA. These projected noise increases are due to the proposed increases in Amtrak train frequency and speed (from 100 to 150 mph), and to the proposed shift in freight operations from daytime to nighttime. Based on the 3 dBA criterion for L_{dn} increase at this site, adverse noise impact is projected for the build alternative only.

Site A-9: Canton, MA. For the no-build alternative, the L_{dn} at this site is expected to increase by less than 1 dBA from an existing level of 69 dBA, with only small increases in Amtrak and commuter rail service. For the build alternative, the L_{max} for the noisiest trains is expected to increase by 7 dBA from 90 to 97 dBA, and the L_{dn} is expected to increase by 5 dBA to a future level of 74 dBA. These projected noise increases are due to the proposed increases in Amtrak train frequency and speed (from 80 to 128 mph), and to the proposed shift in freight operations from daytime to nighttime. Based on the 3 dBA criterion for L_{dn} increase at this site, adverse noise impact is projected for the build alternative only.

Site A-10: Hyde Park, MA. For the no-build alternative, the L_{dn} at this site is expected to increase by less than 1 dBA from an existing level of 72 dBA, despite some increases in Amtrak and commuter rail service. For the build alternative, the L_{max} for the noisiest trains is expected to increase by 6 dBA from 90 to 96 dBA, and the L_{dn} is expected to increase by 4 dBA to a future level of 76 dBA. These projected noise increases are due to the proposed increases in Amtrak train frequency and speed (from 100 to 135 mph). Based on the 3 dBA criterion for L_{dn} increase at this site, adverse noise impact is projected for the build alternative only.

In summary, the results for the representative measurement sites indicate projected L_{dn} increases of 0 to 3 dBA for the no-build alternative, with no increases in the L_{max} for the noisiest trains, indicating no adverse impact at any of the sites. However, noise increases for the build alternative are projected to range from 0 to 8 dBA in terms of L_{max} for the noisiest trains, and 3 to 8 dBA in terms of L_{dn}, indicating adverse impact at all but one site. The primary causes of noise impact for the build alternative are the proposed increases in

Amtrak train frequency and speed. A secondary cause of noise impact is Conrail's proposed day-to-night shift in freight operations which affects two of the sites.

A corridor wide inventory of train noise impact is provided in Table 4-16. This table indicates the estimated number of noise-sensitive sites located within the noise impact zone for the no-build and build alternatives. The noise impact zone was determined by comparing the noise projections with the project criteria along individual segments of the corridor, and by estimating the distances within which impact would occur. These train noise impact distances are given by corridor milepost segment in Table A-2 of Appendix 4.A. The numbers of noise-sensitive sites located within the impact zone were then counted with the aid of land-use maps and aerial photographs of the project corridor.

The results in Table 4-16 indicate minimal noise impact for the no-build alternative, with 67 residences located within the zone of adverse impact. All of these homes are in Rhode Island, and most are located in Warwick. This impact is due to the proposed introduction of new commuter rail service by Rhode Island D.O.T., which is expected to occur regardless of whether the corridor is electrified.

For the build alternative, Table 4-16 indicates a total of 787 residences, 2 churches and 2 recreational areas within the zone of adverse noise impact. Of the 787 residences, 155 are in Connecticut (with nearly half in Stonington), 385 are in Rhode Island (with more than half in Warwick) and 247 are in Massachusetts (with about half in Boston). The primary causes of this impact are the increased Amtrak train frequency and speed along the corridor.

4.4.2 Traffic Noise Impact Near Railroad Stations

The improvements in train service with the Northeast Corridor North End Electrification Project have the potential to affect the noise environment in the vicinity of railroad stations along the corridor due to project-induced passenger traffic. Noise impact criteria, projections and assessment for the proposed changes in motor vehicle traffic near railroad stations are described below.

TABLE 4-16. CORRIDOR-WIDE TRAIN NOISE IMPACT INVENTORY

MUNICIPALITY	MILEPOST From	MILEPOST To	CORRIDOR LENGTH (mi)	NO-BUILD ALTERNATIVE # Resid.	NO-BUILD ALTERNATIVE # Other*	BUILD ALTERNATIVE # Resid.	BUILD ALTERNATIVE # Other*
New Haven	72.0	77.0	5.0	0	0	0	0
East Haven	77.0	79.0	2.0	0	0	0	0
Branford	79.0	86.0	7.0	0	0	6	0
Guilford	86.0	90.5	4.5	0	0	4	0
Madison	90.5	94.9	4.4	0	0	6	0
Clinton	94.9	98.9	4.0	0	0	11	0
Westbrook	98.9	102.5	3.6	0	0	2	0
Old Saybrook	102.5	106.6	4.1	0	0	2	0
Old Lyme	106.6	112.3	5.7	0	0	18	0
East Lyme	112.3	116.7	4.4	0	0	24	0
Waterford	116.7	121.1	4.4	0	0	2	0
New London	121.1	123.9	2.8	0	0	3	1R[1]
Groton	123.9	132.5	8.6	0	0	6	1R[2]
Stonington	132.5	141.0	8.5	0	0	71	1C[3]
TOTAL CT	72.0	141.0	69.0	0	0	155	1C+2R
Westerly	141.0	146.1	5.1	0	0	23	0
Hopkinton	146.1	147.2	1.1	0	0	0	0
Charlestown	147.2	153.6	6.4	0	0	6	0
Richmond	150.3	155.8	5.5	0	0	7	0
South Kingstown	155.8	160.7	4.9	17	0	27	0
Exeter	160.7	161.9	1.2	0	0	1	0
North Kingstown	161.9	170.8	8.9	7	0	68	0
East Greenwich	170.8	172.1	1.3	3	0	31	0
Warwick	172.1	178.8	6.7	40	0	203	0
Cranston	178.8	181.0	2.2	0	0	0	0
Providence	181.0	187.5	6.5	0	0	5	0
Pawtucket	187.5	189.8	2.3	0	0	12	0
Central Falls	189.8	190.9	1.1	0	0	2	0
TOTAL RI	141.0	190.9	49.9	67	0	385	0
Attleboro	190.9	199.7	8.8	0	0	58	1C[4]
Mansfield	199.7	204.9	5.2	0	0	32	0
Foxborough	204.9	207.6	2.7	0	0	6	0
Sharon	207.6	212.7	5.1	0	0	1	0
Canton	212.7	216.2	3.5	0	0	9	0
Westwood	216.2	217.2	1.0	0	0	0	0
Dedham	217.2	218.9	1.7	0	0	14	0
Boston	218.9	228.8	9.9	0	0	127	0
TOTAL MA	190.9	228.8	37.9	0	0	247	1C
TOTAL CORRIDOR	72.0	228.8	156.8	67	0	787	2C+2R

* "C denotes Church and "R" denotes a recreational area.
(1) Caulkins Park
(2) Bluff Point State Park
(3) Family Christian Center
(4) Second Congregational Church

4.4.2.1 Traffic Noise Impact Criteria. The significance of noise impacts from project-generated traffic near railroad stations along the Northeast Corridor for the no-build and project build alternatives will be assessed based on the projected noise increase relative to the noise from existing traffic near the stations. Because the greatest changes in traffic volumes are expected to occur during peak commuting periods, the noise increase will be evaluated in terms of the peak-hour L_{eq}.

Significance criteria for traffic noise impact are based on existing FTA guidelines (UMTA, 1979). According these guidelines, a noise level increase of greater than 5 dBA is considered to represent an adverse impact. The existing FTA criteria are used here rather than the proposed FTA criteria due to the general, non-site specific nature of the traffic noise impact assessment. This assessment predicts only the change in traffic noise resulting from the projected change in traffic volumes near the stations, and not the absolute traffic noise levels at specific noise-sensitive locations in the community.

4.4.2.2 Traffic Noise Impact Assessment. The potential for noise impact due to project-generated traffic has been evaluated for streets near the express train stations where traffic changes are expected to be greatest. These stations include Boston South Station, Route 128 Station and Providence Station. The future increases in peak-hour vehicle trips at these stations are projected to be 132, 497 and 228, respectively, compared to only 64 at Back Bay Station and 38 at New Haven Station. Although the land use near the stations is primarily commercial, there are residential neighborhoods as well as institutional buildings along the nearby streets in some cases.

The traffic noise impact assessment has been carried out on a relative basis, by estimating the change in peak-hour traffic noise along the nearest streets. The change in traffic noise level along each affected street was estimated based on the change in peak-hour traffic volume for the future No-Build and Build project alternatives, relative to the existing traffic volume. With all other conditions equal, the change in peak-hour traffic noise level can be calculated as follows:

$$\text{Change in Traffic Noise (in dBA)} = 10 \log_{10} (V_F/V_E)$$

where: V_F = Future (No-build or Build) traffic volume (vehicles per hour)

V_E = Existing traffic volume (vehicles per hour)

A summary of the existing and projected future peak-hour traffic volumes on surface streets near each of the three selected train stations is provided in Table 4-17. This table also indicates the predicted change in traffic noise level for each of these streets, based on the expected change in traffic volume. The results indicate that future traffic noise levels in the vicinity of the train stations are expected to range from 3 dBA below to 6 dBA above the existing traffic noise levels.

TABLE 4-17. CHANGES IN TRAFFIC NOISE NEAR TRAIN STATIONS

TRAIN STATION	ROADWAY NAME	ROADWAY LOCATION	PEAK HOUR	TRAFFIC VOLUME (VEHICLES PER HOUR)			NOISE LEVEL CHANGE (dBA)	
				Exist	No-Bld	Build	No-Bld	Build
Boston South Station	Summer Street	W/of Atlantic	AM	1720	910	948	-3	-3
			PM	2186	1200	1244	-3	-2
		E/of Atlantic	AM	2049	1260	1340	-2	-2
			PM	2290	1350	1434	-2	-2
	Atlantic Avenue	N/of Summer	AM	1124	1270	1274	+1	+1
			PM	19[illegible]1	950	978	-3	-3
		S/of Summer	AM	1615	1300	1338	-1	-1
			PM	1635	1100	1112	-2	-2
Route 128 Station	Blue Hill Drive	W/of 128 Ramp	AM	185	271	293	+2	+2
			PM	134	246	267	+3	+3
		E/of 128 Ramp	AM	740	1082	1188	+2	+2
			PM	983	1809	1968	+3	+3
		W/of Univ. Av	AM	785	1200	1308	+2	+2
			PM	1120	1971	2139	+2	+3
	University Avenue	N/of Blue Hill	AM	1054	1616	1775	+2	+2
			PM	871	1394	1551	+2	+3
		S/of Blue Hill	AM	1215	1860	1910	+2	+2
			PM	1267	2231	2281	+2	+3
Providence Station	Gaspee St	W/of Francis	AM	1246	2256	2303	+3	+3
			PM	1223	2067	2115	+2	+2
		E/of Francis	AM	974	1763	1824	+3	+3
			PM	945	1597	1650	+2	+2
		N/of Smith	AM	203	669	669	+5	+5
			PM	271	984	984	+6	+6
		S/of Smith	AM	342	732	793	+3	+4
			PM	685	851	903	+1	+1
	Francis St	S/of Gaspee	AM	412	745	827	+3	+3
			PM	432	730	821	+2	+3
	Smith St	W/of Gaspee	AM	767	1893	1906	+4	+4
			PM	1219	1773	1777	+2	+2
		E/of Gaspee	AM	1068	2234	2282	+3	+3
			PM	1295	2242	2290	+2	+2

There was only one roadway (Gaspee Street, north of Smith Street near Providence Station) where the traffic noise increase was projected to exceed the 5 dBA criterion for adverse impact. However, because the existing traffic on this roadway is small, it is likely that other sources dominate the existing noise during peak hours and that the total increase in noise will be lower. Furthermore, because traffic noise levels are projected to be no more than 1 dBA greater for the Build Alternative than for the No-build Alternative, traffic noise impact due to the project in the vicinity of the train stations is not expected to be significant.

Finally, it should be noted that the above assessment is based on conservative assumptions, and thus it is likely that the actual noise changes near the train stations will be less than indicated. For example, the projections assume that peak-hour noise levels at locations along the streets near the stations are dominated by the traffic on those streets. Furthermore, the projections assume the same vehicle mix for all cases.

In reality, the peak-hour noise levels may be affected by other community sources such as aircraft overflights and traffic on major highways (e.g. I-95). In addition, the existing traffic volumes are based on traffic counts which may include loud trucks, whereas the future build traffic changes consider only passenger vehicles, which tend to be quieter than trucks. Due to these factors, it is likely that future noise level changes will be less than predicted above.

4.4.3 Noise Impact From Fixed Facilities

The fixed facilities to be constructed as part of the Northeast Corridor North End Electrification Project include traction power substations, paralleling stations and switching stations. Such facilities contain noise-producing electrical and mechanical equipment that could affect nearby noise-sensitive land use areas. Noise impact criteria, projections and assessment related to fixed facilities of the project are described below.

4.4.3.1 Noise Impact Criteria for Fixed Facilities. The significance of noise impacts from fixed facilities will be assessed based on the projected A-weighted sound level and tonal characteristics of such sources at the property line of nearby noise-sensitive locations, as well as on the type of land use and existing background noise. Significance criteria for fixed facility noise impact are based on a review of state and local regulations applicable to such facilities (see Section 4.2 above). Based on the most stringent provisions of these regulations, these criteria are as follows:

- For noise-sensitive land use in general, adverse impact will be assessed when the projected facility noise level is 5 dBA or more above the minimum background noise level during the hours when the land use is normally occupied, provided that the projected level also exceeds the land use thresholds given below. For the purpose of these criteria, the background noise level is defined as the hourly L_{90}, or the A-weighted sound level exceeded during 90 percent of a given hour.

- For noise-sensitive land use with solely daytime (7 A.M. to 10 P.M.) occupancy (e.g. schools and places of worship), adverse impact will not be assessed unless the projected facility noise exceeds a threshold of 55 dBA.

- For noise-sensitive land use with nighttime (10 P.M. to 7 A.M.) occupancy (e.g. residences, hospitals and hotels), adverse impact will not be assessed unless the facility noise exceeds a threshold of 50 dBA.

- For fixed facility noise sources with audible discrete tones (e.g. transformers), adverse impact will be assessed at facility noise levels that are 5 decibels lower than indicated above. Thus, adverse impact will be assessed when the projected facility noise level equals or exceeds the background noise, provided the facility noise level also exceeds 50 dBA for daytime-only land use and 45 dBA for land use with nighttime occupancy.

4.4.3.2 Noise Projections for Fixed Facilities. The major equipment noise sources at the project facilities are expected to include outdoor, oil-cooled transformers and HVAC units for station control buildings. Baseline noise levels, at a reference distance of 500 feet, have been calculated for these sources based on their anticipated operating characteristics, using standard prediction methods as described below.

Transformers. The space-averaged, A-weighted sound level (L_p) produced by the core of an average transformer (without built-in noise abatement) at an unobstructed distance of 500 feet can be estimated using the following empirical relation (Beranek, 1992):

$$L_p(500\text{ ft}) = 26 + 8.5 \log_{10}(\text{MVA})$$

where MVA is the maximum rating of the transformer in million volt-amperes.

HVAC Systems. The A-weighted sound power level, $L_w(A)$, for a packaged rooftop HVAC system can be estimated using the following empirical relation (Blazier, 1981):

$$L_w(A) = 80 + 12 \log_{10}(\text{TR})$$

where TR is the rated cooling capacity of the system in tons of refrigeration (1 ton equals 12,000 BTU/hr). Assuming hemispherical sound radiation from a point source, the A-weighted sound level (L_p) produced by the HVAC unit at an unobstructed distance of 500 feet can be calculated as follows:

$$L_p(500\text{ ft}) = L_w(A) - 52 = 28 + 12 \log_{10}(\text{TR})$$

Traction Power Substations. It is anticipated that each traction power substation will contain two transformers rated at up to 50 MVA, as well as an HVAC system rated at up to 10 tons. Using the above relationships, it is estimated that at an unobstructed distance of 500 feet, each transformer will produce a sound level of 40 dBA and that the HVAC system will also produce a sound level of 40 dBA. Combining these sources, it is estimated that each substation will generate a total sound level of 45 dBA at an unobstructed distance of 500 feet. Assuming point-source sound propagation, the sound level at a given distance may be calculated as follows:

$$L_p(d) = 45 + 20 \log_{10}(500/d)$$

where d is the distance from the substation center, in feet.

Paralleling and Switching Stations. It is anticipated that each of these facilities will contain up to 3 transformers rated at up to 5 MVA each, as well as an HVAC system rated at up to 10 tons. Using the above relationships, it is estimated that at an unobstructed distance of 500 feet, each transformer will produce a sound level of 32 dBA and that the HVAC system will produce a sound level of 40 dBA. Combining these sources, it is estimated that each of these stations will generate a total sound level of 42 dBA at an unobstructed distance of 500 feet.

Assuming point-source sound propagation, the sound level at a given distance may be calculated as follows:

$$L_p(d) = 42 + 20 \log_{10}(500/d)$$

where d is the distance from the center of the station, in feet.

4.4.3.3 Noise Impact Assessment for Fixed Facilities. The assessment of fixed facility noise impact has been carried out by evaluating the noise projections described in Section 4.4.3.2 with respect to the criteria presented in Section 4.4.3.1, to obtain screening distances for noise impact. An inventory of noise-sensitive land use within these screening distances was then performed to assess potential impact.

Because the electrical station facilities contain tonal noise sources (e.g. transformers and possibly HVAC fans), the criteria indicate noise impact when the facility noise level at noise-sensitive sites exceeds 45 dBA for sites with nighttime occupancy or 50 dBA for sites with only daytime occupancy. However, if the minimum background ambient noise level (L_{90}) exceeds these limits, the criteria indicate noise impact when the facility noise level exceeds the background level.

A review of the ambient noise measurements summarized in Section 4.3 indicates that minimum background noise levels at the 10 representative measurement locations along the project corridor range between 25 dBA and 47 dBA. Thus, the criteria would indicate noise impact at 45-47 dBA at sites with nighttime occupancy and 50 dBA at sites with daytime occupancy. For a conservative impact screening, however, criteria of 45 dBA and 50 dBA were applied for nighttime and daytime use, respectively. Applying the above criteria to the noise projections yields the following noise impact screening distances:

- Traction Power Substations: 500 feet (Nighttime)
  280 feet (Daytime Only)

- Paralleling & Switching Stations: 350 feet (Nighttime)
  200 feet (Daytime Only)

The noise impact assessment for fixed facility operation is summarized in Table 4-18. This table provides the number of residences within the noise impact zones defined by the above screening distances, based on an inventory of noise-sensitive land use near each facility site. The results indicate potential noise impact at a total of 82 residences along the project corridor, with 37 located near traction power substation sites, 4 located near switching station sites and 41 located near paralleling station sites. In terms of the number of residences, the facilities with the greatest potential for noise impact are the Warwick Substation and the Grove Beach Paralleling Station, which are to be located near more densely populated areas.

4.4.4 Construction Noise Impact

Although construction activities related to the Electrification Project would be short-term in nature, these activities have the potential to cause noise impact at nearby noise-sensitive locations depending on their intensity and schedule. Noise impact criteria are presented below, followed by an assessment of potential impact from the proposed catenary installation, fixed facility construction and bridge modifications.

4.4.4.1 Construction Noise Impact Criteria. The significance of noise impacts from project construction activities will be assessed based on the predicted day-night sound level (L_{dn}). A criterion of 75 dBA for all noise-sensitive areas has been selected based on the standards established by the U.S. Department of Housing and Urban Development (HUD, 1979). These standards classify areas with L_{dn} greater than 75 dBA as unacceptable for long-term residential use. However, to account for the limited duration of construction, adverse impact is assessed only when the activity will occur for 30 days or more at a given location.

It should be noted that the above criterion was also applied to non-residential, noise-sensitive locations with only daytime use (e.g. schools). Although the applicable noise measure for such sites is $L_{eq}(24)$, the $L_{eq}(24)$ would be the same as the L_{dn} if construction occurs only during the day. Since nighttime construction noise would not affect sites with only daytime use, the same criterion can be used for all noise-sensitive sites.

4.4.4.2 Catenary Installation. The catenary installation is expected to include the placement of pole foundations at the rate or 20 to 60 per day, followed by the installation of the catenary at a rate of about one track mile per day. Typical construction equipment will include post-hole diggers, rail-mounted platform trucks and cranes, and material-handling equipment. Because this work will be performed using hi-rail vehicles on the tracks, it is anticipated that this activity will generally occur at night.

TABLE 4-18. POTENTIAL NOISE IMPACT FROM FIXED FACILITIES

FACILITY TYPE	FACILITY LOCATION	# OF RESIDENCES IN IMPACT ZONE
Substation	Branford (CT)	1
	New London (CT)	2
	Warwick (RI)	34
	All Substations	37
Switching Station	Westbrook (CT)	3
	Norton (MA)	1
	All Switching Sta.	4
Paralleling Station	Leetes Island (CT)	1
	Grove Beach (CT)	15
	Noank (CT)	4
	State Line (CT)	5
	Attleboro (MA)	2
	East Foxboro (MA)	2
	Canton (MA)	6
	Readville (MA)	6
	All Paralleling Sta.	41
ALL TYPES	ALL LOCATIONS	82

Construction noise exposure during catenary installation was estimated based on noise estimates made during the Programmatic Environmental Impact Study for the Northeast Corridor Improvement Project (FRA, 1978). Based on this study, the average L_{dn} for the noisiest period of nighttime catenary installation was taken to be 73 dBA at a distance of 50 feet. Assuming this reference level, along with line-source sound attenuation of 3 decibels per distance doubling, the noise impact screening distance (to the 75 dBA L_{dn} criterion level) was estimated to be about 30 feet.

A screening of the corridor indicated 78 residences where the L_{dn} during catenary installation is projected to exceed 75 dBA. Of this number, 20 are in Connecticut, 40 are in Rhode Island and 18 are in Massachusetts. However, because exposure to this noise will be limited to only a few nights at any one residence, no adverse impact is expected during catenary installation.

4.4.4.3 Construction of Fixed Facilities. The construction of fixed facilities is expected to include clearing, foundation work, equipment installation and finishing. Construction machinery is likely to include the types of equipment typically used for light industrial construction, such as graders, bulldozers, backhoes, cranes and trucks. For traction power substations, construction is expected to occur intermittently over a five-month period, with some overlap of the construction phases. Shorter construction periods are anticipated for the paralleling and switching stations, with durations of two months and three months per unit, respectively. Construction will typically occur during 8 to 10 hour weekday, daytime periods.

Fixed facility construction noise exposure was estimated using equipment noise levels and scenarios that are typical for non-residential construction (EPA, 1971). Based on this prototypical data, an average workday L_{eq} of 90 dBA at 50 feet was assumed. For an 8 to 10 hour workday, this corresponds to an L_{dn} at 50 feet of 86 dBA for daytime construction. To obtain a screening distance for noise impact assessment, point-source attenuation of 6 decibels per distance doubling was assumed. Based on the noise level at 50 feet, the distance to the 75 dBA L_{dn} impact criterion was estimated to be 180 feet.

An inventory of noise-sensitive land use within the above screening distance has been performed to assess potential noise impact from fixed facility construction. The results, provided in Table 4-19, indicate minimal impact with only 8 residences within the 75 dBA L_{dn} zone of potential impact. Because this activity will occur over 2 to 5-month periods, the noise impact is expected to be adverse at these locations.

4.4.4.4 Modifications at Bridges. Modifications are expected to be required at numerous overhead bridge locations along the Northeast Corridor to provide the necessary clearance for catenary installation. Depending on location, these modifications will include either (1) bridge raising, (2) bridge replacement or (3) bridge undercutting.

Equipment for bridge raising or replacement will include cranes, trucks, jacks, material-handling equipment and other heavy-duty construction equipment. This work is expected to be carried out during normal daylight hours, with an approximate duration of 2 to 9 months per bridge. Bridge undercutting will require the use of trackwork equipment such as specialized diesel-powered equipment, work trains and tampers. Because this work will be done within the rail right-of-way, it is anticipated that undercutting will generally occur at night, with a duration of about 4 days per bridge.

Construction noise exposure for the modifications at bridges was estimated based on noise projections for this activity that were made during the Programmatic Environmental Impact Study for the Northeast Corridor Improvement Project (FRA, 1978). Based on this study, the average daily L_{dn} at 50 feet were taken to be 84 dBA for daytime bridge raising, 90 dBA for daytime bridge replacement and 83 dBA at 50 feet for nighttime undercutting.

To obtain screening distances for noise impact assessment, point-source sound attenuation was assumed for bridge raising and replacement and line-source sound attenuation was assumed for

TABLE 4-19. FACILITY CONSTRUCTION NOISE IMPACT ASSESSMENT

FACILITY TYPE	FACILITY LOCATION	# OF RESIDENCES IN IMPACT ZONE
Substation	Warwick (RI)	5
Paralleling Station	Leetes Island (CT)	1
	Grove Beach (CT)	2
ALL TYPES	ALL LOCATIONS	8

undercutting. Based on the noise levels at 50 feet, the distances to the 75 dBA L_{dn} impact criterion were estimated to be 140 feet for bridge raising, 280 feet for bridge replacement and 320 feet for bridge undercutting.

An inventory of noise-sensitive land use within the above screening distances has been performed to assess potential noise impact from the proposed modifications at bridges. The results, summarized in Table 4-20, project a total of 913 residences within the zone of potential noise impact near 31 bridges out of the 40 to be modified. About 98 percent of these residences will be exposed to noise from undercutting, which will occur at night over 2500-ft long segments of track. However, the noise impact from bridge undercutting operations will be limited to about four nights at any given site, and is not expected to be significant. In summary, adverse noise impact is anticipated at only 21 residences near 4 bridges scheduled for replacement over 2 to 9-month construction periods.

4.4.5 Vibration Impact From Train Operations

The changes in train equipment, schedules and speeds along the Northeast Corridor that are proposed as part of the North End Electrification Project have the potential to affect the ground-borne vibration environment along the corridor. Vibration impact criteria, projections and assessment for the proposed changes in train operations are described below.

4.4.5.1 Train Vibration Impact Criteria. The significance of vibration impacts from train operations on the corridor will be assessed based on the projected root-mean-square (rms) ground vibration velocity level (V_{dB}), expressed in decibels relative to a reference velocity of one μin. per second. The criteria are given in terms of velocity because the sensitivity of humans, buildings and equipment to vibration has typically been found to correspond to a constant level of vibration velocity amplitude within the low-frequency range of most concern for environmental vibration (roughly 5 to 100 Hz).

Although the peak particle velocity (PPV) is commonly used to quantify vibration amplitude for blast damage criteria, response to train vibration is better related to the rms amplitude, defined

TABLE 4-20. NOISE IMPACT FROM BRIDGE MODIFICATIONS

STRUCTURE NAME	LOCATION	MILEPOST	ACTION PROPOSED	# RESID. IN IMPACT ZONE
Ferry Street	New Haven, CT	74.36	Undercut	23
Lake Road	East Haven, CT	78.69	Undercut	16
Harbor Street	Bradford, CT	80.95	Undercut	36
Birch Road	Bradford, CT	83.25	Undercut	14
Copse Road	Madison, CT	92.53	Undercut	24
Horse Pond Road	Madison, CT	93.68	Undercut	17
School House Road	Westbrook, CT	103.62	Undercut	4
Ingram Hill Road	Old Saybrook, CT	104.15	Undercut	2
Johnnycake Hill Rd.	Old Lyme, CT	108.51	Replace	1
Buttonball Road	Old Lyme, CT	109.43	Undercut	4
Columbus Avenue	East Lyme, CT	115.62	Undercut	46
Kenyon School Road	Richmond, RI	154.04	Replace	7
Dry Bridge Road	N. Kingstown, RI	163.50	Undercut	1
Col. Rodman Highway	N. Kingstown, RI	165.46	Undercut	6
Hunts River Road	N. Kingstown, RI	169.79	Undercut	32
Pontiac Road	Warwick, RI	175.61	Undercut	18
Pettaconsett Avenue	Warwick, RI	178.46	Replace	12
Signal Bridge	Cranston, RI	180.66	Undercut	39
Route 10		180.69		
Magnan Road	Providence, RI	182.45	Undercut	34
Cranston Road	Providence, RI	182.60	Undercut	17
Gov. Roberts Hwy.	Providence, RI	183.33	Undercut	28
Longsdale Avenue	Pawtucket, RI	188.91	Undercut	94
Washington Street	Attleboro, MA	191.13	Undercut	78
County Street	Attleboro, MA	192.47	Undercut	27
Holden Street	Attleboro, MA	198.01	Undercut	43
Elm Street	Mansfield, MA	201.67	Undercut	26
School Street	Mansfield, MA	202.51	Undercut	4
Depot Street	Sharon, MA	211.04	Replace	1
River Street	Boston, MA	220.74	Undercut	84
Blakemore Street	Boston, MA	222.82	Undercut	134
Arlington/Tremont	Boston, MA	225.13	Undercut	41
			RAISE	0
			REPLACE	21
			UNDERCUT	892
			TOTAL	913

as the average of the squared amplitude of the signal over a one-second time period. Although velocity is normally described in units of inches per second in the USA, the decibel notation, which acts to compress the range of numbers required to describe vibration, can also be used. In this notation, the vibration magnitude is expressed in terms of velocity level, in decibels, defined as follows:

$V_{dB} = 20 \log_{10}(v/v_{ref})$ where: v = rms velocity, μin./sec
$v_{ref} = 1$ μin./sec

Absolute criteria for ground-borne vibration impact are based on those currently being proposed for adoption by the U.S. Federal Transit Administration (FTA, 1990). These criteria, presented in Table 4-21, are based on the maximum ground vibration levels for a single event and account for land use as well as the frequency of events. For consistency, the absolute criterion based on the existing train frequency shall be used to assess impact for the future alternatives.

Because the project involves potential changes in train vibration along an existing rail corridor, adverse impact is assessed only at locations where: (1) projected no-build or project build alternative ground vibration levels exceed the absolute criteria and (2) there will be an increase of at least 25 percent (2 dB) in the magnitude of train vibration, or at least a doubling in the number of daily train operations.

Another area of concern is damage to buildings located near the right-of-way. The criteria for vibration damage are 100 dB for buildings in general, and 95 dB for fragile, historic buildings. However, damage is extremely unlikely except in unusual cases.

4.4.5.2 Train Vibration Source and Propagation Measurements. Ground-borne vibration levels from trains operating on the Northeast Corridor were measured at the 9 supplementary source measurement sites described in Section 4.4.1.2, for the purpose of deriving propagation curves to be used in the vibration projection model. Vibration levels from diesel-powered trains operating along the project corridor were documented (at sites B-1 through B-6) to characterize existing conditions, while levels measured from electric-powered equipment (at sites C-1 through C-3) were used to define the baseline conditions for the future build scenario.

Since the vibration source measurements were conducted concurrently with the noise source measurements, the vibration data apply to all train passages for which noise data were also collected. However, because vibration propagation, or the rate at which ground-borne vibration decays as a function of distance, is dependent on geology and other site-specific factors, simultaneous vibrations measurements were made at multiple locations on the ground for each site. This type of measurement serves to characterize both the vibration source as well as the propagation path.

Each test consisted of placing five accelerometers along the ground at increasing perpendicular distances from the existing railroad track. For consistency, the measurement positions were kept fixed to the greatest extent possible for all sites, and were established as 25, 50, 75, 100 and 150

TABLE 4-21. PROPOSED FTA CRITERIA FOR VIBRATION IMPACT

LAND USE CATEGORY	GROUND-BORNE VIBRATION IMPACT LIMITS (rms Vibration Velocity Level in dB re 1 μin./second)	
	Frequent Events[4]	Infrequent Events[5]
Category 1: Buildings where low ambient vibration is essential for interior operations.	65 dB	65 dB
Category 2: Residences and buildings where people normally sleep.	72 dB	80 dB
Category 3: Institutional land uses with primarily daytime use.	75 dB	83 dB

feet measured from the centerline of the near track. In most cases, a B&K Model 4370 accelerometer was used at the nearest position, a Wilcoxon Model 731 accelerometer was used at the farthest position, and PCB Model 393 accelerometers were used at the intermediate positions. All accelerometers were oriented to measure rms vibration in the vertical direction, and were mounted either on pavement or on ground-driven steel stakes using putty or beeswax to secure them.

The data were recorded on magnetic tape using a Teac Model RD-130TE digital audio tape recorder. For each event recorded in the field, the train consist and track location were noted, and the train speed was clocked using a stopwatch. During subsequent laboratory analysis, the tape-recorded data were played back and processed through a B&K Model 2635 integrating charge amplifier and a Rion Model LR-04 graphic level recorder to provide a continuous record of the rms vibration velocity level at each measurement distance for each train event. The maximum vibration level obtained by sampling the velocity level with a slow (one-second) averaging time constant was determined for each train event.

The results of the train vibration measurements are provided in Table A-3 of Appendix 4.A, including operational as well as vibration data. As for the noise data discussed in Section

[4] "Frequent Events" is defined as more than 70 vibration events per day. Most transit systems fall into this category.

[5] "Infrequent Events" is defined as less than 70 vibration events per day. This category includes most commuter and inter-city rail systems.

4.4.1.2, Table A-3 also provides results for trains observed at the A-sites, where train vibration was monitored for only one measurement position per site. The data in the table are in the form of maximum overall rms velocity level for each train event observed over the five accelerometer positions. These data were used to develop and calibrate the train vibration projection model, as described below.

4.4.5.3 Train Vibration Projection Model. Because ground-borne vibration is a complex phenomenon that is difficult to model and predict accurately, most projection procedures used for rail projects rely on empirical data. This section summarizes the empirical method used to develop a model of vibration generated by trains operating on the project corridor. The model is based on available data from measurements and provides a conservative yet reasonable basis for projecting train vibration along the corridor for existing and future scenarios.

The nine vibration source/propagation measurement sites were selected to cover a large geographic area and represent a wide range of soil types, track configurations and operating conditions. As a result, there is a wide variation in both vibration levels generated by trains and their propagation characteristics.

Figures 4-39 through 4-41 present the measurement data in the form of regression curves obtained by performing a least mean squares curve fit for each group of data points. These curves show that even by sorting the data by train type and normalizing to a single speed of 90 mph, the results vary widely from site to site. To ensure that the projections are conservative, the curves for each train type were energy-averaged and an overall comparison was made between vibration levels generated by the different equipment types. The following general observations were made:

- Amtrak trains, either diesel or electric locomotive-hauled, generated higher vibration levels than any other type of equipment operating on the same corridor segment. This is mainly due to the fact that Amtrak train speeds are higher than either commuter or freight train speeds.

- Both diesel and electric locomotive-hauled Amtrak trains generate about the same level of vibration at similar speeds.

- The limited amount of data obtained for the X2000 equipment shows that at a given speed, X2000 vibration levels are about 5 to 10 dB lower than for the diesel or electric locomotive-powered Amtrak trains currently in service. This may be due, in part, to differences in vehicle design. In particular, the axle load and unsprung mass of the X2000 power car are about half that of the F40PH locomotive. However, as discussed in Section 4.4.1.3, the X2000 train had only been in revenue service for approximately one month when the data was gathered. Thus, the difference in vibration levels compared with standard Amtrak equipment could also be partly due to the fact that the X2000 rolling stock was still in relatively new condition.

In general, it has been found that a 5 dB "degradation factor" can be applied to new equipment to account for the eventual wear of the rolling stock after it has been in service for one year or more. The X2000 vibration propagation characteristic was adjusted with this 5 dB factor, and its rate of decay was calibrated to follow the rate obtained by an energy-average of the diesel and electric Amtrak vibration data. The result is given in Figure 4-42, which shows the projected vibration level as a function of distance for the types of Amtrak equipment currently operating.

The curves in the figure apply to trains at 90 mph, and were used to project maximum existing, future build and no-build vibration levels along the project corridor. To reflect the new equipment that will be required for express trains, the X2000 curve was applied for such trains in the future build case. To be conservative, the Diesel/AEM7 curve was used in all other cases. The following adjustment for speed was applied to account for variations in maximum operating speed:

$$\Delta L = 20\ log_{10}(v/90) \qquad \text{where: } v = \text{train speed (mph)}$$

As is the case for noise, special trackwork can cause ground-borne vibration increases of 5 to 10 dB close to the track. However, because their effects are highly localized and because the project will not alter their locations, a detailed analysis of special trackwork is not required for a reasonable assessment of vibration impact.

Table 4-22 provides a comparison of the predicted and measured maximum ground-borne vibration levels from trains at each of the existing vibration measurement sites. The predicted levels are shown to be within the measured range at four of the sites, above the measured range at four of the sites, and below the measured range at three of the sites. Given the variables involved, the model projections are considered to be valid for the purpose of vibration impact assessment.

4.4.5.4 Train Vibration Impact Assessment. The speed-corrected vibration propagation curve for each segment of the project corridor was used to determine impact screening distances within which impact from vibration is likely to occur. Table 4-23 provides a summary of the projected maximum vibration level from trains at each of the measurement sites for the existing, no-build and build alternatives. The table also applies the site-specific vibration impact criteria to each of the sites, and demonstrates the use of these criteria in determining adverse impact.

The absolute vibration criterion at each site was selected based on the total number of existing train operations per day. A criterion of 80 dB was found to apply at all but site A-10, which is the only one of the eleven sites currently exposed to more than 70 trains per day. Out of the eleven sites, Table 4-23 indicates that projected train vibration levels exceed the absolute criterion at seven sites for the existing and no-build scenarios, and at all sites for the build alternative.

TABLE 4-22. PREDICTED AND MEASURED TRAIN VIBRATION LEVELS

SITE NO.	SITE LOCATION	DIST. TO CORRIDOR C.L. (ft)	MAXIMUM EXISTING RMS VIBRATION VELOCITY LEVEL (dB re 1 μin./sec)	
			Measured	Predicted
A-1	New Haven, CT	94	65-86	80
A-2	Westbrook, CT	111	65-76	79
A-3	Waterford, CT	86	82-86	79
A-3a	West Mystic, CT	42	76-82	85
A-4	Pawcatuck, CT	79	81-87	83
A-5	Charlestown, RI	59	88-92	84
A-6	Warwick, RI	69	86-94	84
A-7	Central Falls, RI	32	86-95	89
A-8	W Mansfield, MA	125	68-74	79
A-9	Canton, MA	68	60-70	84
A-10	Hyde Park, MA	78	78-87	85

Adverse impact for the future alternatives was assessed when the absolute criterion would be exceeded, provided that there was also an increase of at least 2 dB in maximum vibration level or at least a doubling of train frequency. The results in Table 4-23 indicate that adverse vibration impact is projected at two of the sites for the no-build alternative and at six of the sites for the build alternative.

A corridor wide inventory of train vibration impact is provided in Table 4-24. This table indicates the estimated number of vibration-sensitive sites located within the vibration impact zone for the no-build and build alternatives. The vibration impact zone was determined by comparing the vibration projections with the project criteria along individual segments of the corridor, and by estimating the distances within which impact would occur. These train vibration impact distances are given by corridor milepost segment in Table A-4 of Appendix 4.A. The numbers of vibration-sensitive sites located within the impact zone were then counted with the aid of land-use maps and aerial photographs of the project corridor.

The results in Table 4-24 indicate some vibration impact for the no-build alternative, with 369 residences located within the zone of adverse impact. All of these homes are in Rhode Island, and most are located in Warwick. This impact is due to the proposed introduction of new commuter rail service by Rhode Island D.O.T., which is expected to occur regardless of whether the corridor is electrified.

TABLE 4-23. VIBRATION IMPACT ASSESSMENT AT MEASUREMENT SITES

SITE NO.	SITE LOCATION	DIST. TO CORRID OR CENTER LINE (feet)	MAXIMUM RMS VIBRATION VELOCITY LEVEL (dB re 1 μin./sec)							# of Operations Per Day			ADVERSE VIBRATION IMPACT	
			Absolute Level				Increase in Level			Exist	% Increase			
			Crit	Exist	No-Bld	Bld	Crit	No-Bld	Bld		No-Bld	Bld	No-Bld	Bld
A-1	New Haven, CT	94	80.0	79.7	79.7	80.3	2.0	0	0.6	52	23%	71%	No	No
A-2	Westbrook, CT	111	80.0	79.2	79.2	80.2	2.0	0	1.0	52	23%	71%	No	No
A-3	Waterford, CT	86	80.0	79.2	79.2	81.7	2.0	0	2.5	24	75%	179%	No	Yes
A-3a	West Mystic, CT	42	80.0	84.7	84.7	85.7	2.0	0	1.0	20	30%	160%	No	Yes
A-4	Pawcatuck, CT	79	80.0	82.5	82.5	83.0	2.0	0	0.5	20	30%	160%	No	Yes
A-5	Charlestown, RI	59	80.0	84.3	84.3	86.1	2.0	0	1.8	20	30%	160%	No	Yes
A-6	Warwick, RI	69	80.0	84.2	84.2	86.1	2.0	0	1.9	22	136%	255%	Yes	Yes
A-7	Central Falls, RI	32	80.0	88.5	88.5	88.5	2.0	0	0	30	103%	190%	Yes	Yes
A-8	W. Mansfield, MA	125	80.0	79.7	79.7	81.6	2.0	0	1.9	55	7%	47%	No	No
A-9	Canton, MA	68	80.0	83.8	83.8	85.7	2.0	0	1.9	53	8%	53%	No	No
A-10	Hyde Park, MA	78	72.0	84.6	84.6	85.8	2.0	0	1.2	117	32%	55%	No	No

For the build alternative, Table 4-24 indicates a total of 1355 residences and one school within the zone of adverse noise impact. Of the 1355 residences, 162 are in Connecticut (with about 40 percent in Stonington), 461 are in Rhode Island (with more than half in Warwick) and 732 are in Massachusetts (with about 75 percent in Boston and 10 percent in Attleboro). The primary causes of this impact are the increased Amtrak train frequency and speed along the corridor.

Finally, it should be noted that all of the adverse vibration impacts reflect annoyance effects and not building damage effects. In no case do the projected train vibration levels exceed the vibration damage criteria along the corridor.

4.4.6 Construction Vibration Impact

Ground-borne vibration from construction activities related to the Electrification Project have the potential to affect nearby structures and their occupants. The potential for impact is greatest for intense construction activities, such as blasting and pile driving. Construction vibration impact criteria are presented below, followed by an assessment of potential vibration impact from the proposed catenary installation, fixed facility construction and bridge modifications.

TABLE 4-24. CORRIDOR-WIDE TRAIN VIBRATION IMPACT INVENTORY

MUNICIPALITY	MILEPOST		CORRIDOR LENGTH (mi)	NO-BUILD ALTERNATIVE		BUILD ALTERNATIVE	
	From	To		# Resid.	# Other	# Resid.	# Other*
New Haven	72.0	77.0	5.0	0	0	1	0
East Haven	77.0	79.0	2.0	0	0	0	0
Branford	79.0	86.0	7.0	0	0	4	0
Guilford	86.0	90.5	4.5	0	0	5	0
Madison	90.5	94.9	4.4	0	0	1	0
Clinton	94.9	98.9	4.0	0	0	0	0
Westbrook	98.9	102.5	3.6	0	0	0	0
Old Saybrook	102.5	106.6	4.1	0	0	2	0
Old Lyme	106.6	112.3	5.7	0	0	19	0
East Lyme	112.3	116.7	4.4	0	0	36	0
Waterford	116.7	121.1	4.4	0	0	9	0
New London	121.1	123.9	2.8	0	0	10	0
Groton	123.9	132.5	8.6	0	0	8	0
Stonington	132.5	141.0	8.5	0	0	67	0
TOTAL CT	72.0	141.0	69.0	0	0	162	0
Westerly	141.0	146.1	5.1	0	0	12	0
Hopkinton	146.1	147.2	1.1	0	0	0	0
Charlestown	147.2	153.6	6.4	0	0	7	0
Richmond	150.3	155.8	5.5	0	0	13	0
South Kingstown	155.8	160.7	4.9	4	0	8	0
Exeter	160.7	161.9	1.2	0	0	0	0
North Kingstown	161.9	170.8	8.9	59	0	92	0
East Greenwich	170.8	172.1	1.3	32	0	33	0
Warwick	172.1	178.8	6.7	231	0	243	0
Cranston	178.8	181.0	2.2	0	0	0	0
Providence	181.0	187.5	6.5	5	0	6	0
Pawtucket	187.5	189.8	2.3	0	0	13	0
Central Falls	189.8	190.9	1.1	38	0	34	0
TOTAL RI	141.0	190.9	49.9	369	0	461	0
Attleboro	190.9	199.7	8.8	0	0	83	1C**
Mansfield	199.7	204.9	5.2	0	0	3	0
Foxborough	204.9	207.6	2.7	0	0	0	0
Sharon	207.6	212.7	5.1	0	0	0	0
Canton	212.7	216.2	3.5	0	0	18	0
Westwood	216.2	217.2	1.0	0	0	0	0
Dedham	217.2	218.9	1.7	0	0	73	0
Boston	218.9	228.8	9.9	0	0	555	0
TOTAL MA	190.9	228.8	37.9	0	0	732	1C
TOTAL CORRIDOR	72.0	228.8	156.8	369	0	1355	1C

* "C" denotes church
** Second Congregational Church

ground vibration peak particle velocity (PPV) limit of 0.5 in./sec is recommended, based on U.S. Bureau of Mines (BOM) research (Siskind, 1980).

4.4.6.2 Construction Vibration Projections. Ground-borne vibration from construction was estimated based on (1) equipment source data in the literature (Wiss, 1974; FHWA, 1982; FTA, 1990) and (2) the ground vibration propagation characteristics measured along the project rail corridor. Vibration projections were made for three construction equipment categories, based on the relative amount of energy imparted to the ground as follows:

1. Light-duty equipment. This category includes equipment that is expected to be used for catenary installation and bridge undercutting, including post-hole diggers and small earth-moving equipment. A vibration velocity level of 70 dB at 25 feet has been chosen as the source level for these types of equipment and activities.

2. Heavy-duty equipment. This category includes heavy trucks and large earth-moving equipment that are expected to be used for fixed facility construction, bridge raising and bridge replacement. A vibration velocity level of 85 dB at 25 feet has been chosen as the source level for these types of equipment and activities.

3. Pile-driving equipment. A vibration velocity level of 100 dB at 25 feet has been chosen as the source level for impact pile driving equipment that is likely to be used during overhead bridge replacement.

The above source levels cover the range of ground vibration likely to be generated during project construction. Since blasting is not anticipated, pile drivers represent the greatest potential source of construction vibration impact.

Estimates of construction vibration at distances other than 25 feet were made based on the ground vibration propagation characteristics measured along the project rail corridor. These measurements indicated vibration attenuations of 6 dB per distance doubling within 50 feet, 9 dB per distance doubling between 50 feet and 100 feet, and 12 dB per distance doubling beyond 100 feet.

4.4.6.3 Construction Vibration Impact Assessment. To obtain screening distances for construction vibration impact assessment, the method described above was used to project vibration levels as a function of distance for each type of construction activity. Then, the distances to the various impact criterion levels were determined. The resulting vibration impact screening distances are given in Table 4-25. With the aid of aerial photographs of the project corridor, an inventory of vibration-sensitive land use within the screening distances was performed to assess potential vibration impact from the proposed construction activities.

The results of the screening indicate little potential for vibration impact from catenary installation, with only 17 residences located within the zone of potential impact along the entire

TABLE 4-25. CONSTRUCTION VIBRATION IMPACT SCREENING DISTANCES

General Types of Construction Activities	Approx. Distance for Vibration Impact (ft)				
	Building Damage		Bldg. Occupant Annoyance		
	General (100 dB)	Fragile (95 dB)	Cat. 3 (75 dB)	Cat. 2 (72 dB)	Cat. 1 (65 dB)
Catenary Inst. & Bridge Undercut. (70 dB @ 25 ft)	--	--	15	20	45
Facility Constr. & Bridge Raising or Replacement (85 dB @ 25 ft)	--	--	70	85	135
Pile Driving for Bridge Replacmt. (100 dB @ 25 ft)	25	45	180	210	320

corridor. However, because this activity will be limited to only a few nights at any one residence, no adverse vibration impact is anticipated during catenary installation.

Regarding vibration impact from facility construction, the screening indicated only 2 residences near the Grove Beach (CT) Paralleling Station that are within the facility construction vibration impact zone. However, because of the 2 to 5-month construction period, adverse impact may occur at these locations.

Of all the construction activities, the bridge modifications have the greatest potential for generating vibration impact. As shown in Table 4-26, vibration impact from bridge replacement is projected to be adverse at a total of 14 residences near 3 out of the 40 bridges to be modified along the project corridor. The greatest potential source of vibration impact is pile driving for the bridge replacements. Without pile driving, the total number of residences within the bridge construction vibration impact zone would be reduced to 4.

Finally, it should be noted that all of the adverse vibration impacts identified are related to annoyance effects and not to building damage effects. In no case do the projected construction vibration levels exceed the vibration damage criteria along the project corridor.

TABLE 4-26. VIBRATION IMPACT FROM BRIDGE MODIFICATIONS

STRUCTURE NAME	LOCATION	MILEPOST	ACTION PROPOSED	# RESID. IN IMPACT ZONE
Johnnycake Hill Rd.	Old Lyme, CT	108.51	Replace	1
Kenyon School Road	Richmond, RI	154.04	Replace	6
Pettaconsett Avenue	Warwick, RI	178.46	Replace	7
			TOTAL	14

4.4.7 Summary of Impacts

4.4.7.1 Train Noise Impact. The train noise evaluation projects a total of 787 residences, 2 churches and 2 recreational areas to be within the zone of adverse noise impact for the project build alternative. The analysis also indicates that the primary sources of this impact are expected to be the increased Amtrak train frequency and speed.

4.4.7.2 Traffic Noise Impact. The assessment indicates that traffic noise impact due to the project in the vicinity of the train stations is not expected to be adverse.

4.4.7.3 Fixed Facility Noise Impact. The assessment indicates that there is the potential for adverse noise impact to occur at 82 residences located near 3 substations, 2 switching stations and 8 paralleling stations along the project corridor. The sources of this potential impact include outdoor transformers and control building ventilation equipment.

4.4.7.4 Construction Noise Impact. The assessment estimates that adverse construction noise impact will occur at 8 homes during construction at 3 electrical facilities, and at 21 homes during the replacement of 4 bridges along the project corridor. Although short-term impacts may occur at 78 homes during catenary installation and at 892 homes during the undercutting of 28 bridges along the corridor, these impacts are not expected to be adverse due to their limited duration.

4.4.7.5 Train Vibration Impact. The train vibration evaluation projects a total of 1355 residences and 1 church to be within the zone of adverse impact for the project build alternative. It should be emphasized that all of these impacts are related to annoyance effects and not to building damage effects. The analysis also indicates that the primary sources of this impact are expected to be the increased Amtrak train frequency and speed.

4.4.7.6 Construction Vibration Impact. According to the assessment, adverse construction vibration impact is anticipated at 2 residences during construction of one paralleling station, and at 14 homes during the replacement of 3 bridges along the project corridor. The greatest potential source of construction vibration impact is pile driving for the bridge replacements. All of the adverse impacts identified are related to annoyance effects and not to building damage effects, and will occur during daytime hours. Although short-term impacts may occur at 17 homes during nighttime catenary installation, these impacts are not expected to be adverse due to their limited duration.

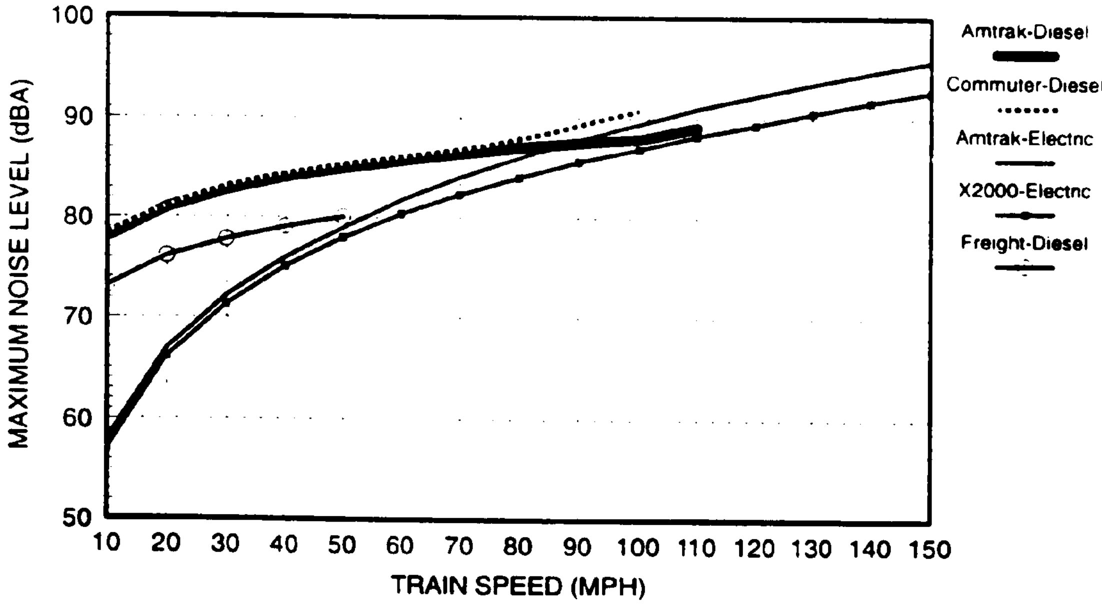

FIGURE 4-26. PROJECTED L_{max} FOR TRAINS AT 100 FEET

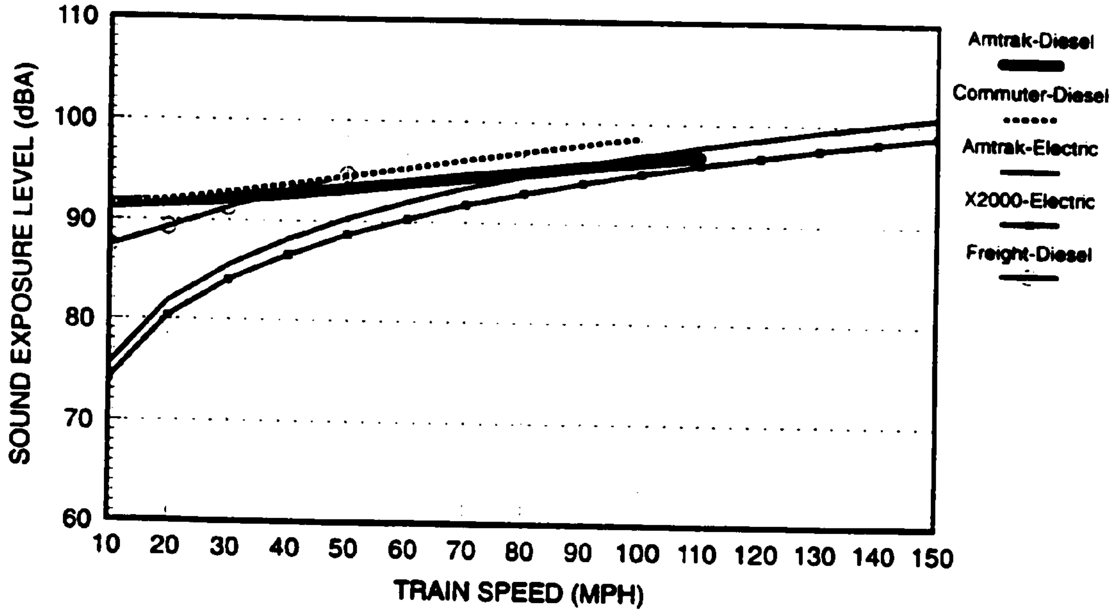

FIGURE 4-27. PROJECTED SEL FOR TRAINS AT 100 FEET

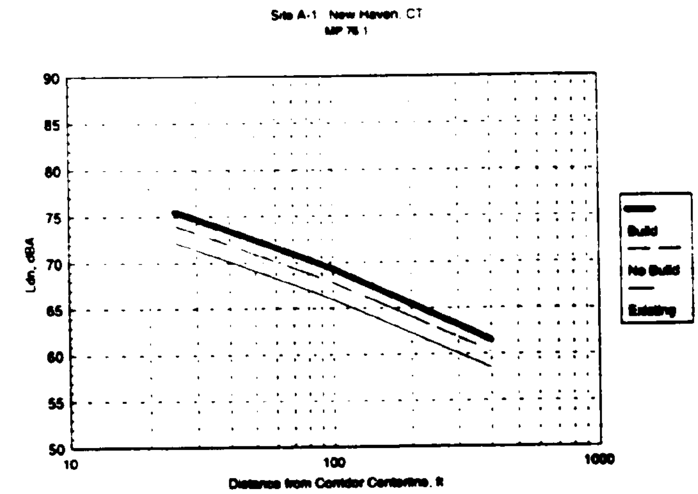

FIGURE 4-28. PROJECTED TRAIN NOISE LEVELS NEAR SITE A-1

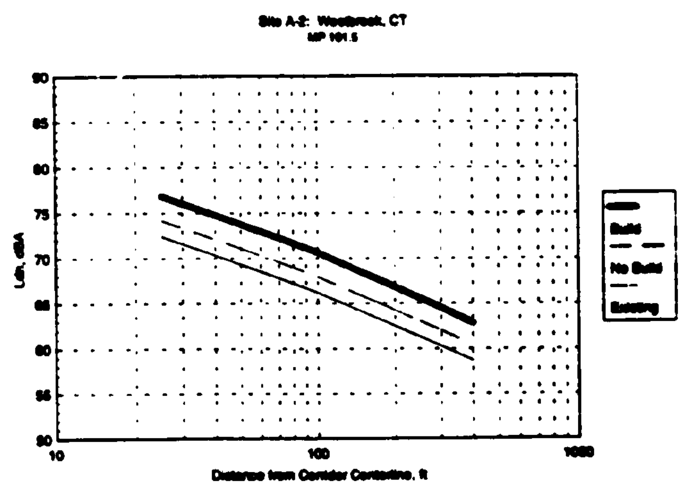

FIGURE 4-29. PROJECTED TRAIN NOISE LEVELS NEAR SITE A-2

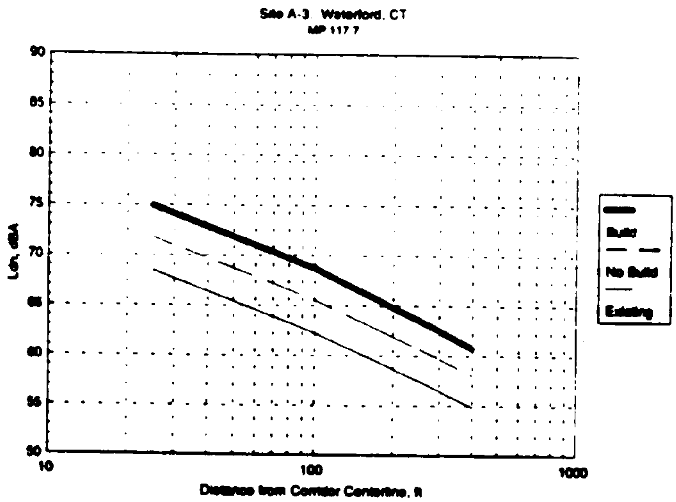

FIGURE 4-30. PROJECTED TRAIN NOISE LEVELS NEAR SITE A-3

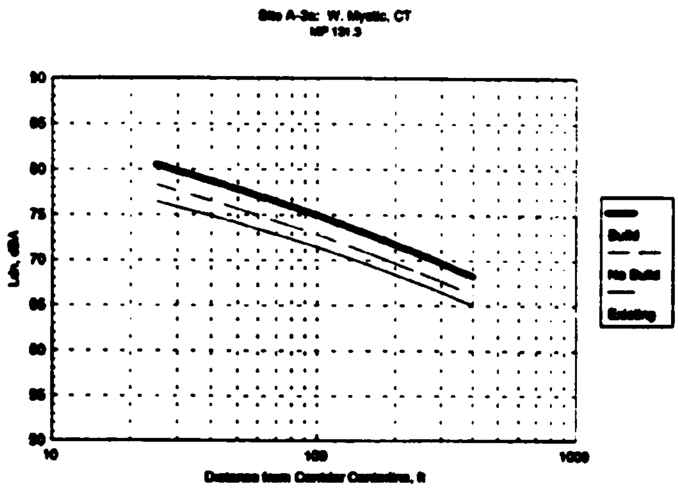

FIGURE 4-31. PROJECTED TRAIN NOISE LEVELS NEAR SITE A-3a

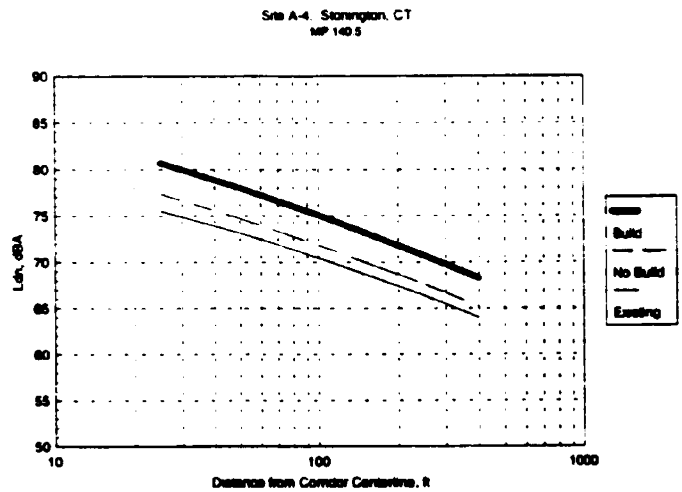

FIGURE 4-32. PROJECTED TRAIN NOISE LEVELS NEAR SITE A-4

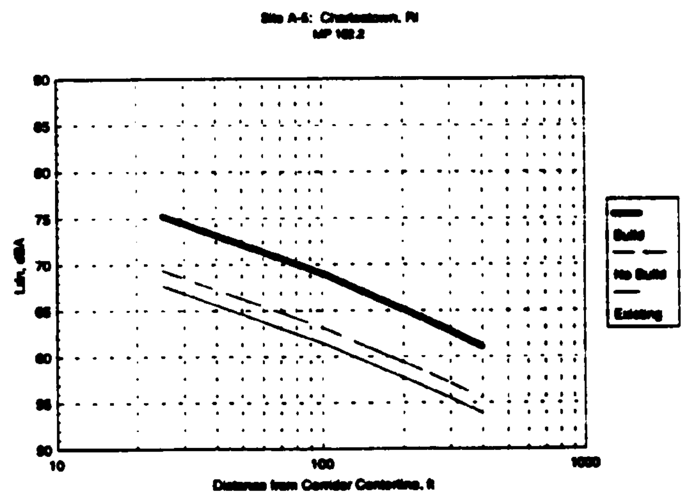

FIGURE 4-33. PROJECTED TRAIN NOISE LEVELS NEAR SITE A-5

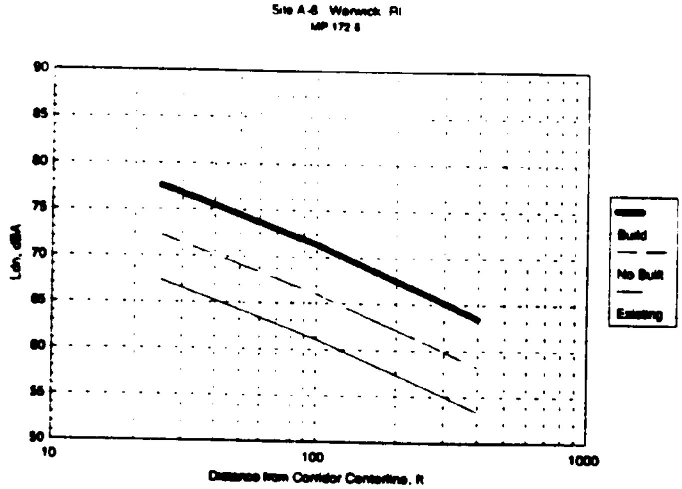

FIGURE 4-34. PROJECTED TRAIN NOISE LEVELS NEAR SITE A-6

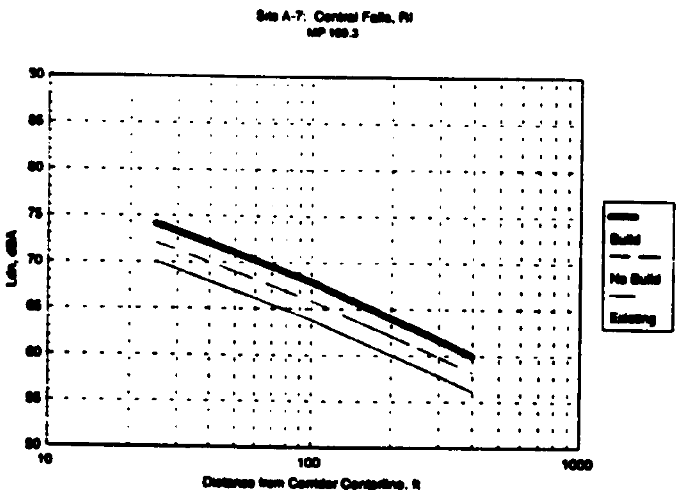

FIGURE 4-35. PROJECTED TRAIN NOISE LEVELS NEAR SITE A-7

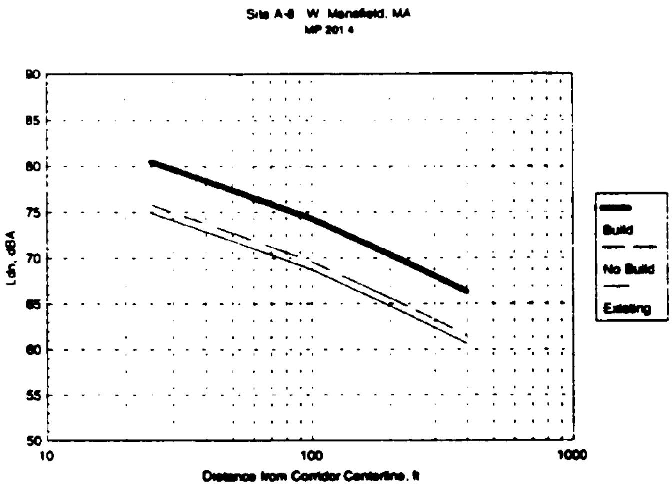

FIGURE 4-36. PROJECTED TRAIN NOISE LEVELS NEAR SITE A-8

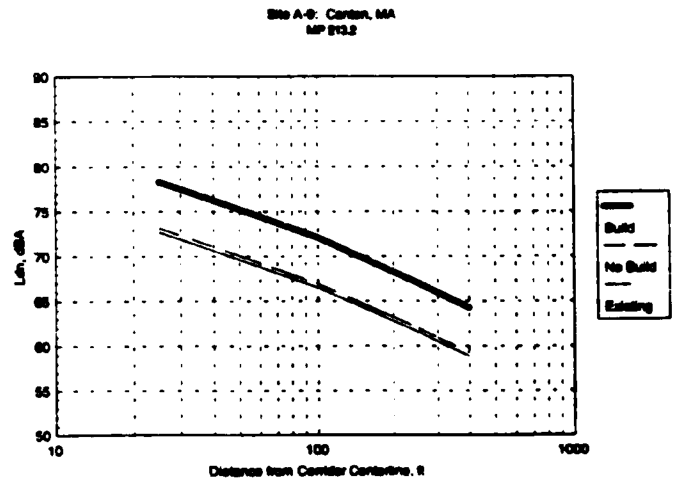

FIGURE 4-37. PROJECTED TRAIN NOISE LEVELS NEAR SITE A-9

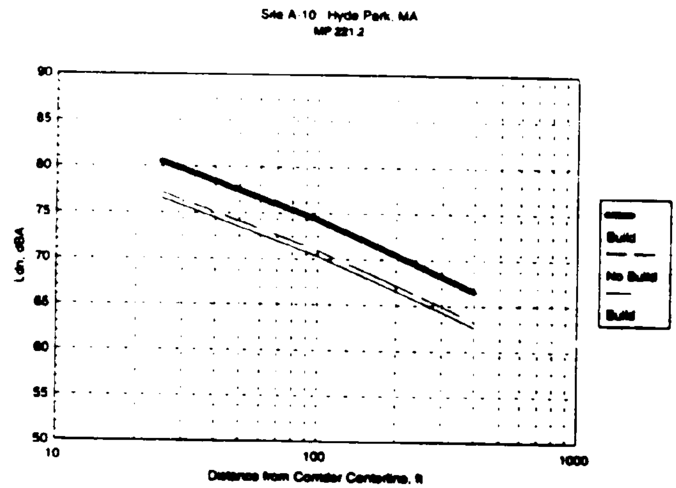

FIGURE 4-38. PROJECTED TRAIN NOISE LEVELS NEAR SITE A-10

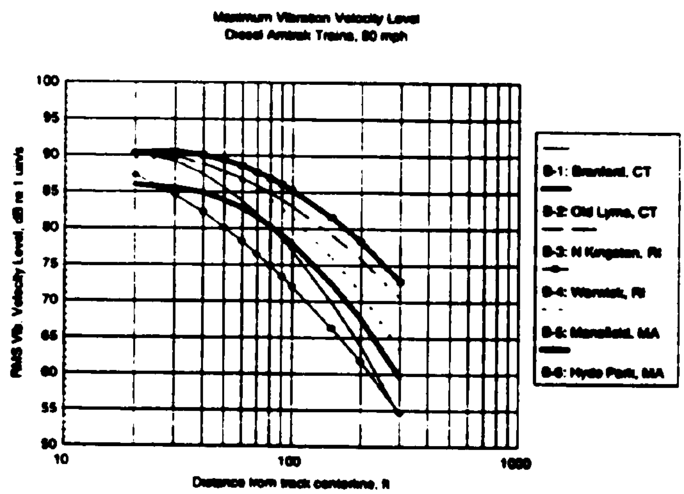

FIGURE 4-39. VIBRATION LEVELS FROM DIESEL AMTRAK TRAINS

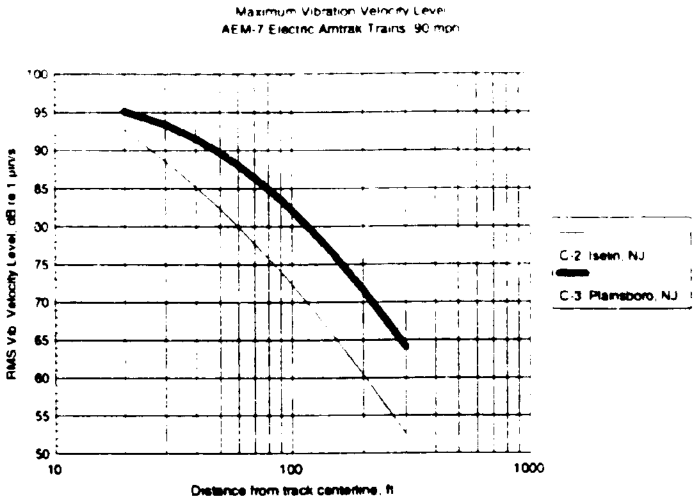

FIGURE 4-40. VIBRATION LEVELS FROM ELECTRIC AMTRAK TRAINS

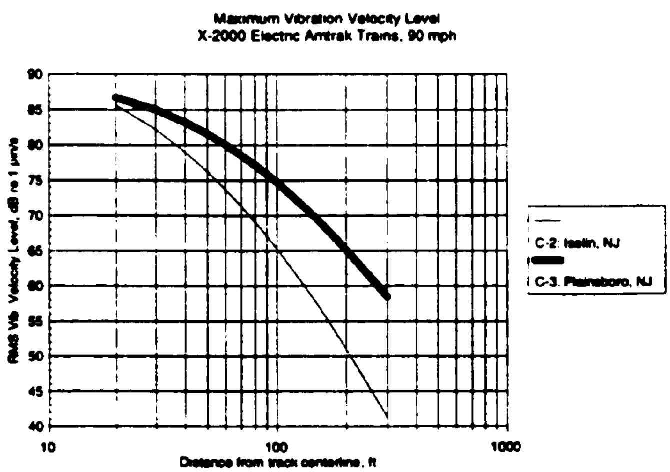

FIGURE 4-41. VIBRATION LEVELS FROM X2000 TRAIN

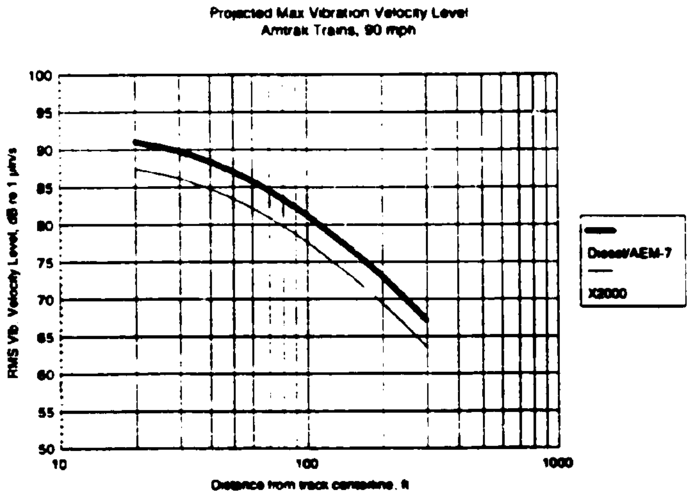

FIGURE 4-42. PROJECTED VIBRATION FOR ALL AMTRAK TRAIN TYPES

4.5 MITIGATION MEASURES

This section presents potential measures to mitigate the noise and vibration impacts identified in Section 4.4, as well as rough estimates for the extent of mitigation treatments. While all of the recommended measures are physically possible, it should be noted that cost-effectiveness is always an important factor in determining the extent to which mitigation measures are implemented. Thus, based on more detailed studies to be undertaken during the final design phase of the project, only those mitigation measures that are found to be reasonable and feasible should be implemented.

Measures that can be considered to mitigate potential impacts from train noise, fixed facility noise, construction noise, train vibration and construction vibration are discussed below in sections 4.5.1 through 4.5.5. Because the assessment indicated that traffic noise impact due to the project in the vicinity of the train stations is not expected to be adverse, traffic noise mitigation measures are not required.

4.5.1 Train Noise Impact Mitigation

As indicated in Section 4.4.1.5, the train noise evaluation projects a total of 787 residences, 2 churches and 2 recreational areas to be within the zone of adverse noise impact for the project build alternative. The analysis also indicates that the primary sources of this impact are expected to be the increased Amtrak train frequency and speed. To address potential impact mitigation, source, path and receiver noise control measures have been considered as described below.

4.5.1.1 Source Noise Control. Train noise control at the source can involve equipment and track-related measures as well as operational modifications. Since the dominant noise source of the proposed electric trains at high speeds is the wheel and rail interaction, one of the most important mitigation measures will be to ensure a good maintenance program. Such a program includes the installation of equipment to detect vehicle flat wheels on a continuing basis, along with periodic wheel truing and rail grinding. However, because Amtrak already has an on-going track maintenance program, maintenance alone cannot be relied upon to provide the required noise mitigation.

Another mitigation measure could be the elimination of at-grade crossings and the associated train horn noise, which would significantly reduce train noise impact for nearby sites. Although this may occur anyhow, since FRA intends that most such crossings be eliminated by 1997, it may not be sufficient to eliminate impact at all sites near the crossings.

Although a reduction of train frequency and speed would reduce the noise impact, such operational measures are not feasible since increased speed and service are among the primary objectives of the corridor improvement project.

4.5.1.2 Path Noise Control. The installation of wayside noise barriers, designed to block the direct sound path between the trains and the noise-sensitive sites along the corridor, is often the most effective measure to mitigate train noise impact. Such barriers would need to be heavy enough, high enough and long enough to provide the necessary shielding.

In terms of weight, most any impervious material with no holes or gaps and with a density of at least 6 pounds per square foot is adequate. Since earth berms are not likely to be practical due to space limitations within the railroad right-of-way, barrier walls are the most likely option. The barriers walls can be made of wood, concrete, metal or other material, with the choice dependent on design, aesthetic and cost considerations.

With regard to height, the train noise barriers need to be high enough to effectively block the line-of-sight between the noise source and the receiver. For example, if it were required to shield diesel locomotive noise or to protect higher floors of residences, 16 foot high barriers would be needed. However, since the dominant source of train noise impact for the project build alternative will be the wheel-rail interaction, relatively low barriers located close to the track could be effective. Considering the height of the top-of-rail with respect to the adjacent grade elevation, it is estimated that a minimum barrier height of 8 feet would be required at the right-of-way line. A barrier of this height is expected to provide a noise reduction of about 5 dBA in terms of L_{dn} at outdoor and first-floor spaces of most impacted sites.

In addition to being high enough, the train noise barriers need to extend far enough to each side of the receiver location so that the train noise from beyond the ends of the barrier does not significantly degrade its acoustical performance. As a rule of thumb, the barrier should be long enough to shield the entire train for an angle of at least 60 degrees in either direction. Thus, for the nearest impacted homes, located at an average distance of 60 feet from the rail corridor, the barrier should extend at least 100 feet to each side of the homes.

A rough estimate of the extent of barrier needed to mitigate train noise impact has been made based on the results of the impact inventory. The estimate assumes that about 200 feet of barrier length will be required to shield each residence, except in densely populated areas where land use maps were used to estimate the barrier length. Since there were very few non-residential sites within the impact zone, and because some of these sites were in residential areas, the estimates of barrier extent were based on residential noise impact only.

A summary of potential train noise mitigation is provided in Table 4-27. This table indicates the estimated length of noise barrier needed to mitigate all train noise impact for the build alternative in each community along the project corridor. Table 4-27 indicates that a total barrier length of 117,800 feet, or about 22.3 miles, would be required to mitigate train noise impact along the entire corridor. In terms of geographical distribution, 26 percent would be in Connecticut, 44 percent would be in Rhode Island and 30 percent would be in Massachusetts. The actual locations of the barriers would be within the corridor milepost segments where noise impact is projected to occur (see Table A-2 of Appendix 4.A).

TABLE 4-27. SUMMARY OF POTENTIAL TRAIN NOISE MITIGATION

MUNICIPALITY	MILEPOST		NUMBER OF IMPACTED RESIDENCES	POTENTIAL NOISE BARRIER Length (ft)
	From	To		
New Haven	72.0	77.0	0	0
East Haven	77.0	79.0	0	0
Branford	79.0	86.0	6	1,200
Guilford	86.0	90.5	4	800
Madison	90.5	94.9	6	1,200
Clinton	94.9	98.9	11	2,200
Westbrook	98.9	102.5	2	400
Old Saybrook	102.5	106.6	2	400
Old Lyme	106.6	112.3	18	3,600
East Lyme	112.3	116.7	24	4,800
Waterford	116.7	121.1	2	400
New London	121.1	123.9	3	600
Groton	123.9	132.5	6	1,200
Stonington	132.5	141.0	71	14,200
TOTAL CT	72.0	141.0	155	31,000
Westerly	141.0	146.1	23	4,600
Hopkinton	146.1	147.2	0	0
Charlestown	147.2	153.6	6	1,200
Richmond	150.3	155.8	7	1,400
South Kingstown	155.8	160.7	27	5,400
Exeter	160.7	161.9	1	200
North Kingstown	161.9	170.8	68	8,500
East Greenwich	170.8	172.1	31	3,000
Warwick	172.1	178.8	203	23,700
Cranston	178.8	181.0	0	0
Providence	181.0	187.5	5	1,000
Pawtucket	187.5	189.8	12	2,400
Central Falls	189.8	190.9	2	400
TOTAL RI	141.0	190.9	385	51,800
Attleboro	190.9	199.7	58	11,600
Mansfield	199.7	204.9	32	4,900
Foxborough	204.9	207.6	6	1,200
Sharon	207.6	212.7	1	200
Canton	212.7	216.2	9	1,800
Westwood	216.2	217.2	0	0
Dedham	217.2	218.9	14	2,800
Boston	218.9	228.8	127	12,500
TOTAL MA	190.9	228.8	247	35,000
TOTAL CORRIDOR	72.0	228.8	787	117,800

It is important to note that the barrier locations, lengths and heights estimated in this study are preliminary. Detailed barrier designs will be developed during the final design phase of the project, and the barriers will be constructed if they are found to be reasonable and feasible. Some of the factors that will need to be addressed at that point are the structural, aesthetic and acoustical feasibility of the barriers, as well as their cost effectiveness with respect to their acoustical benefits. For example, barriers that protect only one or two homes in one area are less likely to be constructed than those that protect large numbers of homes.

4.5.1.3 Receiver Noise Control. Although noise control at the receiver is usually least desirable, it provides an alternative approach where source or path treatments are not feasible. Potential mitigation measures include property acquisition or the application of sound-insulation treatment to noise-sensitive buildings within the impact zone. One disadvantage of sound-insulation treatment is that it has no effect on noise in exterior areas. However, it may be the best choice for sites where noise barriers are not feasible, and for schools or churches where indoor noise sensitivity is most important.

Substantial improvements in building sound insulation (on the order of 5 to 10 dBA) can usually be achieved by adding an extra layer of glazing to the windows, by improving the weather stripping around doors and windows, by sealing any holes in exterior surfaces that act as sound leaks, and by providing forced ventilation and air conditioning so that windows do not need to be opened. If warranted, such treatments will be investigated during the final design phase of the project.

4.5.2 Fixed Facility Noise Impact Mitigation

The assessment in Section 4.4.3.3 indicated that there is the potential for adverse noise impact to occur at 82 residences located near 3 substations, 2 switching stations and 8 paralleling stations along the project corridor. The sources of this potential impact include outdoor transformers and control building ventilation equipment. Mitigation measures that could be considered include sound-absorptive barrier walls in the case of transformer noise, and quiet fans and/or fan silencers in the case of ventilation equipment noise.

During the design phase of the project, when more detailed equipment information becomes available, the facility noise projections will be refined and mitigation measures will be further developed. Noise control treatments and specifications will then be incorporated into the project plans and construction contract documents to ensure that the electrical facility noise levels do not exceed the 45 dBA project noise criterion at any residential location.

4.5.3 Construction Noise Impact Mitigation

The noise impact assessment in Section 4.4.4 estimates that adverse construction noise impact will occur at 8 homes during construction at 3 electrical facilities, and at 21 homes during the replacement of 4 bridges along the project corridor. Although short-term impacts may occur at 78 homes during catenary installation and at 892 homes during the undercutting of 28 bridges along the corridor, these impacts are not expected to be adverse due to their limited duration.

There are a number of measures that can be taken to minimize intrusion without placing unreasonable constraints on the construction process or measurably increasing costs. These include noise monitoring to ensure that contractors take all reasonable steps to minimize noise, inspections and noise testing of equipment to ensure that all equipment on the site is in good condition and effectively muffled, and an active community liaison program.

It is essential that residents be kept informed about construction activities so they can plan around periods of particularly high noise levels, and that they have a means to express any concerns or complaints about noise. It is particularly important that residents be forewarned with regard to the dates, times and durations of all nighttime construction activities along the project corridor.

The primary construction noise impact mitigation measure is including specific noise control requirements in the construction specifications. These should require the contractor to:

1. Perform all construction in a manner to minimize noise. The contractor should be required to select construction processes and techniques that generate the lowest noise levels. Examples are using pre-drilled piles instead of impact pile driving, mixing concrete off site instead of on site, and using hydraulic tools instead of pneumatic impact tools.

2. Use equipment with effective mufflers. Diesel engines are often the major noise source on construction sites. Contractors should be required to employ equipment fitted with the most effective commercially-available mufflers.

3. Perform construction in a manner to maintain noise levels at noise-sensitive locations below specific limits.

4. Perform noise monitoring to demonstrate compliance with the noise limits. Independent noise monitoring should be performed to check compliance in particularly sensitive areas.

5. Select haul routes that minimize truck noise intrusion in residential areas.

4.5.4 Train Vibration Impact Mitigation

As indicated in Section 4.4.5.4, the train vibration evaluation projects a total of 1355 residences and one church to be within the zone of adverse impact for the project build alternative. All of these impacts are related to annoyance effects and not to building damage effects. The analysis also indicates that the primary sources of this impact are expected to be the increased Amtrak train frequency and speed. As for train noise, source, path and receiver vibration impact mitigation measures have been considered as described below.

4.5.4.1 Source Vibration Control. Train vibration control at the source can involve equipment and track-related measures as well as operational modifications. Since the source of ground-borne vibration is the wheel and rail interaction, equipment and track-related measures are essentially limited to ensuring good maintenance practices. However, as in the case of train noise mitigation, because Amtrak already has an on-going track maintenance program, maintenance alone cannot be relied upon to provide the required vibration mitigation.

Although a reduction of train frequency and speed would reduce the vibration impact, such operational measures are not feasible since increased speed and service are among the primary objectives of the corridor improvement project.

4.5.4.2 Path Vibration Control. Potential path vibration control treatments include (1) ballast mats, (2) floating slabs, (3) the use of wood rather than concrete ties and (4) trenches or underground barriers. These measures are discussed below.

- Ballast Mats. Ballast mats typically consist of a 2 to 3 inch thick elastomer mat placed under the normal track ballast. Most ballast mat installations are supported on concrete foundations in subway tunnels, or on concrete railroad bridges. Although there are some examples of ballast mats being installed for at-grade track, there is limited data on the effectiveness of at-grade installation. However, the available information indicates that ballast mats could reduce vibration levels along the Northeast Corridor by 3 to 6 dB in some locations, sufficient to eliminate much of the projected vibration impact in those areas.

  The main disadvantage of ballast mats is that they tend to be expensive, particularly for retrofit installations, and are not cost-effective to protect only a few houses.

- Floating Slabs. Floating slabs consist of 1-ft thick or thicker concrete slabs supported by resilient pads on a concrete foundation. The tracks are mounted on top of the floating slabs. Most successful floating slab installations are in subways. To use them with at-grade track, a concrete foundation must first be constructed for the slab to work against.

  Construction of a floating slab track bed is much more expensive than tie and ballast at-grade track construction, even with ballast mats. Therefore, floating slabs are unlikely to be cost effective for this project.

- Wood vs. Concrete Ties. There is some evidence that ground vibration levels can be as much as 5 dB lower for trains operating on wood tie and ballast track compared to trains operating on concrete tie and ballast track. However, the measurements made for this project did not indicate any significant difference in ground vibration level based on track usage at Northeast Corridor locations where one track had wood ties and the other track had concrete ties. Therefore, this is not likely to be an effective vibration impact mitigation measure for this project.

- Trenches or Underground Barriers. Although rarely used, a deep trench, 30 to 80 ft deep, can be an effective barrier to ground-borne vibration. The trench can be either open or filled with concrete or similar dense material. However, this is not likely to be a viable option for the Northeast Corridor.

Of the above measures, ballast mats appear to have the greatest potential to provide reliable and effective train vibration impact mitigation. A summary of the potential extent of this treatment is provided in Table 4-28, based on the vibration impact inventory. This table provides rough estimates of the length of ballast mat needed to mitigate train vibration impact for the build alternative in each community along the project corridor. The required lengths for ballast mats were estimated by assuming that 100 feet of the rail corridor would need to be treated to protect each affected residence, except in more densely populated areas where the lengths were estimated from land use maps. It is expected that 12.5-ft wide ballast mats would be required for each of the two high-speed tracks. The actual locations of the mats would be within the corridor milepost segments where vibration impact is projected to occur (see Table A-4 of Appendix 4.A).

The results in Table 4-28 estimate that ballast mats would be required along a total corridor length of 67,700 feet, or about 12.8 miles, to mitigate all train vibration impact. In terms of geographical distribution, 24 percent would be in Connecticut, 54 percent would be in Rhode Island and 22 percent would be in Massachusetts.

It is important to note that the ballast mat locations, lengths and widths developed in this study are preliminary. Site-specific investigations will be required during the final design phase of the project to determine where the use of ballast mats is reasonable and feasible. Some of the factors that must be addressed at that point are the frequency content of the ground-borne vibration at specific locations, which affects the performance of this treatment, as well as cost effectiveness.

With regard to feasibility, ballast mats may not be able to provide sufficient vibration reduction at locations where the ground-borne train vibration is dominated by very low-frequency components. Furthermore, ballast mats may not be cost effective in areas where there are a small number of homes to be protected. It will also be necessary to carefully select the ballast mat material and installation procedure to ensure adequate train vibration control.

4.5.4.3 Receiver Vibration Control. Practical vibration mitigation measures at the receiver are generally limited to property acquisition or the purchase of vibration easements. In cases where the cost of reducing ground-borne vibration levels to acceptable limits exceeds the value of the affected property, such measures may provide the most cost-effective means for train vibration impact mitigation.

TABLE 4-28. SUMMARY OF POTENTIAL TRAIN VIBRATION MITIGATION

MUNICIPALITY	MILEPOST From	MILEPOST To	NUMBER OF IMPACTED RESIDENCES	POTENTIAL BALLAST MAT Length (ft)
New Haven	72.0	77.0	1	100
East Haven	77.0	79.0	0	0
Branford	79.0	86.0	4	400
Guilford	86.0	90.5	5	500
Madison	90.5	94.9	1	100
Clinton	94.9	98.9	0	0
Westbrook	98.9	102.5	0	0
Old Saybrook	102.5	106.6	2	200
Old Lyme	106.6	112.3	19	1,900
East Lyme	112.3	116.7	36	3,600
Waterford	116.7	121.1	9	900
New London	121.1	123.9	10	1,000
Groton	123.9	132.5	8	800
Stonington	132.5	141.0	67	6,700
TOTAL CT	72.0	141.0	162	16,200
Westerly	141.0	146.1	12	1,200
Hopkinton	146.1	147.2	0	0
Charlestown	147.2	153.6	7	700
Richmond	150.3	155.8	13	1,300
South Kingstown	155.8	160.7	8	800
Exeter	160.7	161.9	0	0
North Kingstown	161.9	170.8	92	6,600
East Greenwich	170.8	172.1	33	3,300
Warwick	172.1	178.8	243	17,200
Cranston	178.8	181.0	0	0
Providence	181.0	187.5	6	600
Pawtucket	187.5	189.8	13	1,300
Central Falls	189.8	190.9	34	3,400
TOTAL RI	141.0	190.9	461	36,400
Attleboro	190.9	199.7	83	8,300
Mansfield	199.7	204.9	3	300
Foxborough	204.9	207.6	0	0
Sharon	207.6	212.7	0	0
Canton	212.7	216.2	18	1,000
Westwood	216.2	217.2	0	0
Dedham	217.2	218.9	73	1,500
Boston	218.9	228.8	555	4,000
TOTAL MA	190.9	228.8	732	15,100
TOTAL CORRIDOR	72.0	228.8	1355	67,700

4.5.5 Construction Vibration Impact Mitigation

As indicated in Section 4.4.6.3, adverse construction vibration impact is anticipated at 2 residences during construction of one paralleling station, and at 14 homes during the replacement of 3 bridges along the project corridor. The greatest potential source of construction vibration impact is pile driving for the bridge replacements. All of the potential impacts identified are related to annoyance effects and not to building damage effects, and will occur during daytime hours. Although short-term impacts may occur at 17 homes during nighttime catenary installation, these impacts are not expected to be adverse due to their limited duration.

The following are some procedures that can be used to minimize the potential for annoyance from construction vibration:

1. Restrict procedures that contractors can use in vibration sensitive areas, and specify alternative techniques that generate lower vibration levels. For example, using the cast-in-drilled-hole piling method instead of impact pile driving would elir ıate most potential for vibration impact from the piling.

2. Restrict the hours of vibration-intensive activities, such as pile driving, to weekdays during daytime hours.

3. Require vibration monitoring during vibration-intensive activities.

4.6 CONCLUSIONS

The results of the noise and vibration technical study suggest that the most significant consequences of the Northeast Corridor North End Electrification Project will be increased train noise and ground-borne vibration resulting from increased Amtrak train frequency and speed. However, it is expected that all of this impact can be mitigated to existing levels or below, subject to available funding. The conclusions of the study are summarized below in each of the various environmental impact categories.

4.6.1 Train Noise Impact

Without mitigation, it is projected that a total of 787 residences, 2 churches and 2 recreational areas will experience adverse noise impact from train operations for the project build alternative. However, it is expected that nearly all of this impact can be mitigated by installing about 22.3 miles of wayside noise barriers.

At locations where barriers are not feasible, due to receiver height, low cost-effectiveness, or the creation of other impacts (e.g. blocking valuable views), building sound-insulation treatment or property acquisition are alternative measures. Other potential mitigation measures include source treatments, such as eliminating the remaining at-grade crossings to reduce train horn noise, and instituting enhanced track and vehicle maintenance programs to minimize wheel/rail noise.

4.6.2 Traffic Noise Impact

The assessment results indicate that traffic noise impact due to the project in the vicinity of the train stations is not expected to be adverse. Therefore, traffic noise impact mitigation measures are not required.

4.6.3 Fixed Facility Noise Impact

Without mitigation, adverse noise impact is projected at 82 residences in the vicinity of 3 substations, 2 switching stations and 8 paralleling stations due to transformer and ventilation equipment at these facilities. However, it is expected that all of this impact can be mitigated by incorporating sound-absorptive barrier walls, quiet fans and/or fan silencers into the facility design. During final design, noise control treatments and specifications will be incorporated into the project plans and construction contract documents as required to ensure that the electrical facility noise levels do not exceed the project noise impact criteria.

4.6.4 Construction Noise Impact

Without mitigation, it is projected that adverse construction noise impact will occur at 8 homes during construction at 3 electrical facilities, and at 21 homes during the replacement of 4 bridges along the project corridor. Although short-term impacts may occur at 78 homes during catenary installation and at 892 homes during the undercutting of 28 bridges along the corridor, these impacts are not expected to be adverse due to their limited duration.

It is expected that most construction noise impact can be mitigated by including specific noise control requirements in the construction contract specifications. These should require contractors to select the equipment and techniques that generate the lowest noise levels, use equipment with effective mufflers, certify compliance with noise limits by monitoring, and select haul routes that minimize truck noise intrusion in the surrounding communities.

In addition to the specification requirements, an active community liaison program is essential to ensure that residents are kept informed about construction activities, and that they have a means to express any concerns or complaints with regard to construction noise. This is particularly important in areas where nighttime construction activities will occur.

4.6.5 Train Vibration Impact

Without mitigation, it is projected that 1355 residences and one church will experience adverse vibration impact from train operation for the project build alternative. All of this impact is related to occupant annoyance rather than building damage.

A potential mitigation measure that targets the major train vibration source is instituting enhanced track and vehicle maintenance programs to minimize vibration from wheel/rail interaction. However, because Amtrak already has an on-going track maintenance program, maintenance alone cannot be relied upon to provide the required vibration mitigation.

However, it is expected that most of the train vibration impact can be mitigated by the installation of about 12.8 miles of ballast mat track-bed treatment. At locations where ballast mats are not feasible, due to the frequency content of the train vibration or to low cost-effectiveness, property acquisition and the purchase of vibration easements are alternative measures.

4.6.6 Construction Vibration Impact

Without mitigation, adverse construction vibration impact is anticipated at 2 residences during construction of one paralleling station, and at 14 homes during the replacement of 3 bridges along the project corridor. The greatest potential source of construction vibration impact is pile driving for the bridge replacements. All of the potential impacts identified are related to annoyance effects and not to building damage effects, and will occur during daytime hours. Although short-term impacts may occur at 17 homes during nighttime catenary installation, these impacts are not expected to be adverse due to their limited duration.

It is expected that construction vibration impacts can be mitigated by restricting the procedures and time periods for vibration-intensive activities in vibration-sensitive areas, and by requiring vibration monitoring to certify compliance with vibration limits in such cases. These measures are primarily applicable to pile driving operations.

APPENDIX A: NOISE AND VIBRATION DATA SUMMARY TABLES

TABLE A-1. TRAIN SOURCE NOISE MEASUREMENT DATA

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	NOISE LEVEL(dBA)	
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	Lmax	SEL
A-1	11-05-92	Amtrak	Diesel	1	7	100	64	87.1	92.8
				1	4	100	56	86.2	89.9
				1	7	88	67	86.5	93.0
				1	3	88	59	85.1	89.4
		Commuter	Diesel	1	3	100	55	84.8	89.3
				1	3	100	59	89.9	94.0
				1	3	88	57	95.6	99.5
A-2	11-04-92	Amtrak	Diesel	1	6	105	41	79.9	86.7
				1	7	105	75	82.6	88.1
				1	5	105	73	88.4	92.6
				1	5	117	68	82.4	88.3
				1	4	117	68	83.1	87.9
		Commuter	Diesel	1	3	105	38	91.1	98.6
				1	5	117	75	91.3	95.9
A-3	11-02-92	Amtrak	Diesel	1	6	80	63	88.2	95.2
				1	5	80	70	91.4	96.4
				1	5	80	80	92.2	97.8
				1	7	92	61	84.8	90.3
				1	4	92	51	84.0	87.9
A-3a	11-05-92	Amtrak	Diesel	1	5	35	52	94.0	99.3
				1	5	48	62	103.0	103.0
				1	4	35	70	97.8	97.4
				2	6	48	66	107.0	109.0
A-4	11-03-92	Amtrak	Diesel	1	8	85	78	104.0	107.0
				1	4	85	60	109.0	110.0
				1	5	73	76	104.0	105.0
				1	5	73	75	105.0	107.0
				1	4	73	79	105.0	105.0
A-5	10-30-92	Amtrak	Diesel	1	7	53	74	92.2	96.2
				1	6	53	75	94.3	98.7
				1	6	66	80	92.5	94.7
				1	5	66	83	91.6	93.2
				1	5	66	75	88.4	91.5
A-6	10-30-92	Amtrak	Diesel	1	8	63	80	95.9	100.0
				1	5	63	74	93.9	97.6
				1	7	63	86	97.1	100.0
				1	9	63	85	102.0	103.0
A-7	10-29-92	Amtrak	Diesel	1	6	25	66	87.3	91.6

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	NOISE LEVEL(dBA)	
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	Lmax	SEL
A-7	10-29-92	Amtrak	Diesel	1	5	38	54	89.1	93.0
				1	4	38	48	86.9	90.4
				1	4	25	53	93.7	99.4
				1	5	38	49	94.0	99.8
		Commuter	Diesel	1	6	38	60	88.1	96.2
				1	5	25	42	94.2	102.0
A-8	10-29-92	Amtrak	Diesel	1	3	119	71	85.7	89.4
				1	5	119	53	85.5	88.2
				1	5	119	61	87.8	90.8
				2	7	134	101	85.7	90.3
		Commuter	Diesel	1	7	119	74	83.5	89.8
				1	7	119	74	86.1	92.9
				1	7	134	75	86.6	90.8
				1	7	134	77	84.0	89.9
				1	7	134	71	85.3	92.1
				1	8	134	76	86.8	92.9
A-9	10-27-92	Amtrak	Diesel	1	4	75	82	91.8	94.6
				1	3	75	67	92.3	94.6
				2	6	60	78	92.7	97.2
		Commuter	Diesel	1	7	75	38	89.0	94.7
				1	7	75	31	88.5	95.7
				1	9	75	31	89.1	96.5
				1	7	60	74	96.2	99.5
				1	7	60	54	89.4	96.2
A-10	10-28-92	Amtrak	Diesel	1	5	85	64	91.0	92.4
				1	5	85	83	90.3	92.6
				1	11	70	88	95.2	100.0
		Commuter	Diesel	1	7	85	60	90.2	94.8
				1	7	70	49	90.2	96.3
				1	7	85	62	91.0	98.1
				1	9	70	48	87.4	95.5
				1	5	70	56	90.0	96.0
				1	7	85	67	90.4	94.3
				1	7	70	51	91.3	96.3
				1	7	85	72	87.0	90.4
				1	7	70	61	90.8	95.0
				1	7	100	42	96.2	88.2
				1	7	70	50	90.0	95.1
				1	9	70	49	88.6	95.7
				1	7	70	53	91.2	95.8
B-1	11-05-92	Amtrak	Diesel	1	5	100	64	87.0	94.4

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	NOISE LEVEL(dBA)	
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	Lmax	SEL
				1	4	100	59	85.0	91.7
				1	5	100	66	85.0	92.2
				1	6	113	73	83.0	91.3
				1	3	113	63	82.0	88.8
B-2	11-02-92	Amtrak	Diesel	1	7	75	66	81.0	88.4
				1	5	75	73	81.0	88.3
				1	4	88	73	87.0	91.2
				1	6	88	71	84.0	90.0
		Freight	Diesel	1	8	88	48	81.0	90.8
B-3	10-30-92	Amtrak	Diesel	1	6	100	100	83.0	87.5
				1	7	113	88	79.0	84.5
	11-06-92	Amtrak	Diesel	1	7	73	101	89.6	95.9
				1	5	85	92	89.0	94.4
B-4	10-30-92	Amtrak	Diesel	1	7	100	76	90.0	96.4
				1	8	100	83	88.0	95.7
				1	5	100	93	86.0	92.6
				2	9	113	99	91.0	98.2
		Freight	Diesel	2	14	113	44	88.0	93.7
B-5	10-29-92	Amtrak	Diesel	1	6	100	90	92.0	97.9
				1	5	100	91	91.0	97.4
				1	4	100	96	91.0	96.3
		Commuter	Diesel	1	7	100	72	93.0	100.3
				1	7	113	78	93.0	99.5
				1	7	113	72	88.0	95.2
		Freight	Diesel	2	20	100	52	85.0	94.8
				2	16	113	39	82.0	94.1
B-6	10-29-92	Amtrak	Diesel	2	7	100	99	80.0	85.5
				1	4	113	89	85.0	87.7
				1	5	113	81	80.0	85.6
				1	5	113	94	81.0	85.5
		Commuter	Diesel	1	8	100	55	75.0	83.9
				1	7	100	58	75.0	81.4
				1	7	100	62	76.0	81.4
				1	7	113	40	81.0	87.9
				1	7	113	72	78.0	80.0
C-1	11-05-92	Amtrak	Electric	2	10	100	81	79.0	88.4
				1	6	113	74	82.0	89.3
				1	5	113	71	79.0	86.5
				1	6	113	84	79.0	85.4
C-2	10-22-92	Amtrak	Electric	2	11	110	79	89.3	94.5
				1	5	123	85	86.6	91.9

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	NOISE LEVEL(dBA)	
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	Lmax	SEL
				1	6	97	104	87.6	92.9
				1	9	84	85	95.2	100.6
				1	6	123	85	81.3	88.0
				1	8	97	96	87.1	92.5
				1	6	97	84	84.4	91.1
				1	8	110	80	87.6	93.2
				1	5	97	110	83.5	89.2
				1	5	123	55	73.0	81.6
				1	6	97	99	84.5	90.0
	03-03-93	Amtrak	Electric	1	6	76	104	83.3	89.5
				1	7	50	80	88.8	95.8
				1	6	76	106	90.3	93.5
				1	5	63	108	87.9	92.6
				1	8	76	105	85.2	91.4
				1	5	76	106	84.8	90.3
				1	18	76	72	87.1	84.0
				1	9	76	95	83.3	90.5
				1	5	50	67	86.4	93.3
				1	6	76	34	74.7	81.7
		X2000	Electric	1	5	63	81	84.3	88.9
				1	5	76	113	85.0	89.8
C-3	03-05-93	Amtrak	Electric	1	8	63	102	95.8	101.6
				1	16	63	90	97.6	105.3
				1	5	76	84	91.2	95.7
				1	6	50	84	93.7	100.3
				1	6	63	109	93.5	99.0
				1	6	76	111	94.5	99.0
				1	9	63	95	94.0	100.1
				1	18	50	79	101.0	108.9
				1	6	76	120	93.0	98.3
		X2000	Electric	1	5	76	127	94.0	98.1
				1	5	63	135	95.8	100.4

TABLE A-2. TRAIN NOISE IMPACT DISTANCE SUMMARY

MUNICIPALITY*	MILEPOST		DISTANCE TO SIGNIFICANT NOISE IMPACT (ft)**			
	From	To	RESIDENCES		INSTITUTIONAL BLDGS	
			BUILD	NO-BUILD	BUILD	NO-BUILD
New Haven	72.2	72.5	25	25	25	25
New Haven	72.5	73.3	25	25	25	25
New Haven	73.3	73.7	25	25	25	25
New Haven	73.7	74.2	40	25	25	25
New Haven	74.2	74.7	25	25	25	25
New Haven	74.7	76.0	40	25	25	25
New Haven	76.0	76.3	50	25	25	25
New Haven	76.3	76.6	25	25	25	25
New Haven	76.6	76.8	25	25	25	25
New Haven	76.8	77.0	25	25	25	25
East Haven	77.0	77.6	50	25	25	25
East Haven	77.6	78.1	40	25	25	25
East Haven	78.1	79.0	40	25	25	25
Branford	79.0	79.5	50	25	25	25
Branford	79.5	80.0	40	25	25	25
Branford	80.0	81.2	50	25	25	25
Branford	81.2	82.0	40	25	25	25
Branford	82.0	82.7	75	25	25	25
Branford	82.7	83.9	75	25	25	25
Branford	83.9	84.7	100	25	25	25
Branford	84.7	85.1	50	25	25	25
Branford	85.1	86.0	75	25	25	25
Guilford	86.0	86.5	75	25	25	25
Guilford	86.5	87.4	75	25	25	25
Guilford	87.4	88.3	75	25	25	25
Guilford	88.3	90.5	100	25	40	25
Madison	90.5	91.0	100	25	40	25
Madison	91.0	91.3	100	25	40	25
Madison	91.3	91.7	100	25	25	25
Madison	91.7	93.0	75	25	25	25
Madison	93.0	94.6	75	25	25	25

* (H) indicates noise from TRAIN HORNS is dominant source

** Distance measured from centerline of rail corridor

MUNICIPALITY*	MILEPOST		DISTANCE TO SIGNIFICANT NOISE IMPACT (ft)**			
	From	To	RESIDENCES		INSTITUTIONAL BLDGS	
			BUILD	NO-BUILD	BUILD	NO-BUILD
Madison	94.6	94.9	75	25	25	25
Clinton	94.9	95.3	75	25	25	25
Clinton	95.3	95.9	100	25	40	25
Clinton	95.9	96.0	75	25	25	25
Clinton	96.0	96.5	100	25	25	25
Clinton	96.5	97.1	100	25	25	25
Clinton	97.1	98.9	100	25	25	25
Westbrook	98.9	99.6	100	25	25	25
Westbrook	99.6	100.5	50	25	25	25
Westbrook	100.5	101.3	75	25	25	25
Westbrook	101.3	102.0	75	25	25	25
Westbrook	102.0	102.5	50	25	25	25
Old Saybrook	102.5	102.8	75	25	25	25
Old Saybrook	102.8	103.6	75	25	25	25
Old Saybrook	103.6	103.9	75	25	25	25
Old Saybrook	103.9	104.7	50	25	25	25
Old Saybrook	104.7	105.1	40	25	25	25
Old Saybrook	105.1	105.9	75	25	25	25
Old Saybrook	105.9	106.6	50	40	25	25
Old Lyme	106.6	107.3	75	25	25	25
Old Lyme	107.3	107.5	125	25	40	25
Old Lyme	107.5	108.8	100	25	40	25
Old Lyme	108.8	109.2	125	25	40	25
Old Lyme	109.2	109.6	100	25	40	25
Old Lyme	109.6	110.0	100	25	40	25
Old Lyme	110.0	110.6	100	25	25	25
Old Lyme	110.6	111.4	100	25	40	25
Old Lyme	111.4	111.7	100	25	25	25
Old Lyme	111.7	111.9	40	25	25	25
Old Lyme (H)	111.9	112.3	500	75	25	25
East Lyme	112.3	112.8	75	40	25	25
East Lyme	112.8	113.0	75	25	25	25
East Lyme	113.0	113.5	40	25	25	25

* (H) indicates noise from TRAIN HORNS is dominant source
** Distance measured from centerline of rail corridor

MUNICIPALITY*	MILEPOST		DISTANCE TO SIGNIFICANT NOISE IMPACT (ft)**			
	From	To	RESIDENCES		INSTITUTIONAL BLDGS	
			BUILD	NO-BUILD	BUILD	NO-BUILD
East Lyme	113.5	113.8	100	25	40	25
East Lyme	113.8	115.0	100	25	25	25
East Lyme	115.0	115.5	75	25	25	25
East Lyme	115.5	116.0	100	25	25	25
East Lyme	116.0	116.5	75	25	25	25
East Lyme	116.5	116.7	50	25	25	25
Waterford	116.7	116.9	50	25	25	25
Waterford	116.9	117.2	40	25	25	25
Waterford	117.2	118.2	75	25	25	25
Waterford	118.2	119.1	75	25	25	25
Waterford	119.1	119.9	50	25	25	25
Waterford (H)	119.9	120.5	100	75	25	25
Waterford	120.5	120.7	75	25	25	25
Waterford	120.7	121.1	40	25	25	25
New London	121.1	122.0	75	25	25	25
New London	122.0	122.5	75	40	25	25
New London (H)	122.5	123.0	50	50	25	25
New London (H)	123.0	123.5	25	25	25	25
New London	123.5	123.9	40	25	25	25
Groton	123.9	124.3	75	25	25	25
Groton	124.3	124.5	75	25	25	25
Groton	124.5	124.7	100	25	25	25
Groton	124.7	125.0	100	25	25	25
Groton	125.0	126.0	25	25	25	25
Groton	126.0	127.0	100	25	25	25
Groton	127.0	127.3	100	25	25	25
Groton	127.3	128.9	75	25	25	25
Groton	128.9	129.5	75	25	25	25
Noank	129.5	130.2	50	25	25	25
West Mystic	130.2	131.3	100	25	25	25
West Mystic (H)	131.3	131.7	75	25	25	25
West Mystic	131.7	132.0	50	25	25	25
West Mystic	132.0	132.2	40	25	25	25

* (H) indicates noise from TRAIN HORNS is dominant source

** Distance measured from centerline of rail corridor

MUNICIPALITY*	MILEPOST		DISTANCE TO SIGNIFICANT NOISE IMPACT (ft)**			
	From	To	RESIDENCES		INSTITUTIONAL BLDGS	
			BUILD	NO-BUILD	BUILD	NO-BUILD
Mystic (H)	132.2	132.5	500	25	25	25
Stonington	132.5	132.8	40	25	25	25
Stonington	132.8	133.2	75	25	25	25
Stonington (H)	133.2	133.6	400	25	25	25
Stonington	133.6	133.8	40	25	25	25
Stonington	133.8	134.7	75	25	25	25
Stonington (H)	134.7	135.2	75	25	25	25
Stonington	135.2	135.5	75	25	25	25
Stonington	135.5	136.1	75	25	25	25
Stonington	136.1	136.5	75	25	25	25
Stonington (H)	136.5	137.2	400	25	25	25
Stonington	137.2	137.6	125	25	40	25
Stonington	137.6	138.5	75	25	25	25
Stonington	138.5	139.1	100	25	25	25
Stonington	139.1	139.7	75	25	25	25
Stonington	139.7	140.0	100	25	25	25
Stonington (H)	140.0	141.0	200	25	25	25
Westerly	141.0	141.3	100	25	25	25
Westerly	141.3	141.8	100	25	25	25
Westerly	141.8	142.5	75	25	25	25
Westerly	142.5	144.6	100	25	40	25
Westerly	144.6	146.1	100	25	25	25
Richmond	146.1	147.2	100	25	25	25
Charlestown	147.2	147.9	75	25	25	25
Charlestown	147.9	148.5	75	25	25	25
Charlestown	148.5	149.3	100	25	40	25
Richmond	149.3	150.3	75	25	25	25
Charlestown	150.3	151.8	75	25	25	25
Charlestown	151.8	152.3	100	25	40	25
Richmond	152.3	153.0	100	25	40	25
Charlestown	153.0	153.4	100	25	40	25
Charlestown	153.4	153.6	75	25	25	25
Richmond	153.6	154.5	75	25	25	25

* (H) indicates noise from TRAIN HORNS is dominant source
** Distance measured from centerline of rail corridor

MUNICIPALITY*	MILEPOST		DISTANCE TO SIGNIFICANT NOISE IMPACT (ft)**			
	From	To	RESIDENCES		INSTITUTIONAL BLDGS	
			BUILD	NO-BUILD	BUILD	NO-BUILD
Richmond	154.5	155.8	150	25	75	25
Kingston	155.8	157.3	125	25	50	25
Kingston	157.3	157.9	125	25	40	25
Kingston	157.9	158.2	125	40	40	25
Kingston	158.2	159.2	125	50	40	25
Kingston	159.2	159.5	200	50	75	25
Kingston (H)	159.5	160.7	1700	280	25	25
Exeter	160.7	161.9	250	40	75	25
N. Kingston	161.9	165.0	150	50	50	25
N. Kingston	165.0	166.1	200	50	50	25
N. Kingston	166.1	168.8	200	50	50	25
N. Kingston	168.8	170.3	200	50	50	25
N. Kingston	170.3	170.8	100	40	40	25
E. Greenwich	170.8	171.3	150	50	40	25
E. Greenwich	171.3	171.8	100	40	40	25
E. Greenwich	171.8	172.1	150	50	40	25
Warwick	172.1	172.3	150	40	40	25
Warwick	172.3	173.0	150	40	40	25
Warwick	173.0	173.7	100	40	40	25
Warwick	173.7	174.1	150	40	40	25
Warwick	174.1	174.6	150	40	40	25
Warwick	174.6	176.3	125	40	40	25
Warwick	176.3	177.8	150	75	50	25
Warwick	177.8	178.8	125	40	40	25
Cranston	178.8	179.7	125	40	40	25
Cranston	179.7	180.3	100	40	40	25
Cranston	180.3	180.6	100	40	40	25
Cranston	180.6	181.0	75	25	25	25
Providence	181.0	181.9	100	40	25	25
Providence	181.9	182.7	40	25	25	25
Providence	182.7	183.2	75	40	25	25
Providence	183.2	183.9	50	25	25	25
Providence	183.9	184.9	75	25	25	25

* (H) indicates noise from TRAIN HORNS is dominant source

** Distance measured from centerline of rail corridor

MUNICIPALITY*	MILEPOST		DISTANCE TO SIGNIFICANT NOISE IMPACT (ft)**			
	From	To	RESIDENCES		INSTITUTIONAL BLDGS	
			BUILD	NO-BUILD	BUILD	NO-BUILD
Providence	184.9	185.2	25	25	25	25
Providence	185.2	185.6	25	25	25	25
Providence	185.6	186.1	25	25	25	25
Providence	186.1	186.7	75	25	25	25
Providence	186.7	187.5	100	25	25	25
Pawtucket	187.5	188.5	75	25	25	25
Pawtucket	188.5	189.8	25	25	25	25
Central Falls	189.8	190.2	25	25	25	25
Central Falls	190.2	190.6	50	25	25	25
Central Falls	190.6	190.9	75	25	25	25
Attleboro	190.9	191.5	40	25	25	25
Attleboro	191.5	192.3	100	25	40	25
Attleboro	192.3	193.0	75	25	25	25
Attleboro	193.0	193.4	75	25	25	25
Attleboro	193.4	195.0	75	25	25	25
Attleboro	195.0	195.7	100	25	40	25
Attleboro	195.7	196.2	100	25	25	25
Attleboro	196.2	196.7	125	25	40	25
Attleboro	196.7	197.0	125	25	50	25
Attleboro	197.0	198.2	100	25	40	25
Attleboro	198.2	198.9	100	25	40	25
Attleboro (H)	198.9	199.7	250	25	25	25
W. Mansfield	199.7	200.4	125	100	40	25
W. Mansfield	200.4	200.9	100	25	40	25
W. Mansfield	200.9	202.4	125	25	40	25
W. Mansfield	202.4	203.1	100	25	25	25
Mansfield	203.1	204.2	125	25	40	25
Mansfield	204.2	204.9	125	25	40	25
Foxboro	204.9	205.5	100	25	40	25
Foxboro	205.5	207.6	100	25	40	25
Sharon	207.6	209.3	100	25	40	25
Sharon	209.3	209.7	100	25	25	25
Sharon	209.7	211.0	125	25	40	25

* (H) indicates noise from TRAIN HORNS is dominant source
** Distance measured from centerline of rail corridor

MUNICIPALITY*	MILEPOST		DISTANCE TO SIGNIFICANT NOISE IMPACT (ft)**			
	From	To	RESIDENCES		INSTITUTIONAL BLDGS	
			BUILD	NO-BUILD	BUILD	NO-BUILD
Sharon	211.0	211.7	100	25	25	25
Sharon	211.7	212.7	100	25	25	25
Canton	212.7	213.4	100	25	25	25
Canton	213.4	214.0	100	25	25	25
Canton	214.0	214.6	40	25	25	25
Canton	214.6	215.2	40	25	25	25
Canton	215.2	216.2	50	25	25	25
Canton	216.2	217.2	40	25	25	25
Dedham	217.2	217.5	25	25	25	25
Dedham	217.5	218.5	75	25	25	25
Dedham	218.5	218.7	75	25	25	25
Dedham	218.7	218.9	75	25	25	25
Boston	218.9	219.2	100	25	25	25
Boston	219.2	219.8	75	25	25	25
Boston	219.8	220.0	75	25	25	25
Boston	220.0	221.1	75	25	25	25
Boston	221.1	221.8	50	25	25	25
Boston	221.8	222.3	75	25	25	25
Boston	222.3	223.4	75	25	25	25
Boston	223.4	223.8	40	25	25	25
Boston	223.8	224.7	40	25	25	25
Boston	224.7	225.7	40	25	25	25
Boston	225.7	227.0	25	25	25	25
Boston	227.0	227.5	25	25	25	25
Boston	227.5	227.6	25	25	25	25
Boston	227.6	227.7	25	25	25	25
Boston	227.7	228.3	25	25	25	25
Boston	228.3	228.5	25	25	25	25
Boston	228.5	228.8	25	25	25	25

* (H) indicates noise from TRAIN HORNS is dominant source

** Distance measured from centerline of rail corridor

TABLE A-3. TRAIN SOURCE VIBRATION MEASUREMENT DATA

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	MAXIMUM RMS VIBRATION VELOCITY LEVEL
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	(dB re 1 μin./sec)
A-1	11-05-92	Amtrak	Diesel	1	7	100	64	85
				1	4	100	56	85
				1	7	88	67	86
				1	3	88	59	85
		Commuter	Diesel	1	3	100	55	72
				1	3	100	59	83
				1	3	88	57	76
A-2	11-04-92	Amtrak	Diesel	1	6	105	41	70
				1	7	105	75	76
				1	5	105	73	75
				1	5	117	68	75
				1	4	117	68	75
		Commuter	Diesel	1	3	105	38	67
				1	5	117	75	71
A-3	11-02-92	Amtrak	Diesel	1	6	80	63	85
				1	5	80	70	86
				1	5	80	80	86
				1	7	92	61	83
				1	4	92	51	82
A-3a	11-05-92	Amtrak	Diesel	1	5	35	52	79
				1	5	48	62	76
				1	4	35	70	82
				2	6	48	66	79
A-4	11-03-92	Amtrak	Diesel	1	8	85	78	85
				1	4	85	60	81
				1	5	73	76	86
				1	5	73	75	86
				1	4	73	79	87
A-5	10-30-92	Amtrak	Diesel	1	7	53	74	92
				1	6	53	75	91
				1	6	66	80	92
				1	5	66	83	90
				1	5	66	75	91
A-6	10-30-92	Amtrak	Diesel	1	8	63	80	92
				1	5	63	74	90
				1	7	63	86	92
				1	9	63	85	94

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	MAXIMUM RMS VIBRATION VELOCITY LEVEL
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	(dB re 1 μin./sec)
A-7	10-29-92	Amtrak	Diesel	1	6	25	66	106
				1	5	38	54	94
				1	4	38	48	92
				1	4	25	53	96
				1	5	38	49	95
		Commuter	Diesel	1	6	38	60	90
				1	5	25	42	94
A-8	10-29-92	Amtrak	Diesel	1	3	119	71	74
				1	5	119	53	73
				1	5	119	61	74
				2	7	134	101	73
		Commuter	Diesel	1	7	119	74	68
				1	7	119	74	69
				1	7	134	75	69
				1	7	134	77	69
				1	7	134	71	68
				1	8	134	76	70
A-9	10-27-92	Amtrak	Diesel	1	4	75	82	67
				1	3	75	67	64
				2	6	60	78	70
		Commuter	Diesel	1	7	75	38	60
				1	7	75	31	60
				1	7	60	74	70
				1	7	60	54	66
A-10	10-28-92	Amtrak	Diesel	1	5	85	64	84
				1	5	85	83	84
				1	11	70	88	87
		Commuter	Diesel	1	7	85	60	82
				1	7	70	49	82
				1	7	85	62	86
				1	9	70	48	81
				1	5	70	56	83
				1	7	85	67	84
				1	7	70	51	84
				1	7	85	72	83
				1	7	70	61	83
				1	7	100	42	78
				1	7	70	50	84
				1	9	70	49	82
				1	7	70	53	82

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	MAXIMUM RMS VIBRATION VELOCITY LEVEL
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	(dB re 1 μin./sec)
B-1	11-04-92	Amtrak	Diesel	1	3	38	63	84
						63		83
						88		73
						113		53
						163		55
				1	4	25	59	85
						50		83
						75		79
						100		56
						150		53
				1	5	25	64	88
						50		76
						75		77
						100		57
						150		54
				1	5	25	66	89
						50		89
						75		78
						100		71
						150		56
				1	6	38	75	84
						63		83
						88		71
						113		67
						163		55
B-2	11-05-92	Amtrak	Diesel	1	7	50	66	81
						75		81
						100		78
						150		73
						200		65
				1	6	63	71	80
						88		81
						113		75
						163		70
						213		64
				1	5	50	73	80
						75		80
						100		78
						150		72
						200		64

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	MAXIMUM RMS VIBRATION VELOCITY LEVEL (dB re 1 μin./sec)
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	
B-2	11-05-92	Amtrak	Diesel	1	4	63	73	79
						88		81
						113		75
						163		70
						213		63
		Freight	Diesel	1	8	63	57	75
						88		74
						113		71
						163		67
						213		59
B-3	10-30-92	Amtrak	Diesel	1	7	44	88	88
						63		85
						88		82
						113		84
						163		78
				1	6	31	100	91
						50		90
						75		84
						100		88
						150		78
B-4	10-30-92	Amtrak	Diesel	1	5	27	93	83
						50		81
						75		72
						100		70
						150		68
				1	7	27	76	85
						50		81
						75		73
						100		72
						150		67
				1	7	27	72	83
						50		80
						75		71
						100		71
						150		68
				2	9	40	99	85
						63		82
						88		73
						113		71
						163		62

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	MAXIMUM RMS VIBRATION VELOCITY LEVEL
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	(dB re 1 μin./sec)
B-4	10-30-92	Freight	Diesel	2	14	40	52	82
						63		77
						88		69
						113		65
						163		61
B-5	10-29-92	Amtrak	Diesel	1	4	36	102	91
						63		88
						88		88
						113		83
						163		76
				1	5	23	91	90
						50		88
						75		86
						100		79
						150		77
				1	4	23	96	90
						50		87
						75		84
						100		78
						150		75
				1	6	23	90	91
						50		87
						75		84
						100		80
						150		75
				1	4	36	101	88
						63		87
						88		88
						113		83
						163		76
		Commuter	Diesel	1	7	36	72	86
						63		84
						88		83
						113		80
						163		74
				1	7	36	78	88
						63		84
						88		86
						113		80
						163		76

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	MAXIMUM RMS VIBRATION VELOCITY LEVEL
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	(dB re 1 μin./sec)
B-5	10-29-92	Commuter	Diesel	1	7	23	72	88
						50		83
						75		84
						100		77
						150		75
B-6	10-29-92	Amtrak	Diesel	1	5	38	81	91
						63		87
						88		88
						113		85
						163		81
				1	5	38	94	91
						63		88
						88		88
						113		85
						163		80
				1	4	38	89	90
						63		87
						88		87
						113		84
						163		80
				2	7	25	99	91
						50		88
						75		87
						100		83
						150		81
		Commuter	Diesel	1	8	25	55	87
						50		83
						75		83
						100		79
						150		77
				1	7	25	62	86
						50		82
						75		81
						100		78
						150		74
				1	7	25	58	86
						50		82
						75		81
						100		79
						150		74

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	MAXIMUM RMS VIBRATION VELOCITY LEVEL
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	(dB re 1 μin./sec)
B-6	10-29-92	Commuter	Diesel	1	7	38	40	83
						63		80
						88		81
						113		77
						163		72
				1	7	38	42	87
						63		85
						88		83
						113		80
						163		77
C-1	11-03-92	Amtrak	Electric	2	10	25	64	89
						50		79
						75		73
						100		63
						150		60
				1	6	38	73	79
						63		76
						88		73
						113		64
						163		57
				1	5	38	69	76
						63		71
						88		67
						113		55
						163		54
				1	5	38	70	79
						63		67
						88		62
						113		65
						163		56
	11-05-92	Amtrak	Electric	1	6	38	84	67
						63		68
						88		63
						113		64
						163		57
				1	5	38	71	66
						63		68
						88		63
						113		64
						163		56

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	MAXIMUM RMS VIBRATION VELOCITY LEVEL
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	(dB re 1 μin./sec)
C-1	11-05-92	Amtrak	Electric	1	6	38	74	67
						63		70
						88		63
						113		65
						163		58
				2	10	25	81	73
						50		68
						75		64
						100		66
						150		59
C-2	03-03-93	Amtrak	Electric	1	6	51	104	82
						76		78
						101		71
						126		69
						176		64
				1	7	25	80	90
						50		86
						75		80
						100		76
						150		66
				1	6	51	106	82
						76		78
						101		73
						126		71
						176		64
				1	5	38	108	86
						63		77
						88		72
						113		69
						163		62
				1	8	51	105	82
						76		77
						101		72
						126		70
						176		64
				1	5	51	106	83
						76		78
						101		70
						126		68
						176		64

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	MAXIMUM RMS VIBRATION VELOCITY LEVEL
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	(dB re 1 μin./sec)
C-2	03-03-93	Amtrak	Electric	1	18	51	73	79
						76		76
						101		71
						126		69
						176		62
				1	9	51	95	81
						76		77
						101		75
						126		69
						176		63
				1	6	51	28	69
						76		66
						101		60
						126		58
						176		50
				1	5	25	67	89
						50		84
						75		76
						100		75
						150		65
				1	6	51	34	74
						76		70
						101		65
						126		61
						176		56
		X2000	Electric	2	4	38	81	77
						63		72
						88		67
						113		61
						163		53
				2	4	51	113	80
						76		75
						101		66
						126		62
						176		59
C-3	03-05-93	Amtrak	Electric	1	8	38	102	93
						63		89
						88		88
						113		87
						163		76

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	MAXIMUM RMS VIBRATION VELOCITY LEVEL (dB re 1 μin./sec)
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	
C-3	03-05-93	Amtrak	Electric	1	16	38	90	91
						63		83
						88		85
						113		81
						163		75
				1	11	38	96	91
						63		85
						88		85
						113		82
						163		75
				1	5	51	84	86
						76		78
						101		80
						126		80
						176		71
				1	6	25	84	98
						50		88
						75		90
						100		88
						150		77
				1	6	38	109	91
						63		88
						88		87
						113		87
						163		76
				1	6	51	111	88
						76		84
						101		82
						126		80
						176		71
				1	9	38	95	96
						63		89
						88		88
						113		88
						163		77
				1	18	25	79	95
						50		88
						75		88
						100		84
						150		75

SITE	DATE	DESCRIPTION OF TRAIN				DIST	SPEED	MAXIMUM RMS VIBRATION VELOCITY LEVEL
		Train Type	Loc Type	#Loc	#Cars	(ft)	(mph)	(dB re 1 μin./sec)
C-3	03-05-93	Amtrak	Electric	1	6	51	120	89
						76		83
						101		82
						126		81
						176		71
		X2000	Electric	2	4	51	127	85
						76		76
						101		77
						126		78
						176		67
				2	4	63	135	82

TABLE A-4. TRAIN VIBRATION IMPACT DISTANCE SUMMARY

MUNICIPALITY	MILEPOST		DISTANCE TO SIGNIFICANT VIBRATION IMPACT (ft)*			
			RESIDENCES		INSTITUTIONAL BLDGS	
	From	To	BUILD	NO-BUILD	BUILD	NO-BUILD
New Haven	72.2	72.5	66	No impact	42	No impact
New Haven	72.5	73.3	66	No impact	42	No impact
New Haven	73.3	73.7	No impact	No impact	No impact	No impact
New Haven	73.7	74.2	97	No impact	70	No impact
New Haven	74.2	74.7	No impact	No impact	No impact	No impact
New Haven	74.7	76.0	No impact	No impact	No impact	No impact
New Haven	76.0	76.3	No impact	No impact	No impact	No impact
New Haven	76.3	76.6	No impact	No impact	No impact	No impact
New Haven	76.6	76.8	No impact	No impact	No impact	No impact
New Haven	76.8	77.0	No impact	No impact	No impact	No impact
East Haven	77.0	77.6	No impact	No impact	No impact	No impact
East Haven	77.6	78.1	No impact	No impact	No impact	No impact
East Haven	78.1	79.0	No impact	No impact	No impact	No impact
Branford	79.0	79.5	No impact	No impact	No impact	No impact
Branford	79.5	80.0	No impact	No impact	No impact	No impact
Branford	80.0	81.2	No impact	No impact	No impact	No impact
Branford	81.2	82.0	85	No impact	60	No impact
Branford	82.0	82.7	118	No impact	88	No impact
Branford	82.7	83.9	No impact	No impact	No impact	No impact
Branford	83.9	84.7	No impact	No impact	No impact	No impact
Branford	84.7	85.1	No impact	No impact	No impact	No impact
Branford	85.1	86.0	No impact	No impact	No impact	No impact
Guilford	86.0	86.5	No impact	No impact	No impact	No impact
Guilford	86.5	87.4	No impact	No impact	No impact	No impact
Guilford	87.4	88.3	No impact	No impact	No impact	No impact
Guilford	88.3	90.5	137	No impact	104	No impact
Madison	90.5	91.0	132	No impact	100	No impact
Madison	91.0	91.3	No impact	No impact	No impact	No impact
Madison	91.3	91.7	No impact	No impact	No impact	No impact
Madison	91.7	93.0	No impact	No impact	No impact	No impact
Madison	93.0	94.6	No impact	No impact	No impact	No impact
Madison	94.6	94.9	No impact	No impact	No impact	No impact
Clinton	94.9	95.3	No impact	No impact	No impact	No impact
Clinton	95.3	95.9	No impact	No impact	No impact	No impact

* Distance measured from centerline of near track

MUNICIPALITY	MILEPOST		DISTANCE TO SIGNIFICANT VIBRATION IMPACT (ft)*			
			RESIDENCES		INSTITUTIONAL BLDGS	
	From	To	BUILD	NO-BUILD	BUILD	NO-BUILD
Clinton	95.9	96.0	No impact	No impact	No impact	No impact
Clinton	96.0	96.5	No impact	No impact	No impact	No impact
Clinton	96.5	97.1	No impact	No impact	No impact	No impact
Clinton	97.1	98.9	No impact	No impact	No impact	No impact
Westbrook	98.9	99.6	No impact	No impact	No impact	No impact
Westbrook	99.6	100.5	No impact	No impact	No impact	No impact
Westbrook	100.5	101.3	No impact	No impact	No impact	No impact
Westbrook	101.3	102.0	No impact	No impact	No impact	No impact
Westbrook	102.0	102.5	No impact	No impact	No impact	No impact
Old Saybrook	102.5	102.8	No impact	No impact	No impact	No impact
Old Saybrook	102.8	103.6	No impact	No impact	No impact	No impact
Old Saybrook	103.6	103.9	No impact	No impact	No impact	No impact
Old Saybrook	103.9	104.7	No impact	No impact	No impact	No impact
Old Saybrook	104.7	105.1	87	No impact	61	No impact
Old Saybrook	105.1	105.9	85	No impact	60	No impact
Old Saybrook	105.9	106.6	79	No impact	54	No impact
Old Lyme	106.6	107.3	85	No impact	60	No impact
Old Lyme	107.3	107.5	115	No impact	86	No impact
Old Lyme	107.5	108.8	123	No impact	92	No impact
Old Lyme	108.8	109.2	123	No impact	92	No impact
Old Lyme	109.2	109.6	119	No impact	89	No impact
Old Lyme	109.6	110.0	118	No impact	88	No impact
Old Lyme	110.0	110.6	118	No impact	88	No impact
Old Lyme	110.6	111.4	113	No impact	84	No impact
Old Lyme	111.4	111.7	105	No impact	77	No impact
Old Lyme	111.7	111.9	102	No impact	74	No impact
Old Lyme	111.9	112.3	91	No impact	65	No impact
East Lyme	112.3	112.8	91	No impact	65	No impact
East Lyme	112.8	113.0	100	No impact	73	No impact
East Lyme	113.0	113.5	111	No impact	82	No impact
East Lyme	113.5	113.8	113	No impact	84	No impact
East Lyme	113.8	115.0	113	No impact	84	No impact
East Lyme	115.0	115.5	113	No impact	84	No impact
East Lyme	115.5	116.0	103	No impact	75	No impact
East Lyme	116.0	116.5	94	No impact	67	No impact
East Lyme	116.5	116.7	79	No impact	54	No impact

* Distance measured from centerline of near track

MUNICIPALITY	MILEPOST		DISTANCE TO SIGNIFICANT VIBRATION IMPACT (ft)*			
			RESIDENCES		INSTITUTIONAL BLDGS	
	From	To	BUILD	NO-BUILD	BUILD	NO-BUILD
Waterford	116.7	116.9	79	No impact	54	No impact
Waterford	116.9	117.2	97	No impact	70	No impact
Waterford	117.2	118.2	103	No impact	75	No impact
Waterford	118.2	119.1	97	No impact	70	No impact
Waterford	119.1	119.9	97	No impact	70	No impact
Waterford	119.9	120.5	103	No impact	75	No impact
Waterford	120.5	120.7	91	No impact	65	No impact
Waterford	120.7	121.1	79	No impact	54	No impact
New London	121.1	122.0	79	No impact	54	No impact
New London	122.0	122.5	72	No impact	49	No impact
New London	122.5	123.0	42	No impact	19	No impact
New London	123.0	123.5	45	No impact	23	No impact
New London	123.5	123.9	50	No impact	28	No impact
Groton	123.9	124.3	79	No impact	54	No impact
Groton	124.3	124.5	85	No impact	60	No impact
Groton	124.5	124.7	97	No impact	70	No impact
Groton	124.7	125.0	91	No impact	65	No impact
Groton	125.0	126.0	79	No impact	54	No impact
Groton	126.0	127.0	89	No impact	63	No impact
Groton	127.0	127.3	108	No impact	79	No impact
Groton	127.3	128.9	108	No impact	79	No impact
Groton	128.9	129.5	91	No impact	65	No impact
Noank	129.5	130.2	100	No impact	73	No impact
West Mystic	130.2	131.3	103	No impact	75	No impact
West Mystic	131.3	131.7	89	No impact	63	No impact
West Mystic	131.7	132.0	70	No impact	46	No impact
West Mystic	132.0	132.2	58	No impact	6	No impact
Mystic	132.2	132.5	66	No impact	42	No impact
Stonington	132.5	132.8	79	No impact	54	No impact
Stonington	132.8	133.2	85	No impact	60	No impact
Stonington	133.2	133.6	87	No impact	61	No impact
Stonington	133.6	133.8	85	No impact	60	No impact
Stonington	133.8	134.7	99	No impact	72	No impact
Stonington	134.7	135.2	103	No impact	75	No impact
Stonington	135.2	135.5	100	No impact	73	No impact
Stonington	135.5	136.1	91	No impact	65	No impact

* Distance measured from centerline of near track

MUNICIPALITY	MILEPOST		DISTANCE TO SIGNIFICANT VIBRATION IMPACT (ft)*			
			RESIDENCES		INSTITUTIONAL BLDGS	
	From	To	BUILD	NO-BUILD	BUILD	NO-BUILD
Stonington	136.1	136.5	79	No impact	54	No impact
Stonington	136.5	137.2	113	No impact	84	No impact
Stonington	137.2	137.6	122	No impact	91	No impact
Stonington	137.6	138.5	113	No impact	84	No impact
Stonington	138.5	139.1	108	No impact	79	No impact
Stonington	139.1	139.7	108	No impact	79	No impact
Stonington	139.7	140.0	108	No impact	79	No impact
Stonington	140.0	141.0	108	No impact	79	No impact
Westerly	141.0	141.3	118	No impact	88	No impact
Westerly	141.3	141.8	113	No impact	84	No impact
Westerly	141.8	142.5	108	No impact	79	No impact
Westerly	142.5	144.6	113	No impact	84	No impact
Westerly	144.6	146.1	113	No impact	84	No impact
Richmond	146.1	147.2	123	No impact	92	No impact
Charlestown	147.2	147.9	113	No impact	84	No impact
Charlestown	147.9	148.5	116	No impact	86	No impact
Charlestown	148.5	149.3	118	No impact	88	No impact
Richmond	149.3	150.3	118	No impact	88	No impact
Charlestown	150.3	151.8	118	No impact	88	No impact
Charlestown	151.8	152.3	115	No impact	86	No impact
Richmond	152.3	153.0	116	No impact	86	No impact
Charlestown	153.0	153.4	118	No impact	88	No impact
Charlestown	153.4	153.6	118	No impact	88	No impact
Richmond	153.6	154.5	118	No impact	88	No impact
Richmond	154.5	155.8	123	No impact	92	No impact
Kingston	155.8	157.3	122	No impact	92	No impact
Kingston	157.3	157.9	122	No impact	91	No impact
Kingston	157.9	158.2	120	103	90	75
Kingston	158.2	159.2	120	113	89	84
Kingston	159.2	159.5	137	113	104	84
Kingston	159.5	160.7	145	113	111	84
Exeter	160.7	161.9	144	123	110	92
N. Kingston	161.9	165.0	141	128	108	96
N. Kingston	165.0	166.1	139	128	106	96
N. Kingston	166.1	168.8	139	123	106	92
N. Kingston	168.8	170.3	135	118	103	88

* Distance measured from centerline of near track

MUNICIPALITY	MILEPOST		DISTANCE TO SIGNIFICANT VIBRATION IMPACT (ft)*			
			RESIDENCES		INSTITUTIONAL BLDGS	
	From	To	BUILD	NO-BUILD	BUILD	NO-BUILD
N. Kingston	170.3	170.8	132	113	100	84
E. Greenwich	170.8	171.3	130	113	98	84
E. Greenwich	171.3	171.8	128	113	96	84
E. Greenwich	171.8	172.1	128	113	96	84
Warwick	172.1	172.3	128	108	96	79
Warwick	172.3	173.0	129	108	97	79
Warwick	173.0	173.7	125	108	94	79
Warwick	173.7	174.1	123	108	92	79
Warwick	174.1	174.6	126	108	95	79
Warwick	174.6	176.3	128	113	96	84
Warwick	176.3	177.8	128	118	96	88
Warwick	177.8	178.8	128	123	96	92
Cranston	178.8	179.7	128	118	96	88
Cranston	179.7	180.3	118	113	88	84
Cranston	180.3	180.6	112	103	83	75
Cranston	180.6	181.0	108	91	79	65
Providence	181.0	181.9	91	72	65	49
Providence	181.9	182.7	72	63	49	40
Providence	182.7	183.2	88	66	62	42
Providence	183.2	183.9	79	61	54	39
Providence	183.9	184.9	72	58	49	36
Providence	184.9	185.2	32	No impact	1	No impact
Providence	185.2	185.6	75	No impact	51	No impact
Providence	185.6	186.1	72	No impact	49	No impact
Providence	186.1	186.7	97	No impact	70	No impact
Providence	186.7	187.5	108	No impact	79	No impact
Pawtucket	187.5	188.5	97	No impact	70	No impact
Pawtucket	188.5	189.8	79	No impact	54	No impact
Central Falls	189.8	190.2	79	97	54	70
Central Falls	190.2	190.6	85	103	60	75
Central Falls	190.6	190.9	113	108	84	79
Attleboro	190.9	191.5	No impact	No impact	No impact	No impact
Attleboro	191.5	192.3	No impact	No impact	No impact	No impact
Attleboro	192.3	193.0	No impact	No impact	No impact	No impact
Attleboro	193.0	193.4	No impact	No impact	No impact	No impact
Attleboro	193.4	195.0	No impact	No impact	No impact	No impact

* Distance measured from centerline of near track

MUNICIPALITY	MILEPOST		DISTANCE TO SIGNIFICANT VIBRATION IMPACT (ft)*			
			RESIDENCES		INSTITUTIONAL BLDGS	
	From	To	BUILD	NO-BUILD	BUILD	NO-BUILD
Attleboro	195.0	195.7	146	No impact	112	No impact
Attleboro	195.7	196.2	146	No impact	112	No impact
Attleboro	196.2	196.7	146	No impact	112	No impact
Attleboro	196.7	197.0	145	No impact	111	No impact
Attleboro	197.0	198.2	146	No impact	112	No impact
Attleboro	198.2	198.9	146	No impact	112	No impact
Attleboro	198.9	199.7	146	No impact	112	No impact
W. Mansfield	199.7	200.4	146	No impact	112	No impact
W. Mansfield	200.4	200.9	No impact	No impact	No impact	No impact
W. Mansfield	200.9	202.4	No impact	No impact	No impact	No impact
W. Mansfield	202.4	203.1	No impact	No impact	No impact	No impact
Mansfield	203.1	204.2	No impact	No impact	No impact	No impact
Mansfield	204.2	204.9	No impact	No impact	No impact	No impact
Foxboro	204.9	205.5	141	No impact	108	No impact
Foxboro	205.5	207.6	No impact	No impact	No impact	No impact
Sharon	207.6	209.3	No impact	No impact	No impact	No impact
Sharon	209.3	209.7	No impact	No impact	No impact	No impact
Sharon	209.7	211.0	No impact	No impact	No impact	No impact
Sharon	211.0	211.7	No impact	No impact	No impact	No impact
Sharon	211.7	212.7	No impact	No impact	No impact	No impact
Canton	212.7	213.4	No impact	No impact	No impact	No impact
Canton	213.4	214.0	No impact	No impact	No impact	No impact
Canton	214.0	214.6	227	No impact	182	No impact
Canton	214.6	215.2	No impact	No impact	No impact	No impact
Canton	215.2	216.2	No impact	No impact	No impact	No impact
Canton	216.2	217.2	No impact	No impact	No impact	No impact
Dedham	217.2	217.5	No impact	No impact	No impact	No impact
Dedham	217.5	218.5	257	No impact	208	No impact
Dedham	218.5	218.7	257	No impact	208	No impact
Dedham	218.7	218.9	256	No impact	207	No impact
Boston	218.9	219.2	256	No impact	207	No impact
Boston	219.2	219.8	No impact	No impact	No impact	No impact
Boston	219.8	220.0	No impact	No impact	No impact	No impact
Boston	220.0	221.1	No impact	No impact	No impact	No impact
Boston	221.1	221.8	No impact	No impact	No impact	No impact
Boston	221.8	222.3	No impact	No impact	No impact	No impact

* Distance measured from centerline of near track

MUNICIPALITY	MILEPOST		DISTANCE TO SIGNIFICANT VIBRATION IMPACT (ft)*			
			RESIDENCES		INSTITUTIONAL BLDGS	
	From	To	BUILD	NO-BUILD	BUILD	NO-BUILD
Boston	222.3	223.4	No impact	No impact	No impact	No impact
Boston	223.4	223.8	No impact	No impact	No impact	No impact
Boston	223.8	224.7	No impact	No impact	No impact	No impact
Boston	224.7	225.7	No impact	No impact	No impact	No impact
Boston	225.7	227.0	No impact	No impact	No impact	No impact
Boston	227.0	227.5	149	No impact	115	No impact
Boston	227.5	227.6	No impact	No impact	No impact	No impact
Boston	227.6	227.7	No impact	No impact	No impact	No impact
Boston	227.7	228.3	No impact	No impact	No impact	No impact
Boston	228.3	228.5	No impact	No impact	No impact	No impact
Boston	228.5	228.8	No impact	No impact	No impact	No impact

* Distance measured from centerline of near track

REFERENCES

EPA, 1974. U.S. Environmental Protection Agency. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. Report No. 550/9-74-004, March 1974.

UMTA, 1979. U.S. Department of Transportation. Guidelines for Preparing Environmental Assessments. Urban Mass Transportation Administration Circular No. UMTA C 5620.1, October 16, 1979.

FTA, 1990. U.S. Department of Transportation. DRAFT: Guidance Manual for Transit Noise and Vibration Impact Assessment. Federal Transit Administration Report No. UMTA-DC-08-9091-90-1, July 1990.

Nicholls, 1971. Duvall, WL; Johnson, CF; Nicholls, HR. Blasting Vibrations and Their Effects on Structures. U.S. Bureau of Mines, Bulletin 656, 1971.

Siskind, 1980. Dowding, CH; Kopp, JW; Stagg, MS; Siskind, DE. Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting. U.S. Bureau of Mines Report of Investigations 8507, 1980.

Rathe, 1977. Rathe, EJ. Railway Noise Propagation. Journal of Sound and Vibration, Vol. 51, No. 3, pp. 371-388, 1977.

Saurenman, 1982. Wilson, GP; Nelson, JT; Saurenman, HJ. Handbook of Urban Rail Noise and Vibration Control. U.S. Department of Transportation, Urban Mass Transportation Administration Report No. UMTA-MA-06-0099-82-1 and DOT-TSC-UMTA-81-72, October 1982.

Hanson, 1979. Hanson, CE. Measurements of Noise from High Speed Electric Trains in the United States Northeast Railroad Corridor. Journal of Sound and Vibration, Vol. 66, No. 3, pp. 469-471, 1979.

Kurzweil, 1979. Kurzweil, LG. Prediction of Community Noise from Rail Systems. Community Noise, American Society for Testing and Materials Publication No. ASTM STP 692, pp. 197-216, 1979.

Beranek, 1992. Ver, IL; Beranek, LL; editors. Noise and Vibration Control Engineering Principles and Applications. John Wiley and Sons, Inc, 1992.

FHWA, 1978. Barry, TM; Reagan, JA. FHWA Highway Traffic Noise Prediction Model. U.S. Department of Transportation, Federal Highway Administration Report No. FHWA-RD-77-108, December 1978.

FRA, 1978. U.S. Department of Transportation. Northeast Corridor Improvement Project Final Programmatic Environmental Impact Statement. Federal Railroad Administration Document No. FRA-RNC-EIS-77-01-F, June 30, 1978.

Amtrak, 1991. National Railroad Passenger Corporation (Amtrak). Attachment IV, Power Systems Specifications, New Haven-Boston Electrification Project. Issued on November 26, 1991 and revised on January 6, 1992.

Amtrak, 1992. National Railroad Passenger Corporation (Amtrak). Train Performance Calculations. Computer simulations dated 28 April 1992, transmitted by J. Popoff of Amtrak to G. Goulet of the Volpe Center on October 3, 1992.

T. K. Dyer, 1992. Thomas K. Dyer, Inc. MBTA Contract SOPS11 -Planning Services for Operations/Facilities South Side Commuter Rail, and Track and Signal Relocation Design - CA/T South Station - Task 1 - Train Performance Calculations - Boston to Providence, May 29,1992.

Blazier, 1981. Towers, DA; Miller, NP; Blazier, WE. Development of a Mechanical Equipment Noise-Control Permit Scheme for Model Building Code. U.S. Environmental Protection Agency, August 1981.

HUD, 1979. U.S. Department of Housing and Urban Development. Environmental Criteria and Standards. Title 24, Code of Federal Regulations, Part 51, issued at 44 FR 40860 on July 12, 1979; amended by 49 FR 880 on January 6, 1984.

EPA, 1971. U.S. Environmental Protection Agency. Noise From Construction Equipment and Operations, Building Equipment, and Home Appliances. Report No. NTID 300.1, December 31, 1971.

Wiss, 1974. Wiss, JF. Vibrations During Construction Operations. Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Vol. 100, No. CO3, September, 1974.

FHWA, 1982. U.S. Department of Transportation. Draft Environmental Impact Statement/Report, Third Harbor Tunnel Project, Interstate 90, Boston, Massachusetts, Appendix 6 - Noise and Vibration, Federal Highway Administration Report No. FHWA-MA-EIS-82-02-D, December, 1982.

TECHNICAL STUDY 5
ELECTROMAGNETIC FIELD IMPACTS

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ELECTROMAGNETIC FIELD IMPACTS

5.1 INTRODUCTION AND PURPOSE

Electromagnetic fields are generated whenever electricity is used or transported and, therefore, will be produced by electric-powered trains and facilities in the proposed electrification of the rail line between New Haven and Boston. The electromagnetic fields generated will have frequencies at the low end of the electromagnetic spectrum, typically between 3 and 3,000 Hertz (Hz or cycles per second), including the 60 Hz frequency at which alternating current is provided, and are known as extremely-low-frequency (ELF) electromagnetic fields. At these low frequencies, electric and magnetic field components behave as if they are separate forces, i.e., variations in the intensity of the electric field do not influence the measured intensity of the magnetic field and vice versa. The term EMF is commonly used to refer to both electric and magnetic fields. For the sake of comparison, commercial radio and television fields have frequencies between 1×10^6 (1 million) and 1×10^9 (1 billion) Hz and visible light is between 1×10^{14} and 1×10^{15} Hz and both their electric and magnetic field components are closely coupled.

Current flow through power transmission lines, electrified power systems, electric motors, and other electrified devices produces magnetic fields. The intensity of EMF from electrified devices typically varies with time, depending on the current flow through the device. Recently, public and regulatory attention has prompted the need for additional evaluation and research to consider the possibility that time-fluctuating EMF (as well as static and ultra-low frequency EMF between 0 and 3 Hz) pose health risks with long-term exposure.[1, 2, 3] Although all devices using or transporting electricity are sources of magnetic fields, to date most attention has been focused on the most obvious sources such as utility power lines, home appliances, and industrial devices. In the past few years, however, the systematic collection and assessment of magnetic field exposures associated with Magnetic Levitation (Maglev) and other rail-based technologies has been initiated by The Federal Railroad Administration (FRA).[4, 5] Electric fields are of potentially less concern in regards to the electrification of the rail line because of the limited opportunity for exposure to electric fields from electrified trains and facilities. This results from electric field shielding provided by metallic train construction, buildings, and trees. Thus, this report focuses on the impacts of magnetic fields associated with the electrification of the Northeast Corridor (NEC) rail system.

As is described later, most people are continuously exposed to time-varying background EMF generated by electrical devices and circuits. Additionally, we are all exposed to the earth's magnetic field. This study estimates the additional levels of EMF above and beyond background levels to which persons in the vicinity of the project would be exposed. The project-generated exposures considered are to populations on the train (riders, railroad employees) and off-track (populations along railroad easement, station and wayside employees, and the general public). The potential for electromagnetic interference (EMI) with communication systems is also considered.

The design and technical details of the proposed project have been provided by Amtrak, MBTA, the Morrison Knudson/L.K. Comstock/SPIE Group Joint Venture (Constructors) and other parties and reflect the design as of March 1993.

5.2 EXISTING STUDIES AND RESEARCH ON POTENTIAL HEALTH EFFECTS OF MAGNETIC FIELD EXPOSURES

Questions have been raised as to whether exposure to magnetic fields in the ELF range could adversely affect human health. While there has been more than 100 years of biological research on magnetic fields, largely for basic science and potential therapeutic purposes, the speculation that magnetic fields at extremely low frequencies could have adverse effects, particularly relating to cancer, has arisen mainly from epidemiologic studies reported over the past 14 years. The potential health implications of magnetic field exposures like those associated with electrification of the Northeast Corridor are assessed by weighing data obtained from both epidemiologic studies of human populations and laboratory studies of biological responses to magnetic fields in living animals or in isolated cells and tissues.

5.2.1 Epidemiology Studies

Epidemiologic studies provide information directly about people and their illnesses. However, investigators have very limited control over the ascertainment of exposures, genetic make-up, and health-related habits of people who are studied. Strict control over exposure, diet and individual characteristics is obtained only in laboratory studies, where exposures and responses can be manipulated to investigate their relationships and experimentally test the mechanisms involved. Hence, both types of studies contribute to our understanding of the potential for magnetic field exposures to impact health.

Epidemiologic studies describe associations between exposure to a chemical or other agent and the occurrence of disease in people in their everyday environment. That is, differences in the exposures of groups of people in relation to the presence or absence of disease are evaluated for clues as to whether the exposure being studied could cause or otherwise influence disease development. Because these studies are non-experimental and are susceptible to confounding and biases, rarely is it possible to determine whether or not a particular agent does or does not cause disease from just such data alone.

For epidemiologic studies to convincingly demonstrate an association between exposure to ELF magnetic fields and disease, an accurate and reliable assessment of people's exposure to these fields is critical. However, a major issue in many of these studies is the reliability of the methods used to assess exposure to magnetic fields many years in the past. Researchers have employed a variety of indirect (or surrogate) methods to reconstruct an individual's past exposure. To date, such surrogates provide only rough estimates of magnetic field exposures in residential and occupational studies and none has received experimental validation. Although total personal exposure to magnetic fields from all sources is of ultimate importance, all surrogates for exposure to date only have addressed single sources (power lines, appliances, occupation). In addition, it is important to note that few studies have focused on broad-band EMF health or biological effects, and the epidemiological data is generally limited to exposures within a 50-60 Hz frequency band associated with power transmission and distribution in North America and Europe.[6, 7, 8, 9, 10] Magnetic fields with frequencies outside this range are expected to be generated by electric trains and their power systems.[11]

5.2.2 Residential Studies

Most studies of residential exposures to power lines have attempted to estimate the magnetic field levels in residences by characterizing the type of utility wiring outside the home and the distance of the line from residences. This type of surrogate EMF exposure measure is called a wiring code. It does not take into account other sources of magnetic field within homes (wiring, ground currents, appliances). In some studies, spot measurements (i.e. direct measurements of the magnetic field strength at a single point in time) have been made within residences. In one recent study, magnetic fields in the residence also were measured repeatedly over 24 to 72 hours.[10] Other studies have used estimated historical field levels from calculations based on the amount of known or estimated currents flowing in the power lines in the past. This type of indirect measure is known as calculated fields.

It has been reported in several studies that magnetic field exposures of residences of children with leukemia are higher than those of residences of other children when magnetic field exposures are estimated from wiring code ratings,[9, 10, 12] or calculated annual magnetic fields from power lines.[13] In contrast, other methods of estimating magnetic field exposure based upon field levels actually measured within the child's residence have not yielded any reliable associations with leukemia or other cancers of children.[9, 10, 13] Still other studies have reported no associations based upon calculated fields and distance.[14, 15] Some studies have considered other even rarer childhood cancers as well. The short-comings of these and other similar studies preclude any definitive interpretation at this time of their significance for human health. Nevertheless, these studies have prompted proposals for further research with more refined methods to determine whether chronic exposure to power frequency magnetic fields with intensities of even a few milligauss (mG) could influence cancer risks.[16]

Studies of adults have not supported the suggestion of an association between cancer and estimates of magnetic field exposure. Two studies of adults which actually measured magnetic fields[13, 17] did not report an association between magnetic field estimates (based upon either spot measured fields, wire code, or calculated fields) and adult leukemia. Other studies of adults in their communities have not shown a consistent statistical association between proximity to power lines or estimated magnetic field levels and any particular type of cancer.[18, 19, 20, 21]

5.2.3 Occupational Studies

Epidemiological research also has looked for associations between occupations presumed to have greater exposures to magnetic fields and cancer. Job titles are often used as an indirect surrogate measure of field exposure in these studies. Some of the commonly studied occupations are power station operator, electrical engineer, and linesmen. In most of the studies exposures of individuals to magnetic or electric fields have not been measured, and these workers also are considered likely to have other exposures on the job, e.g. chemicals, some of which are potentially carcinogenic. Although studies of this type have reported associations between some types of cancer and electrical occupations, the studies are by no means persuasive evidence of risk.

Despite the acknowledged limitations of the occupational studies in general, some of the studies have looked for associations between work in electric railway transportation and various diseases including cancer. Some studies have one category for railroad worker which includes "conductors and motorman, urban rail transit"[(22)] while other studies differentiate different jobs within the industry, e.g. tram drivers from railroad engine drivers from railroad walkers.[(23)] Since many railroads in this country and elsewhere in the world operate at frequencies other than 60-Hz, e.g. 25 Hz and 16.6 Hz, workers in the railroad industry may be exposed to frequency spectra different from that of workers just exposed to 50-60 Hz power sources.

Electric railway workers, overall, are not at elevated risk for brain cancer, leukemia or health impairment, [(22, 23, 24, 25, 26)] but there are reported exceptions, e.g. engine drivers of Swiss electrified (16.7 Hz) railways.[(27)] While most of the studies relied on job titles, a recent study actually attempted to verify the exposure of Swedish conductors and railway engine drivers to 50-Hz magnetic fields. These workers were exposed to median values of measured magnetic ranging from 20 - 170 mG. Neither occupation was reported to have any increased incidence of any type of leukemia or brain cancers.[(25)]

Another very recent study of the mortality of national railway workers in Japan concluded that "The train crews and workers in electric power facilities were not affected in their death and/or wellness by electric and electromagnetic fields of electrical railroad system.[(26)]" An earlier cross-sectional study of high voltage substation workers in the Italian railway system found no differences in nervous, cardiovascular, or blood cell function between control groups of employees and those with varying degrees of increased magnetic field exposure.[(24)]

5.2.4 Laboratory Research

A wide range of magnetic field intensities at extremely low frequencies has been studied in the laboratory to attempt to elicit biological responses and identify the conditions and mechanisms under which they can be produced. At present, there is no accepted physical mechanism that can readily explain how a cell could respond to low frequency magnetic fields of low intensities. The evaluation of all mechanisms must take into account that body systems are electro-chemical in nature and are themselves sources of voltages and currents. Therefore any imposed external electric and magnetic fields must compete with fundamental fluctuations (noise) and endogenous background biological fields.

Laboratory studies that expose animals or isolated cells and tissues attempt to identify responses or mechanisms that would help predict the responses of humans exposed to in the environment. Most of the laboratory studies involve exposures which are thousands of times higher than the exposure in the environment. From perhaps thousands of studies in the literature, relatively few biological responses are reported to occur with exposure to time-fluctuating magnetic fields at intensities less than one Gauss, and those that have been reported are not adverse. Some findings are reported not to be confirmed by other investigators. Although there is considerable interest in determining whether there is any biological basis for an association between ELF fields and cancer, the available data has not provided any substantive support for this hypothesis. Recently, the FRA has initiated studies to supplement the existing database by targeting studies specifically designed to determine whether magnetic fields with frequency characteristics like those found in electric rail environments are capable of affecting biological processes.[29]

5.2.5 Summary of Studies and Research Findings

In studies of residential exposures to EMF, some have reported associations of higher magnetic fields with childhood leukemia and others have found no associations with childhood leukemia. In several studies in which EMF exposures are estimated from wiring code ratings or calculated annual magnetic fields from power lines, it has been reported magnetic field exposures of children with leukemia are higher than those of residences of other children. In contrast, other methods of estimating magnetic field exposure based upon field levels actually measured within the child's residence have not yielded any reliable associations with leukemia of other cancers. The shortcomings of these and other studies, however, preclude any definitive interpretation at this time, and their significance upon human health. Studies of adults have not supported the suggestion of an association between cancer and estimated of magnetic field exposures.

Epidemiological research has also looked for associations between occupations presumed to have greater than average exposures to magnetic fields and cancer. Electric railway workers overall are not at elevated risk for brain cancer, leukemia, or health impairment. No differences in wellness was found in studies of electrified railway workers in Sweden, Japan or Italy.

Finally, in laboratory research, which exposes animals or isolated cells or tissue to exposures which are thousands of times higher that exposure in the environment, no adverse biological effects have been found to occur.

5.3 REGULATORY SETTING

No Federal standards exist for either environmental or occupational exposures to ELF electric and magnetic fields. However, several states have enacted guidelines governing the design and construction of new transmission line facilities to limit EMF emissions and various professional and scientific organizations in the United States and abroad have proposed voluntary exposure limits. Federal regulations do exist for the field strengths of "unintentional radiators" of electromagnetic fields in the radio frequency range, to govern radio interference.

No enforceable state or local regulations were identified that would cover EMF associated with the proposed project.

5.3.1 Federal Regulations: EMF Exposure

The procedures used for the assessment of potential environmental impacts of EMF associated with the proposed project conform with the general requirements outlined by the Department of Transportation/Federal Railroad Administration in Procedures for Considering Environmental Impacts.[30] Other aspects of the assessment process, specifically those aspects targeted to health issues are based on guidelines of the National Research Council of the National Academy of Sciences made in recommendations to Federal agencies.[31]

Jurisdiction o.er rules, regulations, orders, and standards for all areas of railroad safety involving either regular or high-speed ground transportation systems was given to the FRA in the Railway Safety Improvement Act of 1988. Further research, evaluation, and regulation of Maglev and other high-speed rail transportation technologies has been authorized in the High-Speed Rail Transportation Act of 1991.

None of the above regulations or other Federal statutes address EMF exposures or emissions.

5.3.2 State Regulations: EMF Exposure

The states of Massachusetts, Rhode Island, and Connecticut, through which the proposed electric rail corridor pass, have not enacted any regulations to specifically limit electric or magnetic fields, although various proposals have been considered by legislatures in these states.

However, an act was recently passed in Rhode Island (Rhode Island General Assembly Chapter 439 of the Public Laws of 1992) that directs the Energy Facilities Siting Board (EFSB) to consider transmission lines as "major energy facilities" and to establish regulations "governing construction within the state of high voltage transmission lines of 69 kilovolts (kV) or greater." Furthermore, the act provides for the assessment of "potential health risks associated with EMF exposure," estimated maintenance, operation, and public safety costs, and public notice and hearing requirements. The proposed electrification of the NEC rail system has a design voltage for facilities of 25 kV, which is below the threshold value and, therefore would not be regulated by the EFSB. Higher voltage lines which are constructed to serve the electrical substations which are used in this Project, could be regulated by the EFSB.

The State of Rhode Island also commissioned Commonwealth Associates, Inc. to prepare a study of the relative cost effectiveness of various designs of 115 kV and 345 kV transmission lines in reducing human exposure to magnetic fields.[32]

In Connecticut, the Department of Health Services requested that the Connecticut Academy of Science and Engineering undertake "... an independent assessment of the significance for public health of these published results [regarding EMF]." The Committee that the Connecticut Academy convened consisted of nine scientists, mostly from Yale University School of Medicine and the University of Connecticut. Their response, the report entitled Electromagnetic Field

Health Effects (1992), pointed out that biological effects of fields can occur, but that these effects are not seen as a health hazard. The summary states:

> "Absolute proof of the occurrence of adverse effects of EMF fields at prevailing magnitude cannot be found in the available evidence, and the same evidence does not permit a judgement that adverse effects could not occur, as is true for any putative hazard without a solid base of evidence."

No state has issued regulations based upon a determination that ELF electric fields pose health hazards. Nevertheless, several states in the past two decades have promulgated emission guidelines on 60 Hz electric fields from transmission lines. The states of Minnesota, North Dakota, and Oregon have regulations or guidelines that limit electric fields on the right-of-way to levels between 8-9 kilovolts per meter (kV/m), and Montana and New Jersey have guidelines for emissions at the edge of the right-of-way of 1 kV/m and 3 kV/m, respectively.

Largely because of increasing public interest and concern about 60 Hz magnetic fields associated with high voltage transmission lines, two states, New York and Florida, have recently issued design limits for both magnetic and electric fields on utility rights-of-ways. These design limits are not based upon any assessment of potential hazard to health by the panels of scientific experts that reviewed the scientific literature for state agencies. In each state, the purpose of the design limits was to limit emissions from new facilities. The New York State Public Service Commission proceeded:

> "...from a premise that adoption now of a standard based on health effects would be unreasonable given the current state of research...These considerations support an interim standard that would avoid unnecessary increases in existing levels of exposure to magnetic fields..."[33]

The Department of Environmental Regulation in Florida followed a similar approach:

> "Although there is no conclusive evidence that there is any danger or hazard to public health at the levels of existing 60 Hz electric and magnetic fields found in Florida...[this rule requires] all new and modified transmission lines and substations to meet standards[that not] allow any new or modified line or substation, under normal conditions, to cause electric or magnetic field strengths greater than those that now occur for existing transmission lines and substations..."[34]

The interim emission guidelines for magnetic and electric fields at the right-of-way edge in Florida and New York are listed in Table 5-1. The guidelines for magnetic field limits are

Table 5-1

Summary of Magnetic and Electric Field Emission Guidelines

Source	Voltage Class	Magnetic Field Intensity Edge of Right-of-Way	Electric Field Intensity Edge of Right-of-Way
Transmission Lines & Facilities			
Florida Department of Environmental Reg.[34]	≤ 230 kV ≤ 500 kV ≤ 500 kV (cl. circuit)	150 mG 200 mG 250 mG	2 kV/m 2 kV/m 2 kV/m
New York State Public Service Commission[33]	≥ 345 kV	200 mG	1.6 kV/m

shown in milligauss (mG), since this is a common unit used for expressing magnetic field strength.[1] These guidelines are used later in this report for comparison to the EMF emissions of the proposed electrification project.

5.3.3 Recommended Exposure Guidelines

In contrast to emission guidelines described above, *exposure guidelines* usually are based upon scientific evaluations of the biological and epidemiologic literature and normally represent an exposure level below which adverse health effects would not be expected. These exposure standards are based on modeling, reference, and measurements and not on design. Several U.S. and western European organizations have made recommendations for permissible levels of exposure to time varying electric[2] and magnetic fields (Table 5-2). These upper limits reflect

exposures above which possible biological responses, and at still higher intensities, adverse effects might occur (Table 5-2).

Some of the guidelines differentiate exposure levels based on type or duration of exposure. These guidelines are used later in this report for comparison to the EMF exposures from the proposed electrification project.

[1] The intensity of the earth's static magnetic field is about 500 milliGauss in the Northeastern United States, and varies with time.

[2] Recommended electric field exposure limits are not described here because: 1) shielding of electric field by many materials results in little opportunity for increased long-term exposure; and 2) the electric field guidelines for electric fields published by the organizations in Table 2 are much higher than the emission guidelines for transmission lines described in Table 1.

These guidelines may be considered as relevant to the evaluation of the proposed project from a scientific rather than a regulatory perspective in the absence of any prescriptive Federal or state exposure standards. As points of reference, some common household exposures to magnetic fields are as follows:

- electric range: 4 - 40 mG;
- fluorescent lamp: 5 - 20 mG; and
- television set: 0.4 - 20 mG.

All values are based on a distance of 12 inches from the source.

5.3.3.1 American Conference of Governmental and Industrial Hygienists. The American Conference of Governmental and Industrial Hygienists (ACGIH) routinely develops guidelines to assist in the industrial hygiene practice of controlling occupational exposures to potential health hazards in the work place. The guidelines are designed to "... represent conditions under which it is believed that nearly all workers may be exposed day after day without adverse health effects." The policy statement of the ACGIH states that these guidelines or Threshold Limit Values (TLVs) are intended for use by trained individuals, and should not be regarded as a fine line between safe and dangerous levels. The ACGIH has not found sufficient evidence to conclude that 60 Hz fields pose a cancer risk. Therefore the proposed TLV of 10 G for routine occupational exposures is based on biological effects observed in experimental studies that occur when induced current densities exceed endogenous currents (currents normally present in human tissues). ACGIH also proposed an exposure limit ten-fold lower for workers who wear cardiac pacemakers; for these individuals the proposed TLV is 1 G. This limit was recommended to prevent non-fatal reversion of some older pacemakers to automatic pacing. Most pacemakers are unaffected even by 60 Hz magnetic fields up to 10 G. Threshold limit values for 60 Hz magnetic fields were established by the ACGIH for individuals with occupational exposure, i.e., railroad workers, not the general public.

5.3.3.2 Food and Drug Administration. The Center for Devices and Radiological Health of the Food and Drug Administration (CDRH/FDA) has issued guidance to manufacturers submitting regulations presented in the Code of Federal Regulations (CFR) under the designation applications for review of magnetic resonance (MR) diagnostic devices in accordance with 21 CFR 807.87. Safety concerns are below the level of regulatory concern for specified levels of static (from direct current) magnetic and radio frequency fields. There also is a required labeling guideline for MR devices that might possibly expose persons with cardiac pacemakers or other implanted electronic devices to static or alternating magnetic fields exceeding 0.5 mG (5 Gauss). Evaluations of other devices producing electromagnetic fields are not assessed with respect to formally established guidelines but rather are assessed on a case-by-case basis.

5.3.3.3 Foreign and International Standards. Interim guidelines on limits of exposure to 50 to 60 Hz magnetic fields have been proposed by the International Non-ionizing Radiation Committee of the International Radiation Protection Association. This organization works

Table 5-2

Summary of Magnetic Field Exposure Interim Guidelines

Organization	Frequency	Magnetic Field Intensity	Duration/Class
ACGIH[a]	60 Hz	10 G[b]	--occupational
CDRH/FDA[c]	Static	5 G	--/general
IRPA/INIRC[d]	50/60 Hz	1 G 5 G 50 G	24 hr day/public whole day/ occupational few hours/ occupational
NRPB[e]	< 100 Hz	20 G	--/general
DIN[f]	50 Hz	46 G (rms amplitude) 69 G (peak amplitude)	--/general

Notes:

[a] American Conference of Governmental and Industrial Hygienists[35]
[b] 1 G = 1,000 mG
[c] Center for Devices and Radiologic Health of the Food and Drug Administration[28]
[d] International Non-Ionizing Radiation Committee of the International Radiation Protection Association[36]
[e] National Radiological Protection Board[37]
[f] Deutsche Elektrotechnische Kommission in DIN und VDE[38]

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* Recommended electric field exposure limits are not described here because: 1) shielding of electric fields by many materials results in little opportunity for increased long-term exposure; and 2) the electric field guidelines for electric fields published by the organizations in Table 5-2 are much higher than the emission guidelines for transmission lines described in Table 5-1.

closely with the World Health Organization. The rationale for the guidelines was to limit induced currents within the body or limbs to a level of 10 milliamperes per square meter (10 mA/m^2), a level below most observed biological effects and 10-100 fold below levels at which potential health hazards might occur. The National Radiation Protection Board of Great Britain has also published standards for exposures to electromagnetic fields of frequencies less than 100 Hz. Standards have also been recommended by the Association of German Engineers for the frequency range from 2 - 30 kHz. These guidelines and standards are presented in Table 5-2.

5.3.4 Federal Regulations: Electromagnetic Interference

Electromagnetic interference (EMI) with communications transmissions at frequencies above the EMF range (i.e., 3 KHz and above) caused by electric rail traction systems and associated components is currently covered under the scope of the Federal Communications Commission (FCC) as defined by the Code of Federal Regulations Title 47. Electric rail traction systems fit into the FCC regulatory scope under Subchapter A, Parts 15 and 18.

Under Part 15, electric rail systems are applicable as an "incidental radiator" (Subpart A(N)) and as an "unintentional radiator" (Subpart B) and are, therefore, subject to radiated emission limits, guidelines, provisions, exclusions, and mitigation measures.

Under Part 15 (Subpart B, 15, 10a), unintentional radiators are subject to the following electric field emission limits:

Frequency of Emissions (MHz)	Electric Field Strength (Micro-volts/meter)[a]
30 - 88	100
88 - 216	150
216 - 960	200
above 960	500

[a] Measured at a distance of three meters.

Part 15 also authorizes the FCC to require mitigation measures of unintentional or incidental radiators in the event that interference occurs with commercial or government radio frequency communications. The frequencies cited above are significantly higher than the ELF range of the electromagnetic spectrum under consideration here (although train communications, signalling, control and position sensing systems must comply with these requirements).

Under Part 18, electric rail systems fit into the general classification of industrial, scientific, and medical equipment (ISM). Part 18 defines basic rules and establishes criteria for the safe operation of ISM equipment.

5.4 EXISTING AND AFFECTED ENVIRONMENT

The portion of the Northeast Corridor (NEC) route under consideration for electrification is generally a double track layout 157 miles in length passing through 36 cities and towns.

The route passes through diverse land use and population sectors ranging from unpopulated marshland to highly populated metropolitan areas. Although a majority of the track mileage is characterized by low population densities in the proximity of the right-of-way (ROW), several high population density areas do exist, particularly in the greater Boston and greater Providence regions, and along the Connecticut coast.

5.4.1 Proposed Electrification System

It is necessary to define certain electrification system parameters prior to the development of exposed population estimates because these parameters influence the pattern, intensity, and variation with distance of EMF exposure. Two general parameters require definition: the conceptual design of the electrification system; and the locations of specific EMF-generating sources. The conceptual design governs the magnitude of EMF intensities, the rate of decline of EMF intensity as a function of distance from the generating source, and the duration of the emission. The physical location of generating sources governs the persons who may potentially be exposed.

5.4.1.1 Conceptual Design of Electrification System

The proposed electrification system is similar in design to that in use by modern high-speed rail systems elsewhere internationally, particularly the TGV French rail system. The proposed NEC electrification will be a 2 x 25 kV, 60 Hz power system using an overhead catenary wire for train power pickup and a return power line via the rail (generally referred to as a 2 by 25 kV system). Power is supplied from existing local 115 kV utility transmission lines to four substations (by means of overhead or underground tie-lines). The substations step down the transmission-line voltage to 25 kV. Each substation has two transformers for separate energized sections of track, one in the New Haven direction and one in the Boston direction. The primary differences between the proposed system and the TGV are that the TGV runs on a 50 Hz frequency, and the voltage at which utilities supply power is higher in the TGV (generally 200 Kv) than in the NEC.

The substations connect to the catenary, the rail, and to a separate feeder line. A similar arrangement exists approximately mid-way between substations (approximately ten miles from each substation), where an auto transformer is located connecting the catenary, feeder line, and rail. A diagram of this system is presented in Figure 5-1. The function of this arrangement is to provide power to the moving train with a minimization of reduction of voltage with distance from the substation. The inclusion of the auto transformer provides this function.

The circuit that results from this arrangement is dynamic, in that the direction and balance of current flow among the circuit's elements changes with the position of the trains, which draw power from the nearest substation. As a result, a person standing along the wayside would be exposed to EMF intermittently during periods when the catenary section in their vicinity is supplying power to a train. Passengers, on the other hand, are always in the "current loop", and as a result, any time a train is drawing power, they will be exposed to EMF. The variation in current flow through the feed line, catenary, and rail causes time-variable partial field cancellation effects, whose overall effect is a significant reduction in EMF emissions compared to alternative designs employing DC electrified systems or AC systems with uni-directional current flow. These cancellation effects are described further in Section 5.6, Mitigation Measures.

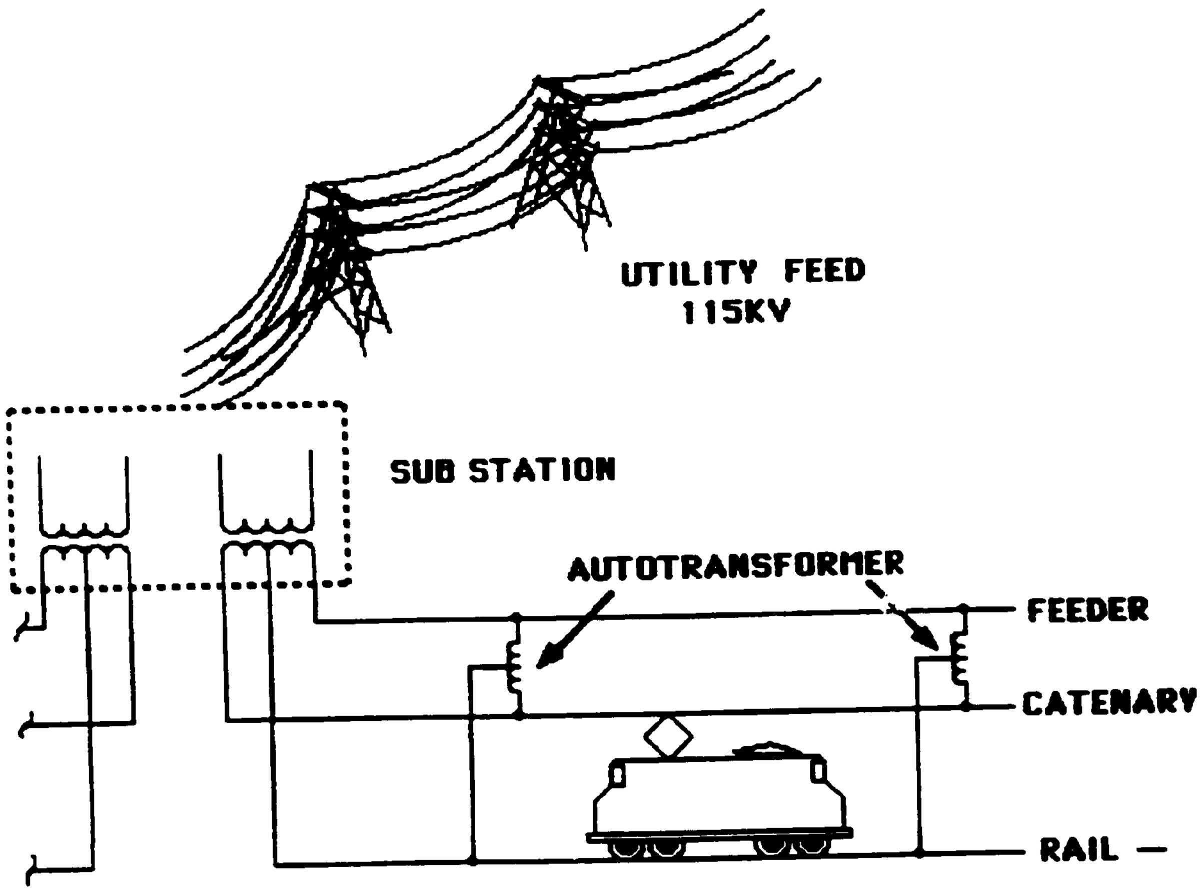


FIGURE 5-1. ELECTRIFICATION DIAGRAM 2X25 KV AUTOTRANSFORMER SYSTEM

Other elements of the electrification system include paralleling stations, phase breaks, and switches. The paralleling stations are auto transformers for voltage-retention purposes and do not participate in circuit balancing as train position changes. The phase breaks are physical separations and define separate catenary sections (also called "blocks") associated with each substation where energization (i.e., current flow) occurs. When a train is drawing current at a specific catenary location, the entire catenary section is energized from one phase break to another.

Switches are located at sites between substations and they allow catenary sections to be energized from adjoining substations if a particular substation is not working. EMF is generated by all of the electrical components in an active circuit.

5.4.1.2 Substation Locations and Tie-line (Utility) Routes

There are four proposed substations along the ROW. These stations are as follows:

Substation	Utility	Tie-line Construction
Branford, Connecticut	Northeast Utilities	Overhead
New London, Connecticut	Northeast Utilities	Underground
Warwick, Rhode Island	Narragansett Electric	Overhead
Roxbury (Boston), Massachusetts	Boston Edison	Underground

The distance between substations ranges from 45 to 53 miles, averaging about 49 miles. Switches are located at sites between substations known as switch stations and they allow catenary sections to be energized from adjoining substations if a particular substation is not working. EMF is generated by all of the electrical components in an active circuit.

Figure 5-2 diagrammatically presents the locations of the substations and auto transformers along the ROW. The length of each energized catenary is the distance between each substation and auto transformer. Detailed maps of the locations of the substations and the specific routes of the tie-lines are presented in a separate Appendix to the draft environmental impact statement.

5.4.2 Categories of Persons Potentially Exposed to EMF Emissions

There are several categories of population that would potentially be exposed to EMF from the electrification project. These categories differ by location and type of exposure. Although there is insufficient scientific evidence to relate a particular combination of EMF exposure level and duration of exposure to a health effect, it is of interest to distinguish between long-term exposures, as would occur in a residential location along the ROW, and short-term or occasional exposures, as would occur for riders on the trains.

One may also distinguish between voluntary and involuntary exposures, because of the fact that, for instance, the train passenger (voluntary exposure) has alternatives and chooses to ride the

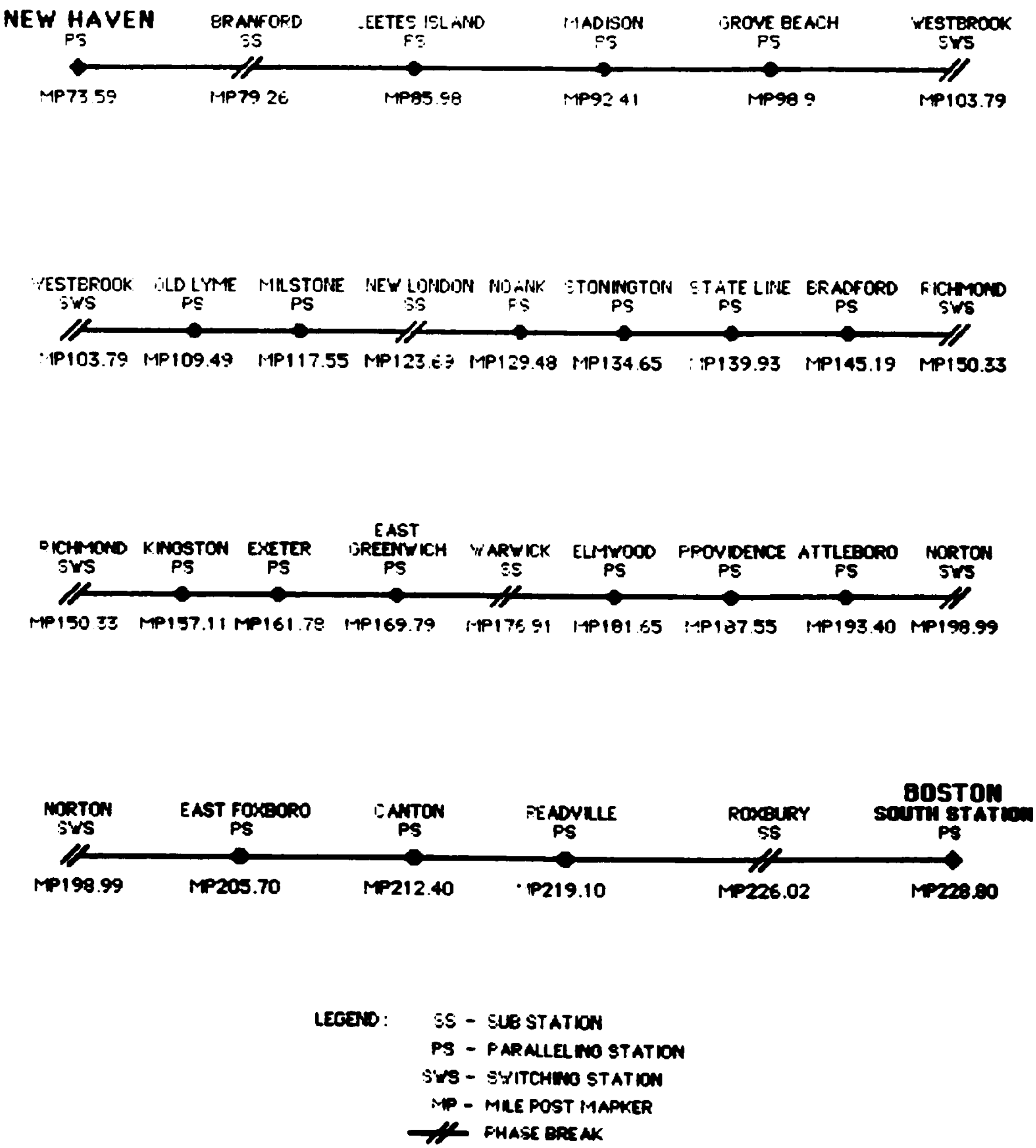


FIGURE 5-2. ELECTRIFICATION ROUTE SEGMENTS FOUR SUBSTATION DESIGN

train rather than use one of the alternatives. Therefore, three broad categories of exposure duration are defined: environmental, occupational and occasional. Environmental exposure refers to exposures resulting from occupancy of a residence and, of the three exposures, is the longest in term. Occupational exposures are those that result from working along the ROW or on electrified trains and are the second longest in term. Occasional exposures are those exposures that arise from short-term occupancy of one of the defined exposure zones, such as passengers on platforms or in trains.

The following persons have the potential to be exposed to EMF emissions from the electrification:

- Persons with residences in the vicinity of the ROW and utility tie-lines,
- Persons who work in the vicinity of the ROW,
- Persons using recreational areas or other public facilities in the vicinity of the ROW,
- rail commuters,
- Inter-city rail travelers,
- Amtrak workers, and
- Connecticut Department of Transportation (ConnDOT), Rhode Island Department of Transportation (RIDOT),Massachusetts Bay Transportation Authority (MBTA), and freight rail workers.

EMF intensity decreases with increased distance from its source. Based upon field measurements of existing electrified tracks and power supply systems, presented in Section 5.5.1 and 5.5.3, EMF intensities from the currently proposed electrical systems are projected to drop off to background levels within 150 feet of their sources. In order to estimate populations and the EMF intensities to which these populations are exposed, this study identifies three equally-spaced zones along the length of the ROW out to a distance of 150 feet away from the ROW. These zones are as follows:

- Zone 1 - From the track edge to 50 feet from the edge of the tracks,
- Zone 2 - From 50 feet to 100 feet, and
- Zone 3 - From 100 feet to 150 feet.

Populations beyond 150 feet of the EMF source are not considered in the estimates of potentially exposed persons, since no incremental EMF exposure is expected beyond this distance as a result of the rail electrification.

The centerline of the tracks typically coincides with the centerline of the ROW, thus, a buffer zone exists between the edge of the tracks and the edge of the ROW. The typical ROW width is 80 to 100 feet and a dual track occupies approximately 20 feet (outside rail to outside rail). This results in a separation of 30 feet or more between the edge of tracks and the abutting properties. Therefore, when assessing general population exposure, only populations within 20 feet of the edge of the ROW have been considered to be within Zone 1. The types of populations analyzed, their category of exposure, and their physical attributes are summarized in Table 5-3. The numbers of people estimated to be in each population type are presented in Section 5.5.8. The detailed methodology for preparing these estimates is described in Appendix A.

5.4.3 Background EMF

It is the magnetic field component rather than the electric field component of exposures associated with electrification that is of concern regarding potential health effects. Electric fields are attenuated externally by buildings and other obstructions and attenuated internally within cells. Magnetic fields, however, are not attenuated, and time-varying magnetic fields may induce electric currents within cells. Thus, when the term "EMF" is used in this section, it is the magnetic component that is of concern, and often only the magnetic component has been measured.

Persons have been exposed to man-made EMF emissions over at least the last 100 years, since the advent and use of electric-powered devices and the establishment of electric line distribution systems. Today, virtually every person is exposed to EMF of highly varying frequencies and intensities and this exposure is essentially continuous. The magnetic field component associated with household appliances or power sources is typically less than 4 mG.[1, 16, 39] Other ranges of potential exposures near specific sources include: electrical appliances, 5 to 3,000 mG; residential distribution lines, 1 to 10 mG; electric blankets, 5 to 13 mG; and under high voltage transmission lines, 12 to 600 mG.

A characterization of the existing street-side EMF environment in Providence, Rhode Island was performed by Electric Research & Management, Inc. (ERM).[40] ERM measured the EMF intensities in the street during a six-mile drive through the city and into its outskirts.

A plot of the data is presented in Figure 5-3. The following conclusions are drawn from the data:

- The recorded EMF ranges from 0 to 26 mG,
- The highest sustained readings are around 10 mG; readings higher than 10 mG occur as instantaneous "spikes" indicative of a narrow sources such as a power line, and
- The average of the data appears to be about 4 mG.

In this sample, it appears that through normal daily activities in a relatively urban area, a person will be exposed to EMF on a continuous basis averaging about 3 to 4 mG in a range of exposures between approximately 1 and 7 mG. Additionally, the person may be exposed to EMF up to 10 mG on an intermittent basis, and will be exposed to EMF considerably higher if operating an electric device (up to 3,000 mG) or passing under a power line (up to 200 mG).

Measurements of EMF were also taken during a drive from New York City to Boston, paralleling the route of the NEC as closely as possible. The results of these measurements are

Table 5-3

Population Categories

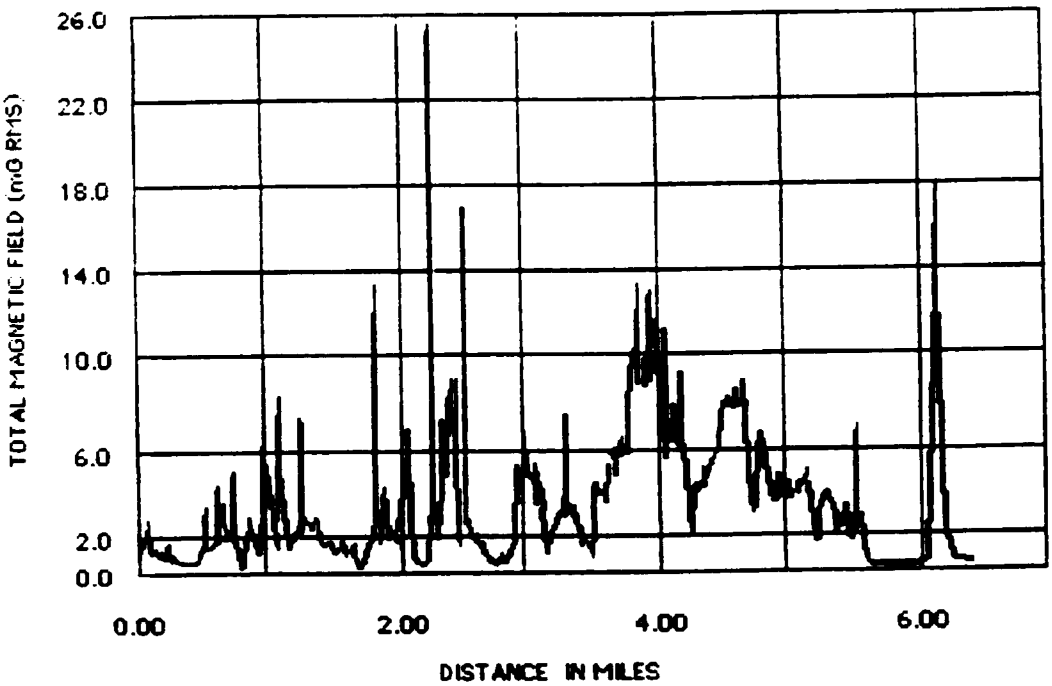
Population Type	Location Description	EMF Exposure Category
Residential	People in residences located:	
Zone 1	0-50 ft from edge of rail or substation	Environmental
Zone 2	50-100 ft from edge of rail or substation	Environmental
Zone 3	100-150 ft from edge of rail or substation	Environmental
Commercial/Industrial	Employees of businesses located:	
Zone 1	0-50 ft from edge of rail or substation	Occupational
Zone 2	50-100 ft from edge of rail or substation	Occupational
Zone 3	100-150 ft from edge of rail or substation	Occupational
Recreational	People utilizing parks located:	
Zone 1	0-50 ft from edge of rail	Occasional
Zone 2	50-100 ft from edge of rail	Occasional
Zone 3	100-150 ft from edge of rail	Occasional
Amtrak/ConnDOT Employees	Employees who work:	
Zone 1	On the train	Occupational
Zone 2	Along the ROW	Occupational
Zone 3	At stations	Occupational
MBTA/Freight Employees	Employees who work:	
On-train	On the train	Occasional[a]
Off-train	Along the ROW	Occasional[a]
Amtrak/ConnDOT/ RIDOT/MBTA Passengers	On the train	Occasional[b]

[a] Since MBTA and freight trains will continue to use diesel fuel, employees will only encounter magnetic fields from the NEC electrification project when passing under or working under an energized catenary section.

[b] Amtrak, RIDOT, and ConnDOT passengers will encounter magnetic fields from the NEC electrification project during the duration of their trips. MBTA passengers will only encounter magnetic fields from the NEC electrification when MBTA trains pass under an energized catenary section.

generally consistent with the data taken during the drive out of Providence. Occasionally, short term spikes of approximately 100 mG were measured while passing under power lines, while values under 10 mG were experienced for the majority of the trip. Due to the higher distribution equipment in urban areas, higher levels of EMF were experienced more frequently in urban than in rural areas.

In addition, as part of the sampling efforts undertaken, (more fully described in Section 5.5.2) EMF measurements were taken in two relatively rural, non-electrified areas along the ROW.



Source: Electric Research & Management, Inc.[40]

FIGURE 5-3. AMBIENT EMF MEASUREMENTS RECORDED DURING DRIVE FROM MANCHESTER STREET AND ALONG CITY STREETS AND U.S. 6, PROVIDENCE, RHODE ISLAND

These two locations are the Stony Creek neighborhood in Branford, Connecticut and Rocky Neck State Park, also in Connecticut. Measurements were taken of peak EMF field strengths at three distances from the rail, with the following results:

Location	Maximum Magnetic Field Intensity (mG)
Stony Creek	
15 feet from rail	0.390
60 feet from rail	0.032
150 feet from rail	0.025
Rocky Neck State Park	
15 feet from rail	1.430
60 feet from rail	0.026
130 feet from rail	0.005

EMF measurements of ambient levels were also taken at a number of residences in close proximity to the NEC. Measurements were taken around the perimeter of properties in West Mystic and Pawcatuck, Connecticut; Charlestown, Rhode Island; and Jamaica Plain, Massachusetts. The peak EMF levels experienced at each resident is as follows:

Location	Maximum Magnetic Field Intensity (mG)
West Mystic	2.2
Pawcatuck	0.9
Charlestown	6.7
Jamaica Plain	2.2

These values help to establish a range of background EMF levels, from close to zero to approximately 7 mG, with localized and short durations of higher exposures.

5.5 ENVIRONMENTAL CONSEQUENCES

EMF emissions result from current flow and their intensities are a direct function of the magnitude of the current (as well as other factors, described below). For the Amtrak electrification, EMF emissions will occur only when the circuit formed by the train, catenary section, rail, feeder line, auto transformer, substation, and tie-line is energized. A specific catenary section is energized when a train passes through it and is not energized at other times. EMF intensity is also a function of the specific design of the electrical devices in the circuit. Phase cancellation can occur between components of opposite phase (described in more detail in Section 5.6). Such cancellation can reduce the intensity of EMF emissions significantly. Another factor that influences EMF intensity is the distance of the receptor from the source of the emissions. The drop in intensity from the source is relatively rapid within a short distance, as some of the figures presented herein demonstrate.

5.5.1 Tie-Line (Utility) EMF

The tie-lines provide 115 kV power to the substations which convert it, through step down transformers, to the 25 kV power supply to the train traction circuit. The tie-line EMF intensities were estimated by ERM, using computer models that simulate high voltage overhead and underground transmission lines. Since the design of the transmission lines has not yet been completed, ERM assumed a design typical for New England utility systems.

The characteristics of an overhead line of vertical design is as follows:

Item	Design Assumption
Voltage	115 kV, 60 Hz
Load	20 MVA (mega volt amps)
Construction	Single Steel Pole
Phase Orientation and Spacing	Vertical Delta, 7 ft
Height at Top	41 ft
Height at Mid-span	35 ft.
Calculation Point	1 meter above ground

The computer modeling provides a profile of magnetic field intensity versus distance from the transmission center line, perpendicular to the direction of the line. One location along the line is used to obtain magnetic field values, at a half-way point between two towers, where the sag of the line brings it closest to the ground. This location is designated as mid-span.

The modeled magnetic field profile at mid-span at one meter (approximately three feet) above ground surface is presented in Figure 5-4. It can be seen that the EMF field strength (labelled here as "Brms Magnitude") varies considerably with distance. In addition, the field strength will vary substantially over time, as the current through the tie line varies. Therefore, a range of EMF field strength values is utilized to characterize expected exposure in each zone, based on the range of distances represented by each zone, and the data presented in Figure 5-4. This can be summarized as follows:

Exposure Zone	Distance From Center Line (ft)	Magnetic Field Intensity (MilliGauss or mG)
Zone 1	0 - 50	5.5 - 13.0
Zone 2	50 - 100	3.0 - 5.5
Zone 3	100 - 150	2.0 - 3.0

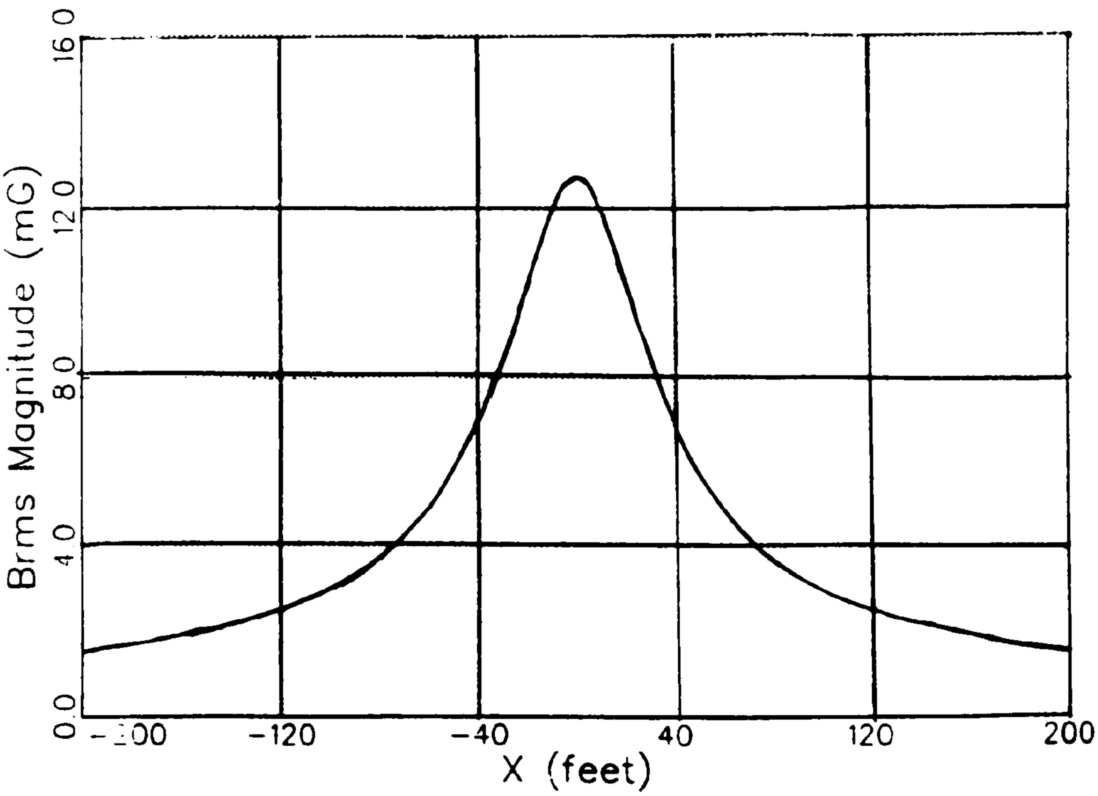


FIGURE 5-4. EMF INTENSITIES GENERATED FROM 115 KV LINE AT MIDSPAN AT GROUND LEVEL

EMF emissions from underground transmission lines have a wide variation, based on the design of the line. The current design of the substations calls for underground tie lines in all substations. The proposed design includes an under-ground line configuration that has been shown to achieve emissions equal to or lower than overhead lines.[32, 41] For the sake of simplicity, this study uses the overhead line EMF estimates provided above which is a highly conservative estimate of the underground line EMF.

5.5.2 X-2000 Sampling

The X-2000 train set is currently being tested by Amtrak for potential future use in the NEC. In order to gather additional EMF data specific to the NEC and the train set under consideration for use in the proposed electrification, an extensive set of measurements were conducted in the electrified portion of the NEC during testing of the X-2000. The testing was done over the course of one week in April 1993. Measurements were taken at two locations along the wayside (Mamaroneck and Harrison, New York), at two train stations (New Haven and New Rochelle), at two substations (Mamaroneck and Harrison), and in the X-2000 coach and locomotive. In addition, measurements were taken at several locations along the non-electrified section of the NEC that is the subject of this report, in order to characterize rural background EMF levels, at several residences in close proximity to the right-of-way, and during a drive along the route of the NEC (The results of measurements taken in rural locations, at residences, and during the drive along the route of the NEC are described in Section 5.4.3).

Measurements were taken with five instruments: three multi-frequency analyzers each utilizing a single external antenna, and two portable meters with internal antennas. Each of these instruments was used in different locations and over different time intervals during the testing in order to assemble the most comprehensive set of data possible. In addition to the different locations and time intervals, the instruments differ in the type of frequency-based measurements taken. The multi-frequency analyzer can take measurements at a variety of frequencies, and report them individually. The two portable meters take so-called broadband measurements, in which intensities over a range of frequencies are combined, using a root-mean-squared averaging technique. Since the 60-Hz frequency so dominates the readings, in practice there is little difference between 60-Hz and broadband measurements. As a result, the measurements included in this report from the multi-frequency analyzer are those for 60 Hz.

In each location, data was taken over a period of several hours in an attempt to characterize the full range of conditions experienced. The multi-frequency analyzer cannot be used continuously for several hours (due to its inability to store the necessary quantity of data), so the data from this instrument represents a series of shorter tests (from 10 minutes to one hour). These tests were conducted under a variety of conditions in order to fully characterize the range of expected EMF intensities. The portable meters were used to gather data over the full period of time that testing was done at a particular location. For simplicity, most of the data presented in this report is compressed into one set of numbers for each location, but it should be recognized that these values represent a number of tests over an extended period of time under a variety of conditions.

The two values reported for each location are average and maximum values. As a result of the large fluctuations in EMF intensity over time, these two values are generally very different. Figure 5-5 presents an example of the variations in EMF intensity over time, for one location along the wayside in Mamaroneck, New York. It can be seen that the maximum value over this time period represents relatively short spikes in intensity, and does not represent the typical exposure over an extended period of time. As a result, average values are used herein to characterize exposures of more than a few minutes duration. Since exposures of passengers at rail stations are generally brief, for some passengers the peak (or maximum) intensity would be representative of their exposure level. Therefore, in order to ensure a conservative analysis, the exposure for all passengers at rail stations is based on maximum EMF intensities. All other exposures are estimated based on average values.

5.5.3 Catenary and Wayside EMF

The electrification design is one that produces highly time variable EMF emissions and intensities over a catenary section. However, for this study, we are assuming that the magnetic field intensities are constant and at their average levels everywhere in the catenary section while a train is present there. In a previous study performed for the FRA, Electric Research and Management, Inc. (ERM) took "wayside" (along the ROW) magnetic field measurements at four locations along the existing electrified portion of the NEC and other locations: Princeton Junction, New Jersey; Rye, New York; and Red Bank, New Jersey (where two sets of measurements were taken at separate locations). As described above, measurements were taken as part of the X-2000 testing at Mamaroneck and Harrison, New York.

The data reported herein was selected from the full set of data prepared for FRA by ERM staff as being representative of wayside exposures along the NEC. As described in Section 5.5.2, the data presented for Mamaroneck and Harrison represents a large number of tests over an extended period of time at these locations. Both sets of data have been adjusted to account for the fact that the existing voltages and that proposed for the electrification project are different (12.5 kV for the existing system, 25 kV for the proposed system). Since EMF intensity is inversely proportional to voltage for a given power requirement, the EMF values have been adjusted accordingly. The data can be summarized as follows:

Distance from Rail	Maximum Magnetic Field (mG)	Average Magnetic Field (mG)
Princeton Junction		
40 ft.	14	2.5
60 ft.	7	1.5
Rye		
40 ft.	23	3
60 ft.	10	1.5

Red Bank North		
20 ft.	7.9	6.5
40 ft.	2.8	2.3
Red Bank South		
20 ft.	60	60
40 ft.	20	20
Mamaroneck		
15 ft.	143	4.9
30 ft.	35	3.5
60 ft.	17	1.4
Harrison		
15 feet	81	12.5
30 feet	24	2.7
55 feet	6	0.8

If the average EMF intensities are plotted versus distance on a graph, a clear relationship is apparent, as well as certain data that deviates from this relationship. Figure 5-6 shows the individual data points for average EMF intensities, as listed above. It can be seen that two of the data points - those for Red Bank South, with field strengths of 60 and 20 mG - are "outliers"; that is, they do not fit the pattern of the rest of the data. If these two data points are excluded, a curve can be determined that fits the pattern of the rest of the data very well. This best-fit curve is shown in Figure 5-6, and can be seen in more detail in Figure 5-7. In Figure 5-7, the two outermost data points have been eliminated, so that the remaining data can be seen on a smaller scale. The best fit curve shown in Figures 5-6 and 5-7 is the same curve and represents a mathematical formula in which the EMF intensity is inversely proportional to the square of the distance from the source. Using this mathematical relationship, the wayside data can be extrapolated so that EMF intensity can be estimated for any distance from the rail. Another source of wayside EMF data is measurements taken of the TGV rail system in France. This rail system runs on direct current for portions of its route, which is not directly applicable to the NEC electrification, but it does run on alternating current for most of the route, and wayside EMF data was taken in this portion. The TGV system, like the proposed NEC electrification is a 2 x 25 kV design, so no adjustment of the data is required for differences in voltage. It should be noted that the TGV runs on 50 Hz, not 60 Hz as the NEC electrification will, so there is a difference in frequency between the two systems. The most relevant data is a set of measurements taken 7.5 meters (approximately 25 feet) from the rail. Measurements were taken at three heights above the ground, with the following results:

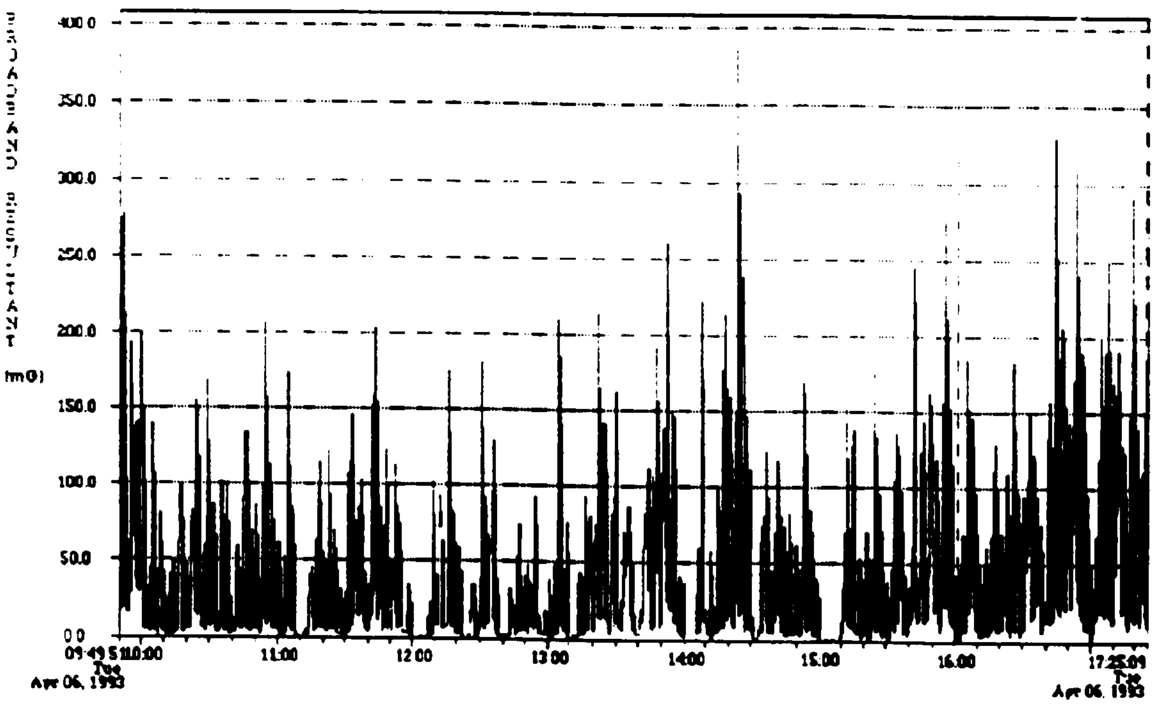


FIGURE 5-5. FLUCTUATIONS IN EMF INTENSITIES OVER TIME

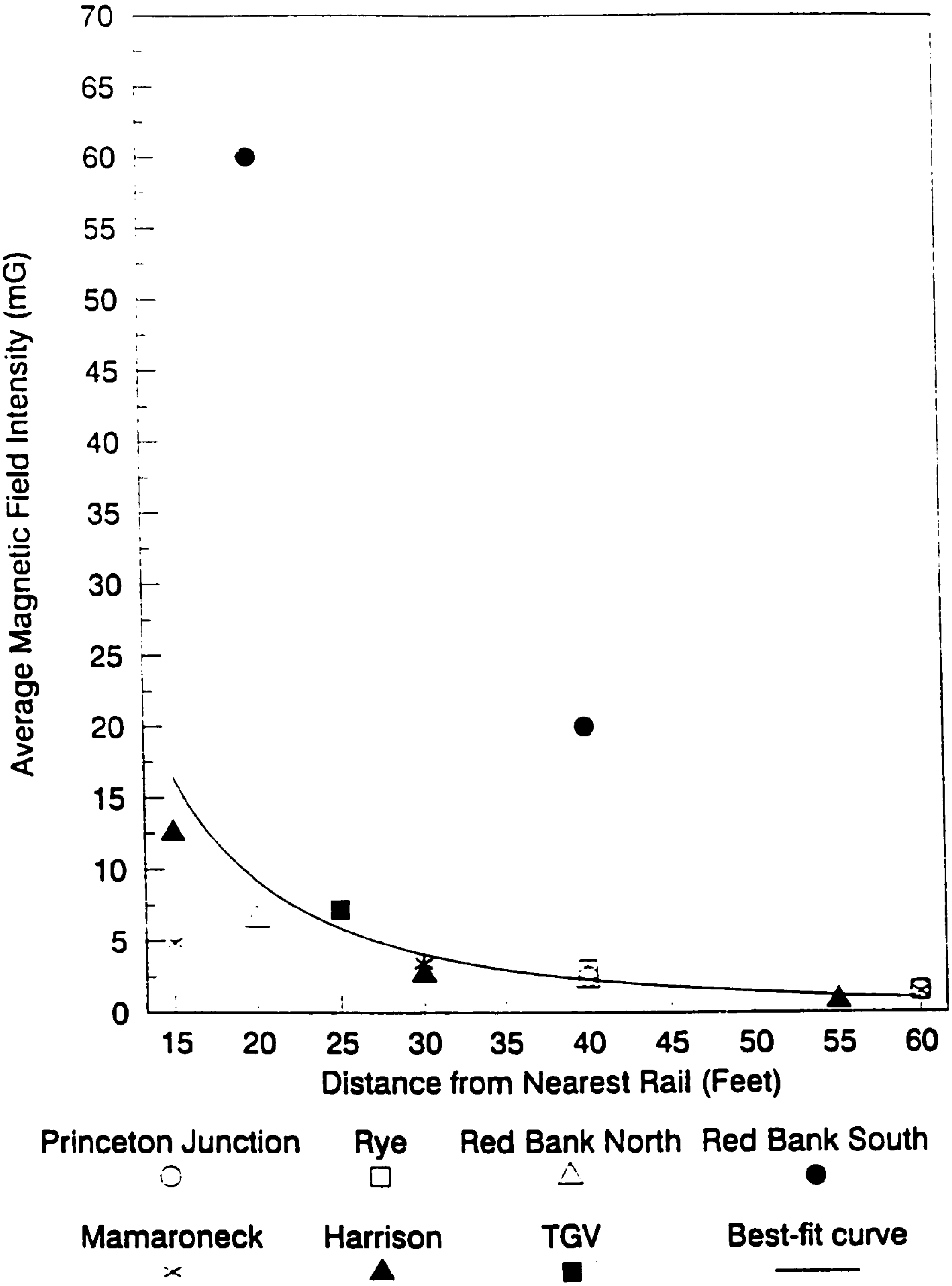


FIGURE 5-6. EMF FIELD STRENGTH AS A FUNCTION OF DISTANCE FROM RAIL

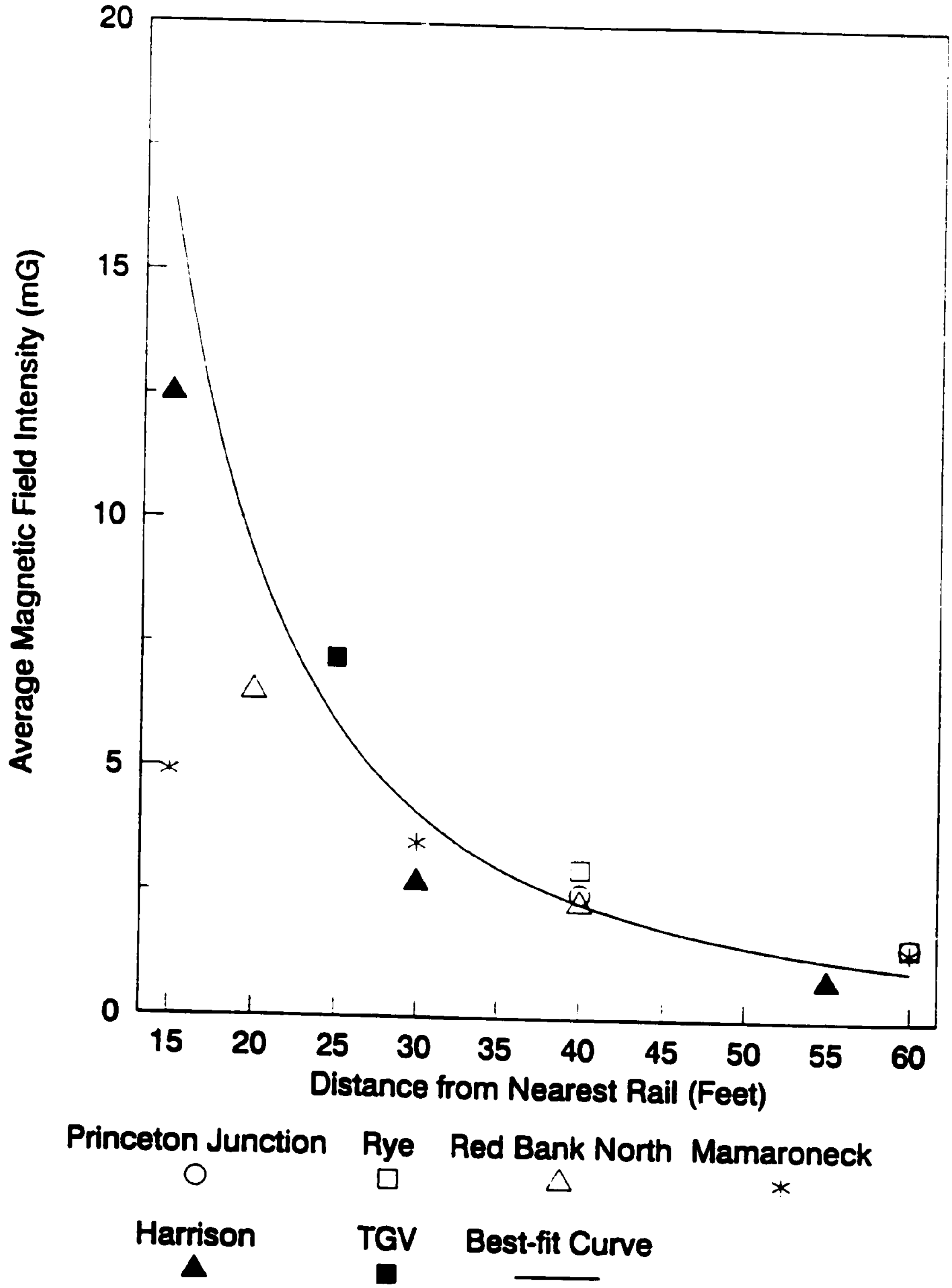


FIGURE 5-7. EMF FIELD STRENGTH AS A FUNCTION OF DISTANCE FROM RAIL

Height Above Ground (cm)	Maximum Magnetic Field (mG)	Average Magnetic Field (mG)
10	18.9	6.4
110	22.1	7.4
160	24.0	7.9
Average	21.7	7.2

This data was considered a single point, with a value of 7.2 mG at a distance of 25 feet from the rail, for inclusion with the rest of the data.

Figure 5-7 is used to estimate the EMF intensity for each population category that is in the proximity of the wayside. A range of values is established for each population because the EMF field strengths vary substantially over time and the procedure of using a best-fit curve has a certain degree of approximation inherent in it. The results can be summarized as follows:

Population Category	Distance from Rail	Average EMF Intensity (mG)
Zone 1, Railroad Workers	10 - 30 feet	4.1 - 37.0
Zone 1, Residents and Other Workers	20 - 50 feet	1.5 - 9.3
Zone 2, All	50 - 100 feet	0.4 - 1.5
Zone 3, All	100 - 150 feet	0.2 - 0.4

5.5.4 Substation EMF

As with the wayside measurements, direct measurements of EMF intensities at and around substations have been taken as part of FRA - sponsored studies for this and previous analyses. ERM has EMF measurements for two substations, one in Mt. Vernon, New York (with underground tie lines) and one in Red Bank, New Jersey (with overhead tie lines). ERM took measurements at three places around the perimeter of the substations: next to the tracks, at a point away from the tie-lines, and under (or on top of) the tie-lines. As part of the X-200 testing measurements were taken at two existing NEC substations, located in Harrison and Mamaroneck, New York. Both have overhead tie lines, and measurements were taken within the substations as well as along the perimeters. The results, adjusted for the NEC electrification voltage, can be summarized as follows:

Location	Magnetic Field Intensity (mG)	
	Mt. Vernon	Red Bank
Away from Tracks and Tie-lines		
Average	1.03	4.0
Maximum	3.38	6.0
Next to Tracks		
Average	Not reported	Not reported
Maximum	0.9	18.5
Under Tie-line		
Average	Not measured	Not reported
Maximum	Not measured	37.5
	Harrison	Mamaroneck
Center of Substation		
Average	12.7	12.7
Maximum	26.7	21.3
Entrance Gate		
Average	13.5	Not measured
Maximum	26.9	Not measured
Perimeter		
Average	Not measured	0.4 -10.7 (4 tests)
Maximum	Not measured	1.7 - 63.5 (4 tests)

It can be seen that the highest average value reported is 13.5 mG. Assuming that this value represents the EMF intensity at a distance of 20 feet from the substation, this should yield a conservative estimate of the EMF exposure from substations. The result of this assumption is that a person 20 feet away from the substation gate is exposed to the same EMF intensity as a person at the gate, thereby over-estimating the exposure level. Using the same mathematical relationship between distance and field strength found for the wayside data, the EMF intensities for areas around substations can be estimated. The same distance ranges will be assumed for each Exposure Zone as for the residential exposure along the wayside (Zone 1: 20 - 50 feet; Zone 2: 50 -100 feet; and Zone 3: 100 -150 feet). The resulting EMF intensity estimates for exposure from substations can be summarized as follows:

Exposure Zone	EMF Intensity (mG)
Zone 1	2.2 - 13.5
Zone 2	0.5 - 2.2
Zone 3	0.2 - 0.5

5.5.5 On-Train EMF

In addition to the wayside and substation measurements described above, measurements of EMF intensities were taken on-board the X-2000 train during testing that occurred on a trip between New York, New Haven, and back to New York. This allowed the opportunity to measure EMF in the coaches and locomotives that are being considered for the NEC electrification. The only adjustment in the data required is to account for the difference in voltage between the proposed electrification and the system currently in place between New York and New Haven.

During the testing of the X-2000, EMF measurements were taken in the coaches and in the locomotive measurements were taken in each location over a period of time ranging from 10 minutes to approximately 6 hours. In some of these tests, the instruments were set to determine the peak values experienced during the test period, and average values were not determined during these tests. The results of this testing, with the data adjusted for the proposed NEC electrification voltage, can be summarized as follows:

Location	Average EMF Intensity (mG)	Maximum EMF Intensity (mG)
Coach		
Test 1	1.6	4.6
Test 2	2.7	12.1
Test 3	Not measured[3]	23.1
Test 4	Not measured[3]	8.5
Test 5	Not measured[3]	29.5
Locomotive	21.7	181.0

In addition, ERM has taken data on coaches in a train with the currently utilized locomotive (the AEM7) on the same section of track. The results of their measurements are an average EMF intensity of 26.2 mG, and a maximum intensity of 204 mG. Measurements taken by ERM in the locomotive of the TGV indicate an average magnetic field of approximately 134 mG and a maximum field of approximately 234 mG. Although the X-2000 train set has the lowest measured magnetic field intensities of the three trains tested, to be conservative, the average

[3] Peak-Hold Test; Average not measured

value from the TGV was included in the range of estimated on-train exposure in the locomotive, and the AEM7 data was included in estimating the range of exposure on the coaches.

Thus for train passengers and on-train rail workers who are not in the locomotive, the range of EMF intensities is estimated to be 2.7 to 26.2 mG in which 2.7 is the highest average value for the X-2000 and 26.2 is the average for the AEM7. For rail workers in the locomotive the EMF field strength is estimated to be between 21.7 and 134 mG in which 21.7 is the average value for the X-2000 and 134 is the average for the TGV.

5.5.6 Train Station Platform EMF

Measurements of EMF intensity have been taken at the New Rochelle and New Haven train stations. All of the data compiled was adjusted to reflect the NEC proposed electrification voltage, and in addition, the ave-age EMF intensity values were adjusted to account for the number of trains drawing power at the time of their measurement. The data can be summarized as follows:

Peak-Hold Test; Average

Location	Average EMF Intensity (mG)	Maximum EMF Intensity (mG)
New Rochelle		
ERM Test	15.6	208.8
Roy F. Weston Inc./RSI Tests:		
15 feet from rail	Not measured[3]	16.2
30 feet from rail	Not measured[3]	11.9
45 feet from rail	Not measured[3]	8.1
15 feet from rail	0.9	8.5
45 feet from rail	0.6	1.3

Location	Average EMF Intensity (mG)	Maximum EMF Intensity (mG)
New Haven		
15 feet from rail	Not measured[3]	5.7
30 feet from rail	Not measured[3]	2.6
65 feet from rail	Not measured[3]	1.0
30 feet from rail	0.4	1.6
65 feet from rail	0.3	0.7

[3] **Peak-Hold Test; Average not measured**

Since passengers spend relatively little time on train platforms or stations, it is appropriate (and conservative) to utilize maximum EMF intensities as a basis of estimating exposure at train stations. Thus, a range of 16 to 209 mG is estimated for EMF exposure at train stations. The low end of the range represents the highest peak value observed during Roy F. Weston Inc.'s testing at both train stations, and the high end of the range represents the highest peak value observed during ERM's testing.

5.5.7 EMF Exposure Assessment

The previous sections have described the estimated level of magnetic field exposure for various locations. In the absence of any conclusive scientific evidence linking a particular level of exposure and/or duration of exposure to a health impact, as described in Section 5.2, the estimated levels of exposure are compared to those levels to the interim guidelines proposed by national and international regulatory agencies and advisory groups, which were detailed in Section 5.3. This comparison is summarized in Table 5-4.

Since there are a number of interim guidelines, a range of values is shown. The interim guideline values are those that are most relevant to each population type. For instance, an interim guideline for 24 hour per day public exposure is used for the residential population. In addition, some interim guidelines are not specific to a particular type or duration of exposure, so these are included in the range of interim guideline values, as appropriate. The interim guidelines are described more fully in Section 5.3.

For all population and exposure categories the estimated levels of magnetic fields from the proposed project are well below any levels specified in the interim guidelines as shown in Table 5-4. In most categories, the estimated levels of exposure are one hundred to one thousand times below the relevant interim guidelines. The highest projected exposure (in stations) is still one-tenth of the lowest applicable interim guideline. It is important to note that this highest estimated level of exposure is based on peak, not average, values. The fact that the exposure levels for the NEC electrification are so much below the interim guidelines, even though the projections are based on conservative estimates of EMF levels, indicates that the magnetic field levels from the NEC electrification are well below the criteria by which an adverse impact could be identified.

The available data indicate that electrification of the Northeast Corridor will potentially increase background levels of exposure to magnetic fields in populations adjacent to power supply facilities or rail corridors, and to train riders and workers. Following electrification, between about 20 per cent and 50 per cent of the total average daily EMF exposure in these populations could be contributed from train and facilities sources. Such exposure impacts would appear to be similar to those of the existing electrified rail system between New York and New Haven[42] and other electrified rail systems.[5]

Table 5-4
Comparison of Estimated EMF Exposure Levels with Interim Guidelines

Population Type	Residential	Commercial/ Industrial	Recreational	Amtrak/Conn-DOT Employees	MBTA/Freight Employees	Rail Passengers
Exposure Type	Environmental	Occupational	Occasional	Occupational	Occasional	Occasional
Relevant Interim Guideline (mG)	1,000 - 46,000	5,000 - 50,000	5,000 - 46,000	5,000 - 50,000	5,000 - 46,000	5,000 - 46,000
	Average EMF	Average EMF	Average EMF	Average EMF	Average EMF	Average EMF
Location	Exposure (mG)	Exposure (mG)	Exposure (mG)	Exposure (mG)	Exposure (mG)	Exposure (mG)
Wayside						
Zone 1	1.5 - 9.3	1.5 - 9.3	1.5 - 9.3	N/A	N/A	N/A
Zone 2	0.4 - 1.5	0.4 - 1.5	0.4 - 1.5	N/A	N/A	N/A
Zone 3	0.2 - 0.4	0.2 - 0.4	0.2 - 0.4	N/A	N/A	N/A
Substation						
Zone 1	2.2 - 13.5	2.2 - 13.5	N/A	N/A	N/A	N/A
Zone 2	0.5 - 2.2	0.5 - 2.2	N/A	N/A	N/A	N/A
Zone 3	0.2 - 0.5	0.2 - 0.5	N/A	N/A	N/A	N/A
Tie Line						
Zone 1	5.5 - 13.0	5.5 - 13.0	N/A	N/A	N/A	N/A
Zone 2	3.0 - 5.5	3.0 - 5.5	N/A	N/A	N/A	N/A
Zone 3	2.0 -3.0	2.0 -3.0	N/A	N/A	N/A	N/A
Electrified Train						
On-Train (Coach)	N/A	N/A	N/A	2.7 - 26.2	N/A	2.7 - 26.2
On-Train (Loco.)	N/A	N/A	N/A	21.7 - 134	N/A	N/A
Off-Train	N/A	N/A	N/A	4.1 - 37.0	N/A	N/A
Station	N/A	N/A	N/A	16 - 209	N/A	16 - 209
Diesel Train						
On-Train	N/A	N/A	N/A	N/A	4.1 - 37.0	4.1 - 37.0
Off-Train	N/A	N/A	N/A	N/A	4.1 - 37.0	N/A

N/A = Not Applicable

In previous sections of this report, the types of populations exposed to EMF from the electrification project have been defined, and the levels of exposure estimated for each of those types. The numbers of people in each of those population types has been estimated and a projection of the numbers of people in those categories in the year 2010 has also been prepared.

These analyses involved detailed review of aerial photographs, a slow-speed rail trip along the NEC, discussions with town officials, review of zoning information and maps, and analysis of population and employment projections. A detailed description of the analytical procedures and results is contained in Appendix A to this report. The results are summarized in Table 5-5.

Table 5-5 shows that the largest population type potentially exposed to EMF from the electrification project is the recreational population, with approximately 54,000 people in 2010. Second largest is the commercial/industrial population along the wayside, with approximately 45 000 people in 2010, which is similar to the ridership population which is projected to be approximately 40,000 passengers per day. The residential wayside population is projected to be approximately 8,700 people in 2010. All other populations are significantly smaller.

5.5.8 Radio Interference

The Japanese railway system has had high-speed electrified rail systems in operation for over 20 years and it has devoted considerable attention over that time period to the reduction of radio interference from train systems. The conclusion arising from these studies is that the principal source of interference is from a breakdown of the connection and connective arc between the pantograph and the overhead catenary line.[43] The most effective mitigation measure employed was a reduction in the number of pantographs. Also, the use of high voltages, such as 25 kV, which is the voltage of the proposed system, minimizes the breakdown of the connection and therefore minimizes the resulting interference. Arcing, itself, is not a cause of interference, rather it is the collapse and reestablishment of the arc that causes radio frequency emissions. Other proposed mitigating measures include mechanical and metallurgical changes to the pantograph and the stringing of metallic netting from the catenary support structures, similar to the wire screen on the viewing window of a microwave oven.[44]

Both the Communications Division of the United States Coast Guard and the Federal Communication Commission (FCC) in Boston, Massachusetts were contacted and asked whether the electrified rail line south of New Haven was a source of interference to radio communications. The Coast Guard stated that it was not aware of any cases of interference to either Coast Guard communications or navigational systems resulting from the Amtrak lines from New York City to New Haven. The Coast Guard communications utilize high frequency (HF), very high frequency (VHF), and ultra high frequency (UHF) signals.[45] The FCC also stated that they had no knowledge of interference with radio or television communications resulting from the existing Amtrak line from New York City to New Haven. The FCC further added that they had not received any complaints regarding interference to communications resulting from the existing Amtrak electrified lines.[46]

5.6 MITIGATION MEASURES

For all population and exposure categories, the estimated levels of magnetic fields from the proposed electrification are well below any levels specified in the interim guidelines presented

Table 5-5
Summary of Estimates of Total Persons Potentially Exposed to Higher than Background EMF Categorized by Distance From EMF Source and By Population Type[a]

Population Type	Population Within Each Zone			
	Exposure Zone 1[b]	Exposure Zone 2[c]	Exposure Zone 3[d]	Totals
Residential - Wayside				
Existing (1993)	300	6,600	1,300	8,200
Projected (2010)	300	7,000	1,400	8,700
Residential - Tie-Line Substation				
Existing (1993)	37	12	7	56
Projected (2010)	37	12	7	56
Commercial/Industrial - Wayside				
Existing (1993)	2,600	18,500	18,500	39,500
Projected (2010)	2,800	20,000	20,800	42,700
Commercial/Industrial - Tie-Line/Substation				
Existing (1993)	8	170	171	349
Projected (2010)	12	184	185	381
Recreational				
Existing (1993)	17,000	17,000	17,000	51,000
Projected (2010)	18,000	18,000	18,000	54,000
Amtrak, ConnDOT, and MBTA Employees[e]				
On-train	250			250
Off-train	560[f]	160[g]		720
Freight Employees				
On-train	18			18
Average NEC Rail Ridership, per day[h] (2010)	40,300			40,300

[a] All estimated exposures are far below interim guidelines (See Table 5-4)
[b] 0 to 50 ft. from edge of rail (0 to 20 ft. from edge of ROW).
[c] 50 to 100 ft. from edge of rail (20 to 70 ft. from edge of ROW).
[d] 100 to 150 ft. from edge of rail (70 to 120 ft. from ROW).
[e] Current estimates; projected estimates not currently developed by rail agencies.
[f] Yard, rail, and maintenance workers.
[g] Station and management workers.
[h] Includes Amtrak, MBTA, RIDOT, and ConnDOT.

in Section 5.3. In almost all exposure categories, the estimated level of exposure are one hundred to one thousand times below the relevant interim guidelines, as shown in Table 5-4. In addition, no radio interference with communication facilities is expected to result from the proposed project.

Due to low intensities of EMF exposure resulting from the proposed electrification and the fact that there are no studies that have found sufficient evidence to conclude that ELF EMF poses health risk, it is not clear that any mitigation measures are necessary. Nonetheless, this section discusses the hypothetical options available for mitigation.

There are two general mechanical/electrical approaches that can be employed for alternating current magnetic field mitigation.[5] These are circuit design for phase cancellation and shielding.

Phase cancellation occurs when parallel electromagnetic fields interact with each other in a manner that results in a reduction of their intensities. This reduction occurs from the alignment of the trough and crest position (or phase) of one wave with the trough and crest position of another. If the positions or phases are such that a trough lines up with a crest, they can cancel each other.

The circuit design of the proposed system -- using a balanced circuit of auto transformers, catenary, rail, and return feeder line -- is one that is used to a great extent worldwide (for instance in France, China, Japan, and Russia) and is one that achieves a high degree of phase cancellation of magnetic field reduction over electric traction system designs.[47] This is because the circuit is balanced and at the same voltage, and has current flow at opposite phase angles.

Shielding is accomplished by the use of metal components that trap, and thus attenuate, external magnetic fields. However, shielding has been shown to be impractical because of the weight, cost, or manufacturability of the shielding materials.[5] Steel plate will reduce field intensity, but its weight is counter-productive to the goal of high-speed and the increased traction power required for such increased weight might result in increased EMF at the wayside (because of increased current flow). Other materials may be used, such as mu metal -- which is a magnetic shielding alloy of nickel, iron, copper, and chromium -- but it extremely expensive and difficult to form and maintain.

Another potential source of magnetic fields are substations and tie-lines. As noted previously, substations are not particularly strong sources of magnetic fields, and therefore are not useful candidates for mitigation. However, the configuration of tie-lines will affect magnetic field exposures of adjacent populations. The preliminary design choice for the new 115 kV transmission tie lines is a delta configuration, which results in substantially lower magnetic fields in comparison to H-frame designs that have been used in the past.[32] Thus, mitigation measures have been incorporated in the design of the tie-lines, and lower levels of magnetic fields are expected than would be generated by traditionally-designed transmission lines. As stated previously, the EMF intensities generated are directly related to current flow through the electrified system. The design voltage of the NEC electrification is 25 kV, which is higher than most existing U.S. systems. This higher voltage results in proportionately lower current flows (and lower EMF levels) than if a lower design voltage were utilized (such as in the system currently employed in the NEC).

On the basis of the information described above, no additional mitigation measures appear to be warranted for EMF exposures. This is particularly true because the projected exposures to EMF are below the interim guidelines for all populations and because mitigation measures have been incorporated into the design.

5.7 CONCLUSIONS

The EMF exposures resulting from the electrification project have been estimated for all potentially exposed populations: people residing or working in the vicinity of the NEC right-of-way, substations and tie lines; rail workers on and off the trains; persons in adjacent recreation areas, and passengers on station platforms and in the trains. These estimates are based on extensive measurements taken on existing electrified systems similar in design and/or using similar train sets to those anticipated for the NEC electrification project. It is believed that the data obtained is representative of the EMF levels that can be expected to be generated from the NEC electrification project, and a conservative interpretation of the data has been used in all instances. The end result of this analysis is that all of the estimated exposure levels are hundreds to thousands of times lower than any of the interim guidelines for exposure recommended by the international scientific community and many of the estimated levels of exposure are of the same order of magnitude as background EMF levels.

APPENDIX A
POPULATION ASSESSMENT

INTRODUCTION

Estimates of existing residential and non-rail employee populations within each zone are made based upon current zoning districts along the corridor and tie-lines. To supplement this information, specific buildings having an occupancy higher than the estimates based on zoning districts and/or in particularly close proximity to the ROW were identified based upon review of aerial photographs, a slow-speed rail trip along the NEC, and discussions with officials from each town/city. This allowed individual estimates of employment for these particular buildings. Increases in residential and non-rail employee populations expected by the year 2010 were then estimated via state growth rates presented in the 1990 United State Census.

Estimates for rail employee populations and for ridership populations are based on information provided by U.S. DOT, Amtrak, the MBTA, and ConnDOT. These estimates are described separately from the residential and non-rail employee estimates. A summary of the total estimated numbers of each category of potentially exposed person is presented in Table A-1.

Residential Population Estimating Methods

Several methods are used to estimate the residential populations along the ROW. The one relied upon to the greatest extent is based upon each town's zoning districts. All zoning designations were identified and occupancy and building location assumptions were made for each zoning category.

The population estimates based on zoning are further refined from observations made during a so-called "high-rail" inspection (a slow-speed trip using an eight-passenger over-the-rail vehicle during November 1992) and from examinations of current aerial photographs, both of which encompassed the entire ROW. Additionally, a third method was used where structures or areas of high occupancy or population density were located along the ROW. These locations were identified from the slow-speed rail inspection, the aerial photographs, and interviews with officials and employers in each of the municipalities, allowing estimates for particular buildings or facilities. The methodology for estimating the population in these high density areas is described later in this Appendix.

Several assumptions were necessary to obtain population estimates. One basic assumption was that zoning requirements can be used as the basis of populations estimates. For example, if the zoning designation is two-family, it is assumed that two families are indeed located in each lot, even though some lots might have only a one-family unit. Similarly, it is assumed that the multi-family zoning designation is occupied everywhere by three families, even though fewer units likely exist on many of the lots. For the cases where more than three families exist on a

Table A-1

Summary of Estimates of Total Potentially Exposed Persons Along ROW Categorized by Distance From EMF Source and By Population Type

Population Type	Population Within Each Zone			
	Exposure Zone 1[a]	Exposure Zone 2[b]	Exposure Zone 3[c]	Totals
Residential - Wayside				
Existing (1993)	300	6,600	1,300	8,200
Projected (2010)	300	7,000	1,400	8,700
Residential - Tie-Line Substation				
Existing (1993)	37	12	7	56
Projected (2010)	37	12	7	56
Commercial/Industrial - Wayside				
Existing (1993)	2,600	18,500	18,500	39,500
Projected (2010)	2,800	20,000	20,800	42,700
Commercial/Industrial - Tie-Line/Substation				
Existing (1993)	8	170	171	349
Projected (2010)	12	184	185	381
Recreational				
Existing (1993)	17,000	17,000	17,000	51,000
Projected (2010)	18,000	18,000	18,000	54,000
Amtrak, ConnDOT, and MBTA Employees[d]				
On-train	250			250
Off-train	560[e]	160[f]		720
Freight Employees				
On-train	18			18
Average NEC Rail Ridership, per day[g] (2010)	40,300			40,300

[a] 0 to 50 ft. from edge of rail (0 to 20 ft. from edge of ROW).
[b] 50 to 100 ft. from edge of rail (20 to 70 ft. from edge of ROW).
[c] 100 to 150 ft. from edge of rail (70 to 120 ft. from ROW).
[d] Current estimates; projected estimates not currently developed by rail agencies.
[e] Yard, rail, and maintenance workers.
[f] Station and management workers.
[g] Includes Amtrak, MBTA, RIDOT, and ConnDOT.

multi-family zoned lot, it is assumed that the separate search for high density populations discovered them.

As may be expected, observations from the aerial photographs and the slow-speed rail trip indicate that structures are set back farther from the ROW as lot size increases. It was also observed that there are very few residences within Zone 1 (up to 30 feet from the tracks). Therefore, in the following areas immediately abutting the ROW, assumptions are made regarding the placement of residential units within the populations zones defined earlier:

- if the residence is in Zone 1, it will be identified from the search of high density populations (using slow-speed rail inspection and aerial photographs), and not from zoning assumptions;

- if the minimum lot size per dwelling from the specific zoning district is 10,000 sq. ft. or less, it is assumed that the residential units are set back from the side of the rail at least 50 feet and therefore are in Zone 2;

- if the minimum lot size per dwelling is between 10,000 and 20,000 sq. ft., it is assumed that the residential units are set back from the side of the rail at least 100 feet and therefore are in Zone 3; and

- if the minimum lot size per dwelling is over 20,000 sq. ft., it is assumed that the residential unit is at least 150 from the side of the rail and is not included in the study.

The following steps are then used to estimate residential populations. First, the maximum "build-out" population is estimated by determining the maximum number of lots (dwelling units) that could abut the ROW if all residentially-zoned areas were developed. (This excludes all non-developable land, such as rivers or roadways.) The maximum number of lots was obtained by using the minimum lot frontage/width requirements specified in the local zoning bylaws. When dimensional requirements were not available, a lot width of 100 ft. was assigned to the residential district. By delineating the zoning districts along the corridor, which define minimum land area and lot width, the maximum (100 percent "build-out") number of dwellings was calculated for each town/city along the ROW. The average number of people per dwelling for each town/city was then determined from United States 1990 Census Data.[(48)] The product of these values establishes the maximum residential population located within each 50 foot EMF exposure zone for the respective town/city.

The projected maximum "build-out" populations are based upon zoning requirements only and are, therefore, considered conservative (i.e., may represent high population estimates). Assumptions that further result in the projections being conservative include the following:

- minimum allowable lot dimensions are assumed, resulting in the maximum number of lots;

- lot orientations perpendicular to the ROW are assumed, which maximizes the number of lots; and

- railroad features, such as sidings, additional non-electrified tracks, and maintenance facilities, which increase the ROW width and, therefore, the buffer to properties are not considered.

Second, existing populations potentially affected by EMFs are estimated based upon a percent "build-out" of each zoning district along the ROW. The percent "build-out" is estimated from field observations and aerial photographs of the ROW. Each zoning district is considered either undeveloped (0 percent developed), partially developed (50 percent developed), or fully developed (100 percent developed). Included in the assessment of percent developed is the density of the development, the orientation and geometry of the development with respect to the tracks/tie-lines, and the relative proximity of the development to the tracks/tie-lines. Land areas which are not available for construction, such as roads or lakes, were considered non-developable, and thus an area in which all of the developable land was built on was considered 100 percent developed.

Finally, projected populations for the year 2010 are estimated by multiplying existing populations by the respective Connecticut, Rhode Island, and Massachusetts state growth rate projections presented in the 1990 United States Census.[49] The projected 1990 to 2010 growth rates for these states are estimated to be 7.7, 8.3, and 6.4 percent, respectively. This methodology provides representative growths in population on a state wide basis. However, at a local level, this methodology may tend to overestimate growth in areas and with a high-density population underestimate growth in areas with low-density population.

Industrial/Commercial Population Estimating Methods

Non-residential uses consist primarily of industrial, manufacturing, commercial, business, and institutional uses. To simplify the assessment and presentation of data, non-residential uses are categorized, based upon employee densities and periods of potential exposure, as either industrial (including industrial and manufacturing) or commercial (including commercial, business, and institutions). These two categories represent relatively low and high population densities, respectively. A third category of non-residential population is associated with recreational facilities and parks. However, since population densities and hours of exposure associated with these facilities significantly differ from other non-residential uses, recreational populations have been estimated separately as part of the analysis of high density populations.

Employee densities were based on data gathered during review of aerial photographs, the low-speed rail trip, conversations with town officials, and relevant literature. During the evaluation of this data, large commercial or industrial facilities were identifiec and questioned regarding their employment and square footage. Based on this information, as well as the data from literature, densities of one and three persons per 1000 square feet (s.f.) are estimated for industrial and commercial facilities, respectively. Data published by the Center for Urban Policy Research[50] suggest employee densities on the order of three persons per 1000 s.f. for both industrial and commercial uses. Due to the observed high number of warehouse facilities and other low populated industries, an industrial density of one person per 1000 s.f. is considered more representative for the industrial buildings along the NEC and has been used in this study. Three persons per 10000 s.f. was the employment density assumed for commercial buildings.

In order to determine commercial/industrial employment, building sizes must be determined and applied to the employment density data. Zoning information was used to determine maximum number of lots under "build-out" conditions, in a similar manner to residential population estimates. When available, the specific dimensional requirements of each zoning district were used to estimate the number of non-residential lots along the corridor. When district zoning dimensions were not available, minimum lot widths of 100 ft and 150 ft. were assigned to industrial and commercial lots, respectively. The maximum number of lots was then adjusted by the percent "built-out" to establish an existing non-residential population exposed to EMFs.

Based upon the collected zoning data, average building to lot area ratios (i.e., lot coverage) of 50 and 60 percent are estimated for industrial and commercial uses, respectively. These lot coverage percentages were used to determine typical building widths along the ROW. Building areas exposed to EMFs are then calculated by multiplying building widths by the depth of the EMF zones. These areas, when multiplied by the appropriate employment density, yield employment per building.

Since few commercial buildings were observed within 20 feet of the ROW, commercial populations within Zone 1 were not estimated based upon general zoning criteria, but instead were developed from the high density population review, which allowed identification of individual structures. For industrial buildings, this study assumes that half the lots zoned industrial contain buildings in Zone 1. This is a conservative assumption (i.e., overstates the Zone 1 structures) based on the slow speed-rail and aerial photograph reviews. For Zones 2 and 3, zoning information was used to determine the number of commercial and industrial buildings.

Finally, projected 2010 non-residential populations were determined by multiplying existing population estimates by the projected 1990 to 2010 growth rate for each respective state. As noted previously, this calculation may tend to overestimate growth in densely populated areas and underestimate growth in low-density areas. On a state-wide basis, growth projections will provide representative estimates.

The non-residential populations estimates have been based upon similar "build-out" assumptions as those described under residential populations and, thus, may represent conservative population estimates. Furthermore, from observations made during the slow-speed rail inspection of the ROW, it was apparent that many industrial and commercial buildings were either abandoned or not fully occupied. However, since the factors that would reduce the full build-out populations could not be determined individually (as was done with the residential case), full build-out was assumed. For these reasons, estimated employee populations are likely high.

High Density Populations Estimating Methods

Existing residences, companies, and facilities containing high population densities (compared to existing zoning criteria) or populations which were particularly close to the EMF sources were estimated individually. These typically included large apartment buildings, mobile home parks, large industrial/business complexes, and recreational areas. These populations were identified by reviewing aerial photographs and from observations made during the slow-speed rail trip along the ROW.

When sufficient information existed to identify these high density population areas. an attempt was made to contact the residence, company, or facility to determine actual populations. When such information could not be gained, building areas and setbacks were approximated from aerial photography, and general population densities described in the previous sections were used to estimate populations. If the location crosses over EMF exposure zones, it was assumed that the persons within the structure are equally divided among the zones.

Telephone interviews were also conducted with officials from each town/city along the ROW to specifically identify industrial or commercial developments adjacent to the tracks. The Assessor's Office or other appropriate office was consulted. All were asked if there were significant industrial or commercial development along the tracks, if there were a single major employer along the tracks, and what level of occupancy existed within developed areas. Generally, the municipal officers corroborated the data which had been gathered while traversing the corridor and through research of aerial photographs. Where the few new industrial/commercial locations were identified, employers were contacted, when possible, to determine approximate distance from the tracks, number of employees, and square footage.

Populations observed in Zones 2 and 3 are considered to be among the population estimates determined from zoning criteria as described earlier, and are not treated separately here except for informational purposes. Residential and commercial populations which are located in Zone 1 and recreational populations are estimated solely by the high density population review and not by zoning methods. This is because few residential and commercial populations were observed in Zone 1. Recreational populations are not considered part of population estimates based on zoning because of their significantly smaller time of occupancy in a zone and so are likewise estimated by the high density population review.

POPULATION ESTIMATES

Existing Residential Population Estimates

The existing residential population which may potentially be exposed to EMFs emitted from the overhead catenary system is estimated to be approximately 8,100. This includes approximately 300 people located in Zone 1, 6,600 people in Zone 2, and 1,300 people in Zone 3. The existing residential population which may potentially be exposed to EMFs produced by substations and tie-lines is estimated to be approximately 60 people. A breakdown of the estimated existing population by town/city and state is presented in Table A-2.

Projected Residential Population Estimates

The projected population, for the year 2010, which could potentially be exposed to EMFs from the overhead catenary system is estimated to be approximately 8,700. This includes approximately 300 people located in Zone 1, 7,000 people in Zone 2, and 1,400 people in Zone 3. The projected residential population in 2010 which may potentially be exposed to EMFs emitted from substations and tie-lines is estimated to remain at approximately 500 people. A breakdown of the projected population by town/city and state is presented in Table A-2.

Existing Commercial/Industrial Populations Estimates

The current non-residential population which may potentially be exposed to EMFs emitted from the overhead catenary system is estimated to be approximately 39,500. This includes approximately 2,500 people located in Zone 1, 18,500 people in Zone 2, and 18,500 people in Zone 3. The current non-residential population which may potentially be exposed to EMFs emitted from power supply systems, including substations, tie-lines, and feeder lines, is estimated to be approximately 350 people. This includes approximately 10 people located in Zone 1, 170 people in Zone 2, and 170 people in Zone 3. A breakdown of the existing population by town/city and state is presented in Table A-3.

Table A-2
Residential Population Estimates

Town	Source	Location of Current Popula			Location of Projected Popula.[a]		
		Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
New Haven	Track	0	2397	80	0	2582	86
East Haven	Track	0	0	31	0	0	33
Branford	Track	0	14	34	0	15	37
	Power Supply[b]	0	0	0	0	0	0
Guilford	Track	0	7	10	0	7	11
Madison	Track	0	12	19	0	13	21
Clinton	Track	0	0	10	0	0	11
Westbrook	Track	7	12	12	9	13	13
Old Saybrook	Track	0	10	10	0	11	11
Old Lyme	Track	10	24	34	10	26	37
East Lyme	Track	7	46	74	7	50	80
Waterford	Track	5	10	10	5	11	11
New London	Track	0	12	31	0	13	33
	Power Supply[b]	37	12	7	37	13	7
Groton (City)	Track	0	57	0	0	62	0
Groton (Town)	Track	0	17	38	0	18	41
Stonington	Track	5	70	113	5	76	122
Total	Track	34	2688	513	36	2910	554
Connecticut	Power Supply[b]	37	12	7	37	12	7
Westerly	Track	2	19	24	0	21	26
Hopkinton	Track	0	0	0	0	0	0
Charlestown	Track	2	0	0	0	0	0
Richmond	Track	2	34	29	2	37	31
S. Kingston	Track	0	0	7	0	0	8
Exeter	Track	2	0	10	2	0	11
N. Kingston	Track	5	10	94	5	11	102
E. Greenwich	Track	0	0	0	0	0	0
Warwick	Track	14	158	72	15	171	78

Table A-2

Residential Population Estimates (Continued)

Town	Source	Location of Current Popula			Location of Projected Popula[a]		
		Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
	Power Supply[b]	0	0	0	0	0	0
Cranston	Track	5	12	5	5	13	5
Providence	Track	24	556	0	26	602	0
Pawtucket	Track	0	48	77	0	52	83
Central Falls	Track	0	5	36	0	5	39
Total	Track	52	842	354	55	912	383
Rhode Island	Power Supply[b]	0	0	0	0	0	0
Attleboro	Track	14	98	204	15	106	220
Mansfield	Track	0	10	67	0	11	72
Foxborough	Track	0	0	17	0	0	18
Sharon	Track	0	0	43	0	0	46
Canton	Track	0	29	60	0	31	65
Westwood	Track	0	17	0	0	18	0
Dedham	Track	0	48	0	0	52	0
Boston	Track	192	2827	0	204	3008	0
	Power Supply[b]	0	0	0	0	0	0
Total	Track	206	3,029	391	219	3,226	421
Massachusetts	Power Supply[b]	0	0	0	0	0	0
Total Corridor	Track	268	6,559	1,258	310	7,048	1,358
	Power Supply[b]	37	12	7	37	12	7

[a] Projected populations are based upon state-wide growth projections, and may tend to overestimate growth in highly populated areas and underestimate growth in low populated areas.

[b] Power supply includes substations and tie-lines.

Table A-3
Commercial/Industrial Population Summary

Town	Source	Current Employee Population			Projected Employee Population		
		Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
New Haven	Track	79	1591	1591	85	1714	1714
East Haven	Track	4	775	775	4	835	835
Branford	Track	158	662	662	170	713	713
	Power Supply	0	0	0	0	0	0
Guilford	Track	13	64	64	14	69	69
Madison	Track	21	204	204	23	220	220
Clinton	Track	60	480	480	65	517	517
Westbrook	Track	14	392	392	15	442	442
Old Saybrook	Track	72	522	522	78	562	562
Old Lyme	Track	0	234	234	0	252	252
East Lyme	Track	0	387	387	0	417	417
Waterford	Track	19	94	94	20	101	101
New London	Track	32	1004	1004	34	1081	1081
	Power Supply[b]	2	155	155	5	167	167
Groton (City)	Track	3	123	123	3	132	132
Groton (Town)	Track	24	507	507	26	546	546
Stonington	Track	47	731	731	51	787	787
Total Connecticut	Track	546	7770	7770	588	8388	8388
	Power Supply[b]	2	155	155	5	167	167
Westerly	Track	43	412	412	47	446	446
Hopkinton	Track	0	0	0	0	0	0
Charlestown	Track	0	0	0	0	0	0
Richmond	Track	4	64	64	4	69	69
South Kingston	Track	9	45	45	10	49	49
Exeter	Track	0	0	0	0	0	0
North Kingston	Track	6	246	246	6	266	266
East Greenwich	Track	8	38	38	9	41	41

Table A-3

Commercial/Industrial Population Summary (Continued)

Town	Source	Current Employee Population			Projected Employee Population		
		Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
Warwick	Track	238	3232	3232	258	3500	3500
	Power Supply[b]	4	7	8	4	8	9
Cranston	Track	58	325	325	63	352	352
Providence	Track	282	1720	1720	305	1863	1863
Pawtucket	Track	25	610	610	27	661	661
Central Falls	Track	6	75	75	6	81	81
Total	Track	678	6767	6767	735	7328	7328
Rhode Island	Power Supply[b]	4	7	8	4	8	9
Attleboro	Track	74	724	724	78	770	770
Mansfield	Track	56	470	470	60	500	500
Foxborough	Track	8	38	38	9	40	40
Sharon	Track	0	0	0	0	0	0
Canton	Track	43	214	214	46	228	228
Westwood	Track	32	158	158	34	168	168
Dedham	Track	4	19	19	4	20	20
Boston	Track	1091	2376	2376	1161	2528	2528
	Power Supply[b]	2	8	8	3	9	9
Total	Track	1306	3999	3999	1392	4254	4254
Massachusetts	Power Supply[b]	2	8	8	3	9	9
Total Corridor	Track	2527	18536	18536	2715	19970	19970
	Power Supply[b]	8	170	171	12	184	185

[a] Projected populations are based upon state-wide growth projections, and may tend to overestimate growth in highly populated areas and underestimate growth in low populated areas.

[b] Power supply includes substation and tie-line.

Projected Commercial/Industrial Population Estimates

The projected non-residential population, for the year 2010, which could potentially be exposed to EMFs from the overhead catenary system at levels distinguishable from background is estimated to be approximately 42,700. This includes approximately 2,700 employees located in Zone 1, 20,000 employees in Zone 2, and 20,000 employees in Zone 3. The projected non-residential population which may potentially be exposed to EMFs emitted from substations and tie-lines is estimated to be 1,750 employees. This includes approximately 50 employees located in Zone 1, 850 employees in Zone 2, and 850 employees in Zone 3. None of these exposures, however, even approach the levels of the interim guidelines. A breakdown of the projected population by town/city and state is presented in Table A-3.

High Density Population Estimates

Thirty-one areas of high density population were identified from aerial photographs, observations made from a low-speed rail trip ride along the ROW, and interviews with town/city officials (see Table A-4). This includes approximately 300 persons located in Zone 1 residences. Because of the low observed residential population within 50 feet of the magnetic field sources, the estimated 300 residential people associated with high density populations represent the total estimated population for that zone (both currently and in 2010). In other words, this methodology is used instead of the zoning-based methodology to determine population in Zone 1 in those areas with high-density populations. For Zones 2 and 3, any residential population identified through the high-density analysis was assumed to be a sub-set of the population estimated using zoning criteria.

The non-residential (commercial and industrial) high density population is estimated to be approximately 2,600 people currently located in Zone 1. This population is projected to increase to approximately 2,700 in the year 2010. As with the residential analysis in Zone 1, the high-density methodology replaces the zoning criteria methodology as a means of estimating commercial/industrial populations in areas with high-density locations. For Zones 2 and 3, the high-density analysis identifies populations that are assumed to be sub-sets of the population estimated using zoning criteria.

Two schools were identified which were located within 150 feet of the track source. English High School in Boston has approximately 1,300 students and staff. The High School is set back approximately 60 feet from the tracks. Half the school's population, 650 people, is presumed to be located within Zone 2 and the other 650 people located within Zone 3. A second school was located from aerial photographs in Pawtucket, Rhode Island. From the aerial photographs, this school appears to be a small neighborhood day-care center, located approximately 100 to 150 feet from the tracks. No additional information was obtained during several telephone calls made to identify the facility. For exposure estimates, a population of 95 students and 5 staff has been estimated. Due to similarities in population density and periods of exposure, schools are considered a subset of commercial populations estimates based upon zoning criteria.

Table A-4

High Density Population Summary

Town	ROW Mile	Type of Facility	Type[a]	Estimated Populations Zone 1	Zone 2	Zone 3
New Haven	73.3	3 Story Apartments	R		72	
East Haven	77.7	4 Building Strip Mall	C		73	73
Branford	80.4	Commercial Building	C[b]	60		
	81.8	Atlantic Wire Company	I	50	50	
Clinton	96.6	Cheeseborough Pond, Inc.	C		117	117
Westbrook	98.9	5 Mobile Homes	R[b]	8		
	98.9	12 Mobile Homes	R			18
Old Saybrook	105.0	Old Saybrook Market Place	C[b]	45		
East Lyme	115.8	12 Unit Apartment Bldg.	R[b]	27		
	112.8	Rocky Neck State Park	O	317	317	316
Town of Groton	126.2	Gordon Industrial Bldg.	I	90	90	90
New London	123.2	42 Unit Apartment Bldg.	R[c]			114
Richmond	153.7	Kenyon Industrial (Office)	I	39	39	
	153.7	Kenyon Industrial	I			77
Warwick	175.3	2 Industrial Buildings	I	13	13	
Cranston	179.6	Heavy Industry	I	25	25	25
Providence	183.4	225 Unit Apartment	R			542
	183.4	10 Retail in Apartments	C			20
	185.1	American Express Offices	C[b]	167	167	167
Pawtucket	189.1	Possible Day Care	C			100
	189.8	197 Unit Elderly Housing	R			453
Attleboro	191.2	22 Mobile Homes	R[b]	56		
	191.8	39 Mobile Homes	R		99	
	193.6	Industrial Building	I	12	12	12
	197.2	Jewelry Manufacturing	I	117	117	117
	197.9	Horton Park	O		25	25

Table A-4

High Density Population Summary (Continued)

Town	ROW Mile	Type of Facility	Type[a]	Estimated Populations Zone 1	Zone 2	Zone 3
Boston	224.2	English High School	C		650	650
		Southwest Corridor Park	O	16666	16667	16667
	227.5	Copley Townhouses-84 Units	R[b]	192		
	227.7	Copley Sq. Mall Retail	C[b]	100	100	100
	227.7	Copley Sq. Hotel-804 Rm	C		400	400
	228.5	U.S. Postal Service	C			2500
	228.9	Stone & Webster	C		725	725
	228.9	South Station Commercial	C[b]	143	143	
	228.9	Propose S. Sta. Commercial	C[b]	650	650	

Notes to Table A-4:

[a] R = Residential; C = Commercial; I = Industrial; O = Open Space/Parks.
Population used to estimate residential and commercial populations within 50 feet of the EMF source.

[b] Population used to estimate residential and commercial populations within 50 feet of the EMF source.

[c] High density population located on power supply lines.

In addition to the buildings in high density areas, three parks were identified with high use near the ROW. Numerous other parks exist along the ROW, however none of the investigatory methods used (aerial photographs, slow-speed rail trip, and interviews with town officials) identified them as having population densities within the zones of interest for this study. The three identified were Rocky Neck State Park (East Lyme, Connecticut), Horton Field playgrounds/ballfield (Attleboro, Massachusetts), and the Southwest Corridor Park (Boston, Massachusetts). Information provided by the Connecticut State Parks Agency indicate that Rocky Neck State Park has approximately 3,700 visitors per day which utilize the beach areas adjacent to the ROW.[51] This beach population was said to occur only during the summer months of June, July, and August. This results in an average year-round use of approximately 950 people per day. No visitation information on Horton Field was available; a population of 200 people per day, during the summer months, was assumed for exposure estimates for Horton Field. This results in an average daily year-round use of 50 people. An official from the Southwest Corridor Park estimated year-round use at 50,000 people per day.[52] However, it should be noted that this estimate was said to include pedestrian travel through the park and to mass transit stations. This type of use results in a relatively brief duration of exposure.

Combining all parks results in an average year-round daily park use of approximately 51,000 people. Since no information was available on the location of the visitors, it is assumed that park populations are equally divided into the zones of EMF exposure in which they are located. This results in approximately 17,000 people per zone.

Based upon the projected state growth rates, average year-round daily uses for Rocky Neck, Horton Field, and Southwest Corridor parks in 2010 are estimated to be approximately 1000, 50, and 53,000 people, respectively. Therefore, the total projected year-round daily park use is estimated to be approximately 54,000 people. This includes approximately 18,000 people located within each of the three 50 foot EMF zones of influence.

Rail Employees and Rail Ridership

The numbers of rail employees was provided by Amtrak and MBTA for their respective companies. The estimated numbers of persons using the trains on a daily basis are based on available ridership estimates and projections. Using the ratio of riders to employees for MBTA and the ridership data for Connecticut Department of Transportation (ConnDOT), it is estimated that four ConnDOT employees would work on the train. It is assumed that no additional occupational exposure occurs for off-train ConnDOT employees.

Amtrak and ConnDOT will be using electric engines and therefore the riders and on-train workers will be exposed to on-board EMF emissions for the duration of the trip. MBTA will be using diesel engines and its riders and on-train workers will be exposed to Zone 1 EMF emissions only when passing under an energized catenary section. Energization occurs when an electric engine is drawing power from the same catenary section, either in the same or the opposite direction.

The number of Amtrak, ConnDOT, MBTA, and freight workers for the Northeast Corridor (NEC) on a daily basis are as follows:

Item	Number of Workers
Amtrak [18]	
On-train	110
Off-train, track side	543
Off-train, station	162
MBTA [19]	
On-train	138
Off-train, track side	18
ConnDOT	
On-train	4
Freight Railroad	
On-train	18

Table A-5 provides the average daily train occupancy at all of the station segments. The average daily ridership in 2010 is determined by averaging the individual route segments, as shown in the table. The averages, and their potential EMF exposure scenarios, are as follows:

Amtrak: 14,610	Continuous, On-board EMF
ConnDOT: 780	Continuous, On-board EMF
MBTA: 23,750	Intermittent, Zone 1 EMF
RIDOT: 1,200	Intermittent, Zone 1 EMF

Table A-5

Northeast Corridor New Haven to Boston
Estimated Segment Daily Ridership for 2010

Rail-Line	Segment	Daily Ridership
Amtrak	New-Haven - Old Saybrook	17,005
	Old Saybrook - New London	16,930
	New London - Mystic	16,607
	Mystic - Westerly	16,570
	Westerly - Kingston	16,532
	Kingston - Providence	16,306
	Providence - Route 128	12,900
	Route 128 - Back Bay	10,114
	Back Bay - South Station	8,555
	Average	14,610
MBTA	Providence - South Attleboro	1,705
	South Attleboro - Attleboro	4,365
	Attleboro - Mansfield	8,312
	Mansfield - Sharon	11,960
	Sharon - Canton Junction	14,280
	Canton Junction - Route 128	20,420
	Route 128 - Readville	24,320
	Readville - Hyde Park	38,260
	Hyde Park - Forest Hills	39,542
	Forest Hills - Ruggles Street	46,427
	Ruggles Street - Back Bay	45,187
	Bay Back - South Station	30,187
	Average	23,750
ConnDOT	New Haven - Branford	1,474
	Branford - Guilford	1,206
	Guilford - Madison	938
	Madison - Clinton	676
	Clinton - Westbrook	506
	Westbrook - Old Saybrook	408
	Old Saybrook - New London	240
	Average	780
RIDOT	Kingston - Wickford Junction	600
	Wickford Junction - Warwick	1,200
	Warwick - Providence	1,800
	Average	1,200

APPENDIX B

REFERENCES

[1] Health Effects of Low Frequency Electric and Magnetic Fields, Prepared by An Oak Ridge Associated Universities Panel for the Committee on Interagency Radiation Research and Policy Coordination, June 1992.

[2] Bailey, WH; Bissel, M; Brambl, RM: Dorn, CR; Hoppel, WA; Sheppard, AR; Stebbings, JH. A Health & Safety Evaluation of the +/-400 KV DC Powerline. Minnesota Environmental Quality Board, December 1982.

[3] Office of Technology (OTA). Biological Effects of Power Frequency Electric and Magnetic Fields. Background Paper #OTA-BP-E-53, May 1989.

[4] Brecher, A. Electromagnetic Fields (EMF) Health and Safety Issues for Rail Systems and Technologies. Abstract of paper CEO27, TRB Session #36, January 13, 1992.

[5] Health Effects of Low Frequency Electromagnetic Fields Due to Maglev and Rail Systems for the Department of Transportation, Final Report: Review of the Research Literature Relevant to Possible Health Hazards Associated with Maglev and Other Advanced High-Speed Rail Technology. Information Ventures, Inc., Philadelphia, Pennsylvania, September 30, 1992.

[6] Bracken, TD; Rankin, RF; Alldredge, JR; Senior, RS. EMDEX Project Residential Study. Electric Power Research Institute. Interim Report. February 1993.

[7] Bowman, JD; Sobel, E; London, SJ; Thomas, DC; Garabrant, DH; Pearce, N; Peters, JM. Electric and Magnetic Field Exposure, Chemical Exposure, and Leukemia Risk in "Electrical" Occupations. Electric Power Research Institute. Final Report. December 1992.

[8] Sahl, JD; Kelsh, MA; Greenland, S. Cohort and nested case-control studies of hematopoietic cancers and brain cancer among electric utility workers. Epidemiology. 4:104-114, 1993.

[9] Savitz, DA; Wachtel, H; Barnes, FA; John, EM; Tvrdik, JG. Case-control study of childhood cancer and exposure to 60-hertz magnetic fields. American Journal of Epidemiology. 128:21-38, 1988.

[10] London, SJ; Thomas, DC; Bowman, JD; Sobel, E; Cheng, T; Peters, JM. Exposure to Residential Electric and Magnetic Fields and Risk of Childhood Leukemia. American Journal of Epidemiology, 134:923-937, 1991.

[11] Federal Railroad Administration. Railroad Electromagnetic Compatibility (EMC): Proceedings of a Symposium Sponsored by the Railroad EMC Working Group - Association of American Railroads, Institute of Electrical & Electronics Engineers, American Railway Engineering Association. U.S. Department of Transportation Federal Railroad Administration, Office of Research and Development. January, 1981. [FRA/ORD-80/46]

[12] Wertheimer, N; Leeper, E. Electrical wiring configurations and childhood cancer. American Journal of Epidemiology. 109:273-284, 1979.

[13] Feychting, M; Ahlbom, A. Magnetic Fields and Cancer in People Residing Near Swedish High Voltage Power Lines Stockholm, Sweden: Karolinska Institute. October 2, 1992.

[14] Fulton, J.P; Cobb, S; Preble, L; Leone, L; Forman, E. Electrical Wiring Configurations and Childhood Leukemia in Rhode Island.
Am J Epidemiology 111(3):292-296\1980\496\5407.

[15] Myers, A; Clayden, A.D; Cartwright, R.A; Carwright, S.C. Childhood Cancer and Overhead Powerlines: A Case-Control Study Br J Cancer 62((6):1008-1014\1990\1085\5481.

[16] Environmental Protection Agency (EPA). Electric and Magnetic Fields: An EPA Perspective on Research Needs and Priorities for Improving Health Risk Assessment. Office of Research and Development. U.S. Environmental Protection Agency. Washington, D.C. [EPA/600/9-91/106F]

[17] Severson, RK; Stevens, RG; Kaune, WT; Thomas, DB; Heuser, L; Davis, S; Sever, LE. Acute nonlymphocytic leukemia and residential exposure to power frequency magnetic fields. American Journal of Epidemiology. 128:10-20, 1988.

[18] McDowall, M.E. Mortality of Persons Resident in the Vicinity of Electricity Transmission Facilities. Br J Cancer 53(2):271-279\1986\965\3008.

[19] Coleman , M; Bell, CMJ; Taylor, HI; Thornton-Jones, H, Leukaemia and Electromagnetic Fields: A Case-Control Study. Presented at the International Conference on Electric and Magnetic Fields in Medicine and Biology. December 4-5\1985\302.

[20] Youngson, J; Clayden, AD; Myers, A; Cartwright, RA. A case/control study of adult hematological malignancies in relation to overhead powerlines. British Journal of Cancer. 63:977-985, 1991.

[21] Schreiber, GH; Swaen, GMH; Meijers, JMM; Slangen, JJM; Sturmans, F. Cancer mortality and residence near electricity transmission equipment; a retrospective cohort study. International Journal of Epidemiology. 22: 9-15.

[22] Wright, WE; Peters, JM; Mack, TM. Leukaemia in workers exposed to electrical and magnetic fields. The Lancet. November 20, 1982.

[23] Tynes, T; Andersen, A; Langmark, F. Incidence of cancer in Norwegian workers potentially exposed to electromagnetic fields. American Journal of Epidemiology. 136:81-88, 1992.

[24] Baroncelli, P; Battisti, S; Checcucci, A; Comba, P; Grandolfo, M; Serio, A; Vecchia, P. A health examination of railway high-voltage substation workers exposed to ELF electromagnetic fields. American Journal of Industrial Medicine. 10:45-55, 1986.

[25] Törnqvist, S; Knave, B; Ahlbom, A; Persson, T. Incidence of leukaemia and brain tumours in some "electrical occupations." British Journal of Industrial Medicine. 48:597-603, 1991.

[26] Nakagawa, M; Tomita, M; Koana, T; Odaka, M; Ohno, K. Estimation of standardized Mortality ratios in JNR (JPN. National Railways)-Cohort by Occupation EMF issues with Maglev in Japan. Railway Technical Research Institute. 1992.[abstract]. The First World Congress for Electricity and Magnetism in Biology Medicine. Lake Buena Vista, Florida. June 14-19, 1992, p. 76.

[27] Balli-Antunes, M; Pfluger, DH; Minder, CE. The mortality from malignancies of hematopoietic and lymphatic systems (MHLS) among railway engine drivers. Environmetrics. 1:121-130, 1990.

[28] Food and Drug Administration (FDA). Guidance for Content and Review of a Magnetic Resonance Diagnostic Device 510(k) Application. Food and Drug Administration, Center for Devices and Radiological Health. August 8, 1988.

[29] Grota, K.R; Chubb, C.B; Collart, F.R; Huberman, E. Effects of Maglev-Spectrum Magnetic Field Exposure on Human Cell Differentiation (Meeting Abstract). First World Congress for Electricity and Magnetism in Biology and Medicine, June 14-19, Lake Buena Vista, Florida. p. 65-66\1992\7021.

[29] Federal Railroad Administration (FRA/Department of Transportation (DOT). Final Procedures for Considering Environmental Impacts. Federal Register, 45:40854-40866, 1980.

[30] National Research Council (NRC) Committee on the Institutional Means for Assessment of Risks to Public Health. Risk Assessment in the Federal Government: Managing the Process. National Academy Press; Washington, DC, 1983.

[31] Commonwealth Associates, Inc. (CAI), Cost Effectiveness Analysis: Mitigation of Electromagnetic Fields. Prepared for: State of Rhode Island and Providence Plantations Committee to Study the Potential Health Effects of Electromagnetic Fields Emanating from High Voltage Transmission Lines, Cost Effectiveness Subcommittees. May 29, 1992.

[32] New York State Public Service Commission (NYSPSC). Statement of Interim Policy of Magnetic Fields of Major Electric Transmission Facilities. September 11, 1990.

[33] Florida Department of Environmental Regulation (DER). Electric and Magnetic Fields. Chapter 17-274, Volume 9, pp 601-606, 1989.

[34] American Conference of Governmental and Industrial Hygienists. (ACGIH) Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices 1991-1992. Cincinnati, Ohio, 1991.

[35] International Non-ionizing Radiation Committee of the International Radiation Protection Association (IRPA/INIRC). Interim Guidelines on Limits of Exposure to 50.60 Hz Electric and Magnetic Fields. Health Physics, 58:113-122, 1990.

[36] National Radiological Protection Board (NRPB). Guidance on Standards, Guidance as to Restrictions on Exposures to Time Varying Electromagnetic Fields and the 1988 Recommendations of the International Non-Ionizing Radiation Committee. NRPB-GS11, 1989.

[37] Deutsche Elektrotechnische Kommission im DIN und VDE (DKE) [German Electrotechnical Commission in DIN and VED]. Safety at Electromagnetic fields; Limits of Field Strengths for the Protection of Persons in the Frequency Range from 0 to 30 kHz. October 1989.

[38] Morgan, M. Granger; Florig, H. Keith; Nair, Indira; and Hester, Gordon L. Controlling Exposure to Transmission Line Electromagnetic Fields: A Regulatory Approach That is Compatible with the Available Science, Public Utilities Fortnightly, March 17, 1988.

[39] Letter from Dr. Petros N. Papas of Electric Research and Management, Inc., Pittsburgh, Pennsylvania; December 1, 1992.

[40] Electromagnetic Fields and Land Use Controls, Slesin, Louis, Connelly, Matthews, Bergman, David. American Planning Association, Planning Advisory Service, Report No. 435, December, 1991.

[41] Oak Ridge Associated Universities Panel (ORAU). Health effects of low-frequency electric and magnetic fields. Oak Ridge Associated Universities for the Committee on Interagency Radiation Research and Policy Coordination (CIRRPC), June, 1992. [ORAU 92/F8]

[42] Radio Disturbance Wave Due to High-Speed Electric Vehicles. Kawamura, Takehiko and Yoshida, Yoshishige. Quarterly Report of the Railway Technical Research Institute, Tokyo, Japan. Volume 33, No. 3, pp 209-214, August 1992.

[43] Possibility of the Reduction of the Electromagnetic Noise of the Shinkansen (Bullet Train) by Installing Conducting Nets, Ameniya, Yoshifumi and Yamaguchi, Takashi, Electronics and Communications in Japan, Volume 64-B, No. 12, 1981.

[44] Conversation between Mr. James Philcox (Roy F. Weston Inc.) and Lt. Cmdr. Glidden (U.S. Coast Guard - Boston, MA), April 8, 1993.

[45] Conversation between Mr. James Philcox (Roy F. Weston Inc.) and Ms. Fran Reimeham (FCC -Boston, MA), April 14, 1993.

[46] French Railroads Efforts to Reduce Traction Electromagnetic Fields. Gourdon, Charles, French National Railroads (SNCF), Paris, France.

[47] State Census Information for Connecticut, Rhode Island, and Massachusetts. U.S. Department of Commerce, Bureau of Census, (Washington, D.C.: Government Printing Office, 1990).

[48] U.S. Department of Commerce, Bureau of the Census, Statistical Abstract of the United States: 1990, 110th ed. (Washington, D.C.: Government Printing Office, 1990), p. 25.

[49] Burchell, Robert W., Listokin, David, and Dolphin, William R. The Fiscal Impact Handbook, Chapter 7. Center for Urban Policy Research: Rutgers, State University of New Jersey, 1978.

[50] Telephone communication by James Philcox of Roy F. Weston Inc. with Connecticut State Park Agency staff. December 10, 1992.

[51] Telephone communication by James Philcox of Roy F. Weston Inc. with Mr. Morris of Metropolitan District Commission. December 10, 1992.

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ENERGY

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TECHNICAL STUDY 6
ENERGY

6.1 INTRODUCTION

The analysis of environmental consequences will consist of a comparison of current consumption of fuel with the energy consumption for the proposed electrified system and the no-build alternative in the year 2010. The current energy consumption to be considered herein is that used in the operation of trains on the 1992 schedule between New Haven and Boston. The affected environment in relation to energy impact refers to the current consumption of fuel by diesel locomotives. This diesel consumption will be compared with the diesel consumption in the no-build alternative, as well as the electricity consumption in the electrification alternative. This comparison will be made by converting all energy consumption to common units of measurement, as described in detail in Section 6.4.

6.2 REGULATORY SETTING

This section describes regulations that establish the requirements for analysis of energy use. No local, Connecticut or Rhode Island regulations have been identified which would impose specific requirements on the energy analyses conducted. The Federal and Massachusetts requirements for energy analysis are for comparative analyses or quantification of energy use; no regulatory thresholds have been established for energy use.

6.2.1 Federal Regulations

Based on discussions with the Federal Energy Regulatory Commission (FERC), they have no regulations or policies that apply to this project. Discussions with the Department of Energy (DOE) indicate that although there are policies that deal generally with the issues involved in this EIS/R there are no specific requirements imposed by DOE on the EIS/R for this project. The same appears to be true regarding the U.S. EPA. Thus, the regulations described below are the specific Federal requirements for the energy analysis to be included in this EIS/R.

The CEQ regulations for implementation of NEPA contain general requirements on the content and format of an EIS/R. There are two requirements listed within this regulation that relate to energy use. The first is a requirement to include within an EIS/R a discussion of the energy requirements and conservation potential of various alternatives and mitigation measures. The second is a requirement for an EIS/R to address depletion of natural resources. Likewise, DOT Order 5610.1C contains a fairly general requirement for addressing energy impacts in an EIS/R. Specifically, this regulation indicates that "the statement should reflect consideration of whether the project or program will have any effect on either the production or consumption of energy and other natural resources, and discuss such effects if they are significant." Section 14 (10) of the FRA Procedures require that an EIS/R include an analysis of any irreversible or irretrievable commitments of energy resources associated with each alternative, especially those that impact on petroleum or natural gas use. The analysis of energy impacts must be conducted in accordance with Executive Order 12185, however a review of this Order indicates that it does not have any provisions that place specific requirements on this EIS/R.

The Massachusetts Secretary of Environmental Affairs has indicated in the Scope of the EIR dated September 9, 1992, prepared pursuant to the requirements of MEPA, that the analysis of energy impacts in the EIS/R must include a comparison with non-train transportation alternatives, and that an acceptable format for comparison would be to analyze the energy requirements based on fuel consumption per mode.

6.3 AFFECTED ENVIRONMENT

The first step in the analysis of current energy consumption is an examination of the current train schedule. The train schedule reviewed for this analysis is the Fall/Winter 1992/1993 Northeast Timetable effective October 25, 1992 through April 3, 1993, published by Amtrak. This schedule is considered to be representative of the "current" train schedule, as it is the train schedule in effect as of the preparation of this analysis. Only those trains travelling on the NEC from New Haven and Boston (or points in-between) are considered. Thus, those trains arriving or departing from Boston or New Haven, but which do not travel on the portion of the NEC under study are not considered. This includes trains that travel from Boston to Springfield or from Windsor Locks to New Haven. Likewise, trains traveling between New Haven and New London en route to Montreal are not considered in this analysis as this service should continue to operate under diesel power in 2010.

The relevant portion of the schedule is summarized below. Between New Haven and Boston, the following trains are on the current schedule:

- 10 trips on each day on Monday through Thursday;
- 12 trips on Fridays (including one Metroliner);
- 8 trips on Saturdays; and
- 9 trips on Sundays.

The schedule is slightly different in the opposite direction (Boston to New Haven), and can be summarized as 10 trips every day.

Using this information, weekly trip totals were calculated. There are 69 trips per week between New Haven and Boston (including one Metroliner), and 70 trips per week between Boston and New Haven. For the purposes of calculating energy consumption it does not matter which direction a train is moving. Therefore, the relevant data is as follows: 139 full one-way trips per week, including one Metroliner trip.

The Metroliner trip is noted separately because the diesel consumption data provides a separate calculation of consumption for Metroliner service. The diesel consumption data is based on Amtrak's Train Performance Characteristic (TPC) model, and indicates that a conventional train with one locomotive and seven cars consumes 340 gallons of diesel fuel on a one-way trip between Boston and New Haven, and a Metroliner with one locomotive and four cars consumes 263 gallons of diesel fuel on the same trip (Popoff, 1992).

Using this data, the annual consumption of diesel for the full trips can be calculated. It is estimated that 2,439,840 gallons of diesel fuel would be consumed annually by the conventional trains, and 13,676 gallons per year for the Metroliner service, yielding a total of 2,453,516 gallons per year. Since diesel fuel typically has a heat content of approximately 141,000 British thermal units (Btu's) per gallon, this represents an annual energy consumption of 345.9 billion Btu's.

One way to compare energy consumption of different modes of transportation is to determine the amount of energy consumed per passenger-mile traveled. Each passenger-mile represents one passenger traveling one mile, and by normalizing energy consumption to these units, comparisons can be made among transportation options with different numbers of passengers and different travel lengths. Table 6-1 shows the calculation of the number of passenger-miles currently traveled on Amtrak trains between New Haven and Boston. This table shows the number of passengers estimated to travel between certain city pairs during 1992.

The data provided by Amtrak indicates a daily passenger count, which has been converted to annual totals using the assumption that the daily totals are averages that apply to all days of the year.

Table 6-1 also shows the distance between each city pair. The product of the number of passengers that travel between each city pair and the distance between each city pair is the estimate of passenger-miles. By summing all of the passenger-miles between each city pair, the total number of passenger-miles travelled between New Haven and Boston in 1992 can be estimated. It can be seen in Table 6-1 that the total estimated number of passenger-miles in 1992 is 182,630,600. Using this in conjunction with the estimate of total energy consumption, it can be determined that 1,894 Btu's per passenger-mile are consumed by the current diesel-based system. This value serves as the point of reference for the energy consumption of the no-build and build scenarios.

There are limitations that are inherent in this analysis of current energy consumption that should be recognized when considering or utilizing this data:

- Special schedules for holidays were not factored into this analysis since data was not available regarding all holidays, however the impact of these special schedules is likely to be relatively minor.

TABLE 6-1

DETERMINATION OF CURRENT PASSENGER-MILES TRAVELED - 1992

SEGMENT OF RAIL LINE	SEGMENT LENGTH (MI.)	ANNUAL RIDERSHIP	PASSENGER-MILES
New Haven to Old Saybrook	32.8	1,301,000	42,672,800
Old Saybrook to New London	17.8	1,287,000	22,908,600
New London to Mystic	10.0	1,227,000	12,270,000
Mystic to Westerly	8.9	1,222,000	10,875,800
Westerly to Kingston	16.5	1,213,000	20,014,500
Kingston to Providence	27.1	1,171,000	31,734,100
Providence to Route 128	32.2	987,000	31,781,400
Route 128 to Back Bay	10.0	891,000	8,910,000
Back Bay to South Station	1.8	813,000	1,463,400
TOTALS	157.1		182,630,600

Source: Amtrak, 1993

- The number of stops that a train makes varies from train-to-train, and this impacts energy consumption. The data provided by Amtrak does not allow a determination of how many stops were assumed in the TPC modelling data and how closely this coincides with the average number of stops in the current schedule.

- The number of cars used on any given train affects the energy consumption, and since the number of cars used varies substantially from train-to-train, it could not be determined if the number of cars assumed in the TPC modelling approximates the average number of cars used in the current train schedule.

- The TPC modelling data has not been field-verified.

6.4 ENVIRONMENTAL CONSEQUENCES

6.4.1 Evaluation Criteria

The evaluation criteria for determining the energy impacts of the project alternatives are shown in Table 6-2.

TABLE 6-2. EVALUATION CRITERIA FOR ENERGY IMPACTS

IMPACT CRITERIA	MEASURE	SIGNIFICANCE THRESHOLD
Energy requirements and conservation potential.	Comparison of total and per passenger energy use for all modes of travel under each alternative.	None
Production or consumption of energy.	Comparison of energy use for all modes of transportation with energy generating capacity within the NEC under each alternative.	Energy requirements exceed production capacity.
Use of petroleum or natural gas.	Comparison of fuel type used for all modes of transportation under each alternative.	None

6.4.2 Projected Energy Consumption for No-Build Alternative

6.4.2.1 Key Data and Assumptions. The no-build scenario consists of the continuation of the existing diesel-based service between New Haven and Boston through the year 2010, the design year for the proposed electrification. The only differences in consumption of energy between the no-build alternative and the current system are those caused by changes in ridership that will occur by 2010. Ridership is expected to increase from the current level. As a result, Amtrak has forecast that two additional trains per day (above and beyond those in the current schedule) will run in each direction in the 2010 no-build alternative.

Many of the sources of data used in this analysis are the same as for the analysis of existing conditions. The key data sources are:

- The Fall/Winter 1992/1993 Northeast Timetable published by Amtrak (which provides current train schedule information);
- Diesel consumption data provided by Amtrak (Popoff, 1992); and
- Ridership forecasts developed as part of the transportation and traffic technical study.

6.4.2.2 Projected Energy Consumption. It is assumed that the energy consumption per train trip remains the same as the current estimate. Thus, the only forecasted change in energy consumption is based on the increase in the number of trains projected to be run each day. The two additional trains per day in each direction projected by Amtrak means that the number of one-way trips per week will increase from 139 in the current schedule to 167 in the 2010 no-build alternative. It is assumed that the additional trips are all conventional train trips (non-Metroliner). Using the energy consumption data per trip presented in Section 6.3, the annual diesel consumption in the 2010 no-build scenario is projected to be 2,948,556 gallons. This represents approximately a 20 percent increase in diesel consumption over the current rate.

The approximately 3 million gallons of diesel per year consumed in the 2010 no-build alternative translates into 415.7 billion Btu's per year. In Table 6-3, it can be seen that the number of passenger-miles projected for this scenario is 295,598,115. As a result, the energy consumption for the 2010 no-build alternative is approximately 1,406 Btu's per passenger-mile. This is about 25 percent lower than the Btu's per passenger-mile estimated for the current schedule, which is a result of Amtrak's projections of ridership (an increase of 55 percent in passenger-miles) and change in schedule (an increase of 20 percent in number of trains). Since the ridership is projected to increase so much more than the number of trains, the energy consumption on a passenger-mile basis decreases.

6.4.3 Projected Energy Consumption for Electrification Alternative

6.4.3.1 Key Data Sources and Assumptions. This analysis assumes that there will be four substations. The demand and energy consumption figures for each of the four substations were supplied by the design engineers for the project and Amtrak staff. A number of publications were also consulted in determining the effect of the additional energy and capacity demands on the utilities (NEPOOL, 1992; Bolbrock, 1992; Tennis, 1992; EEI, 1992; EIA, 1992). The first two publications provided the official projections of system-wide demand and utility-specific supply. The third publication was useful in developing the methodology used in this analysis. The last two documents provided information regarding heat content of fuels and efficiency of electric-generating facilities.

6.4.3.2 Projected Energy Consumption

Electricity Consumption. Electricity consumption is measured in two ways: *energy* use, and *capacity* use. *Capacity* is the total amount of electricity that the generating system can generate, and is generally measured in megawatts (Mw) which is an instantaneous measurement. *Energy* is the amount of electricity that flows in a given amount of time, and is measured in megawatt-hours (MwH). When a customer such as Amtrak needs electrical energy, it uses varying amounts depending on the needs of the moment. This varying instantaneous amount of energy that the customer needs is the customer's *demand* for capacity. The largest instantaneous demand that the customer might ever place on the generating system is its peak demand. If this peak demand occurs at an hour during the day when many other customers are also demanding large quantities of electricity, the capacity of the generating system may have to be expanded to meet these simultaneous demands. A utility expands its capacity through building new power plants or purchasing a share of a power plant outside the service territory.

The power plants and customers for a utility are inter-connected by transmission lines, and each utility's network is connected to that of other utilities forming what is generally referred to as the grid. As a result of this inter-connection of utilities, groups of utilities generally plan how they will meet electricity demand as a group. In New England, this group of utilities is referred to as the New England Power Pool (NEPOOL).

TABLE 6-3

PROJECTION OF PASSENGER-MILES TRAVELED IN 2010

		ANNUAL RIDERSHIP		PASSENGER-MILES	
SEGMENT OF RAIL LINE	SEGMENT LENGTH (MI.)	NO-BUILD	BUILD	NO-BUILD	BUILD
New Haven to Old Saybrook	32.8	2,094,662	4,591,480	68,704,914	150,600,544
Old Saybrook to New London	17.8	2,079,465	4,571,147	37,014,477	81,366,417
New London to Mystic	10.0	2,014,336	4,484,005	20,143,360	44,840,050
Mystic to Westerly	8.9	2,006,737	4,473,839	17,859,959	39,817,167
Westerly to Kingston	16.5	1,999,139	4,463,672	32,985,794	73,650,588
Kingston to Providence	27.1	1,953,548	4,402,673	52,941,151	119,312,438
Providence to Route 128	32.2	1,566,296	3,483,124	50,434,731	112,156,593
Route 128 to Back Bay	10.0	1,337,407	2,730,892	13,374,070	27,308,920
Back Bay to South Station	1.8	1,188,700	2,309,968	2,139,660	4,157,942
TOTALS	157.1			295,598,115	653,210,659

Source: Amtrak, 1993

Demand. In large part, it is the rise in the generating system's peak demand that creates the need for new generating stations, i.e. new capacity. One of the critical questions to be answered in the electrification alternative is whether the new peak demand created by Amtrak is in itself sufficient to create the need for a new generating station in one or more of the utility systems. It might be surmised that if a new generating station is needed solely to satisfy Amtrak, then the environmental impacts of that station are appropriately allocated to the project. However, the location, type of fuel, and size of such a station would be highly speculative. In fact, because of the fluctuating nature of the Amtrak demand, it is very doubtful that a power plant could be dedicated to serve it. This type of variable demand is best served by a large grid wherein the ebb and flow of electricity demands created by many customers tend to level out, resulting in a more level total demand which is much easier for generating facilities to meet. Most electricity demands are met through power supplied from the grid and not from a dedicated generating facility. Thus, for the most part, it is not possible to say that a particular power plant is meeting a specific demand.

The question then becomes one of whether the Amtrak contribution to the utility's peak demand, when added to all other new peak demands from all other customers, might, in the aggregate, require new generating stations. If new generating facilities were required as a result of the NEC electrification, the impacts analysis could focus on those facilities. If, on the other hand, the Amtrak peak demand can be shown to fall within the electricity demand plans already developed by the utilities, then it would be necessary only to allocate a portion of that planned new capacity to the project, and to apportion the environmental impacts (most particularly air quality impacts) accordingly.

The electricity required to power the electric locomotives to be utilized in the planned project is supplied through a series of substations. These substations are the point at which the utilities' transmission systems tie into Amtrak's system which directly powers the locomotives. The current design for the electrified system calls for four substations, each of which provides power for a portion of the route between New Haven and Boston. Each substation actually has two major components, one of which provides power to the overhead catenary on Track 1, and the other provides power to the overhead catenary on Track 2.

The design of the power supply system has evolved over time, with one of the most significant changes being a reduction in the number of substations. A switch from a seven substation system to a five substation design was made in early February 1993. By March, the design evolved to a four substation system.

At this time of this evaluation, detailed energy demand data for the four substation design was unavailable. However, Amtrak indicated that the electricity demand for each utility in the four substation design is very similar to that in the five substation, and the five substation design demand information was available. (Popoff, 1993; Hill, 1993). Thus, the five substation data was used for estimating demand for the four substation design. This approach was considered acceptable because: 1) only the demand for each utility is required, and no substation-specific information on demand is necessary; and 2) it is only the order of magnitude of the demand, and not the precise demand, that is important in assessing how the demand will be met by utilities.

The electricity demand figures for each of the five substations are identified in Table 6-4. It can be seen that the substations will be served by three utilities. These same three utilities will serve the four substation design, with the only change being that Northeast Utilities will only serve two substations (Old Saybrook will be eliminated). In considering the "worst case" total demand on the system, it is not reasonable to add all of the maximum, or peak, power demands. Maximum power is demanded when a train accelerates upon leaving the station and the peaks for each side of the substation represent a combination of trains accelerating simultaneously in the section of track serviced by that side of the substation. These peaks are relatively short-lived and generally speaking, the peak from one substation does not coincide with the peak demands from the other substations.

TABLE 6-4

ENERGY DEMAND BY SUBSTATION

Utility Company/Substation	Side of Substation	Peak Demand (Mw) Instantaneous	15-Minute Average
Northeast Utilities:	New Haven	36	9
Branford	Boston	36	14
Northeast Utilities:	New Haven	27	11
Old Saybrook	Boston	26	8
Northeast Utilities:	New Haven	19	6
New London	Boston	47	19
New England Power:	New Haven	25	13
Warwick	Boston	34	14
Boston Edison:	New Haven	38	19
Roxbury	Boston	36	7

Source: MK/Comstock/Spie, 1993[a]

It can be seen that the 15-minute average peak demand is significantly lower than the instantaneous peak, which indicates the short-lived nature of the peak demand. Although the peaks are not strictly additive, while demand for one side of one substation is reaching a peak, there will be some demand for electricity on the other side of that substation, as well as at other substations. Thus, the question becomes what is the maximum demand that each utility, as well as the entire NEPOOL system will be required to meet as a result of the Amtrak electrification? Since the demand for electricity on each side of each substation fluctuates so significantly over time, and peak demands are so short-lived, even detailed information regarding timing of electricity demands does not easily lend itself to combining of demands. A shift of a few minutes in the schedule of one train can significantly affect the way in which electricity demands combine.

It should also be noted that the data for the four substation design indicated no difference in demand between normal and emergency conditions (Popoff, 1993). The energy supply would be constant throughout the year, and therefore there would be no need for analysis of emergency conditions.

The following approach has been applied to determine demand for each utility:

- For Northeast Utilities, the peak demand is the sum of the highest instantaneous peak demand for the three substations (47 Mw, which is the demand for the Boston side of the New London substation), and the 15-minute average peak demands for the other side of that substation and the other two substations (which total 48 Mw), yielding a utility-wide total of 95 Mw.

- For New England Power, the peak demand is the sum of the instantaneous peak demand for the Boston side of the Warwick substation (34 Mw) and the 15-minute average peak demand for the New Haven side (13 Mw), yielding a total of 47 Mw.
- For Boston Edison, the peak demand is the sum of the instantaneous peak demand for the Boston side of the Roxbury substation (36 Mw) and the 15-minute average peak demand for the New Haven side (19 Mw), yielding a total of 54 Mw.
- For the total NEPOOL system, the peak demand is the sum of the highest instantaneous demand (47 Mw for the Boston side of the New London substation) and the 15-minute average peak demands for the other side of that substation and all other substations, yielding a total peak demand of 148 Mw.

The results of this approach can be summarized as follows:

Utility	Peak Demand
New England Power	47 Mw
Boston Edison	54 Mw
Northeast Utilities	95 Mw
NEPOOL system	148 Mw

Inherent in this approach is the assumption that while one side of one substation is at peak demand, the other side of that substation and the other substations have a demand that is equal to the 15-minute average peak. This assumption is designed to produce a reasonable projection of total peak demands, falling between the extremes of assuming all peaks occur simultaneously and assuming while one substation has peak demand, the others are at zero or a daily average demand.

Although a total NEPOOL (regional) peak demand of 148 Mw is a reasonable estimate, it is more realistic to characterize the total regional peak demand as being in the range of 100 to 200 Mw. Since capacity expansions are planned for the entire region as a whole, it is up to the NEPOOL planning process to determine whether any given source of additional demand would require new capacity additions, and what those capacity additions might be. How this additional capacity may be provided is discussed later in this Technical Study.

Energy. Energy consumption data for the four substation configuration was available from Amtrak. The electricity consumption data is shown in Table 6-5, and is extrapolated from daily consumption to annual use, based on the assumption that electricity consumption is constant throughout the year. To calculate the amount of electricity that would have to be generated to

TABLE 6-5

ANNUAL ELECTRICITY CONSUMPTION FOR THE PROPOSED ACTION IN MEGAWATT-HOURS (MwH)

	Electrical Consumption (MwH/Day)	Annual Electricity Use (MwH/Year)	Total Electricity Generation Required* (MwH/yr)
Northeast Utilities: Branford	110	40,150	43,362
Northeast Utilities: New London	132	48,180	52,034
Subtotal, Northeast Utilities:	242	88,330	95,396
New England Power: Warwick	138	50,370	54,400
Boston Edison: Roxbury	137	50,005	54,005
Total, NEPOOL	517	188,705	203,801

* Based on 8 percent transmission loss.

Source: MK/Comstock/Spie, 1993[b] for daily electrical consumption. All other figures calculated.

meet the demands of the electrification project, an 8 percent allowance for transmission losses is incorporated. This yields an estimate of 203,801 MwH per year of generation by NEPOOL utilities.

Fuel Usage to Supply Electricity. In order to understand the energy use required to generate electricity for the Amtrak electrification, it is necessary to project the mix of fuels that will be used at the generating facilities. This requires an understanding of the plans for use of existing and new generating facilities in the NEPOOL system.

Each year, NEPOOL forecasts the total demands on its system for both energy and capacity using econometric modelling tempered by policy considerations such as the potential for new legislation. Table 6-6 shows the demand projected to occur in 2007 (the latest year for which projections are available) for NEPOOL as a whole. The projections show two sets of numbers -- one with demand side management and one without. Demand side management consists of energy conservation activities (such as switching from incandescent to fluorescent lights) which can reduce electricity consumption. In general, electric vehicles and the electricity needed to

TABLE 6-6

TOTAL PROJECTED DEMAND FOR ENERGY AND CAPACITY
NEPOOL REGION, YEAR 2007

	With Demand Management[1]	Without Demand Management (uncertainty bandwidth)
Summer Peak Load (Mw)	26,734	30,387 (+19% or -19%)
Winter Peak Load (Mw)	25,859	29,616 (+22% or -18%)
Total Energy Sales (MwH)	137,349,000	148,331,000 (+20% or -15%)

[1] Information which would facilitate the estimation of an uncertainty bandwidth for the case with demand management is not in the NEPOOL forecast.

Source: NEPOOL, 1992

charge them are included in both sets of forecasts, but neither includes electrification of railroads. However, even under heavy Amtrak demand conditions of 100 to 200 Mw, the total demand created by the entire electrified rail system would be less than 1 percent of the total summer peak demand projected in 2007 for the entire NEPOOL region.

The energy that would need to be generated to satisfy Amtrak, about 204,000 MwH per year for 2010, is less than 0.2 percent of the total sales projection of 137,349,000 to 148,331,000 MwH for NEPOOL as a whole in 2007.

As is typical with forecasts of this type, forecasts are more limited as one looks farther into the future. The approximate uncertainty bandwidth for the no-demand-management case, shown in the table, was based on information provided by NEPOOL. Table 6-7 shows the capacity that NEPOOL projects would have available, by fuel type, in the year 2007 to meet the demands set out in its demand forecast. Comparing Table 6-7 with Table 6-6 illustrates that even without the Amtrak electrification project, the total projected capacity in the year 2007 falls somewhat short of the total projected demand, by about 2500 Mw in the summer and 800 Mw in the winter, if demand management programs are instituted. If demand management programs are not successfully instituted, the shortfall could be much larger. On the other hand, if there is sluggish economic growth, the shortfall could be greatly reduced or eliminated, even without demand management programs, given the bandwidth of uncertainty.

TABLE 6-7

CAPACITY BY UNIT TYPE, NEPOOL REGION
YEAR 2007

Type of Energy Source	Summer, 2007		Winter, 2007	
	Mw	Percent of Total Generating Capacity	Mw	Percent of Total Generating Capacity
Nuclear	5,851	24.1	5,908	23.6
Coal - Steam	2,654	11.0	2,670	10.7
Wood - Steam	52	0.2	53	0.2
Oil - Steam	5,105	21.1	5,161	20.6
Oil - Combustion Turbine	790	3.3	1,017	4.1
Oil - Combined Cycle	0	0	0	0
Oil - Internal Combustion	161	0.7	167	0.7
Gas - Steam	0	0	0	0
Gas - Combustion Turbine	0	0	0	0
Gas - Combined Cycle	0	0	0	0
Gas - Internal Combustion	0	0	0	0
Oil/Gas Capable - Steam	2,666	11.0	2,718	10.8
Oil/Gas Capable - Combustion Turbine	213	0.9	299	1.2
Oil/Gas Capable - Combined Cycle	769	3.2	904	3.6
Oil/Gas Capable - Internal Combustion	24	0.1	24	0.1
Median Hydro	1,411	5.8	1,424	5.7
Pumped Storage	1,676	6.9	1,698	6.8
Non-Utility Hydro	156	0.6	176	0.7
Non-Utility Thermal	2,327	9.6	2,454	9.8
Net of Purchases and Sales	381	1.6	380	1.5
TOTAL CAPACITY	24,235		25,054	

Source: NEPOOL, 1992.

Based on NEPOOL's projections the projected crossover year, when the NEPOOL region as a whole has inadequate capacity available to meet demand, would be 2005 for the summer peak and 2007 for the winter peak. As the year 2005 grows closer, if actual experience seems to be following this forecast, NEPOOL will make plans for new capacity additions (normally to be developed and owned by the utilities in which the greatest share of the demand growth occurs). The demand could be met by utilities purchasing power from privately-developed generating facilities, or from other utilities outside of NEPOOL.

Table 6-8 shows the projected mix of fuels for the generating capacity in the year 2007. This table represents a consolidation of the data in Table 6-7 by fuel type. Since all of the gas-firing facilities in the region also have the capability to fire oil, an assumption had to be made regarding how to characterize this capacity. The reason that most gas-fired facilities have the capability to fire oil as well is that interruptible natural gas supplies are much less expensive than guaranteed gas supplies. As a result, most gas-fired facilities contract for natural gas on an interruptible basis, in which the flow of gas can be stopped, at the seller's discretion, for a period with a not-to-exceed maximum length each year.

If this interruption occurs, the gas-fired facilities switch to oil for that period of time. Typically that period is relatively short, and in some years, the flow of gas may not be interrupted at all. Therefore, it is assumed that the oil/gas capable units burn gas 95 percent of the time and thus 95 percent of their capacity is included in the gas category and 5 percent in the oil category.

Ideally the same type of projections would be available for each of the affected utilities. Projections are done on a regional basis, however, and even if this information was available for each of the utilities, it is not clear that it would be useful. The first reason for this is that utilities share generating capacity and sell electricity between themselves. This means that fuel mix projections are better suited to regional projections and application. The second reason is that the total fuel mix for all generating capacity in a region is not necessarily indicative of the mix of fuels that would be utilized to generate electricity for a new electrical load. For example, adding an electrical load that is equal to 1 percent of total generating capacity does not mean each facility in the system will increase output 1 percent (which would provide the same fuel mix for this load as for the total generating system).

This particular situation is complicated by the fact that the projections of generating capacity fall short of projected demand and thus, unless the projections of demand turn out to be an over-estimation, additional generating capacity will have to be constructed or capacity purchased from outside of the region. If the new demand anticipated for the NEC electrification were very large, it might be possible to project specific new facilities or types of facilities that would be constructed to serve this demand. However, on a regional electrical system basis, the demand anticipated for the Amtrak electrification is relatively small.

Thus, the way this demand would likely be met is by incremental use of a number of existing and/or planned generating facilities. It is the fuel mix of this incremental or marginal electricity

TABLE 6-8

CAPACITY BY FUEL TYPE, NEPOOL REGION, YEAR 2007

Type of Energy Source	Summer, 2007		Winter, 2007	
	Mw	Percent of Total Generating Capacity	Mw	Percent of Total Generating Capacity
Nuclear	5,851	24.1	5,908	23.6
Coal	2,654	11.0	2,670	10.7
Oil[1]	6,240	25.7	6,542	26.1
Gas[1]	3,488	14.3	3,748	15.0
Hydro-electric[2]	3,243	13.4	3,298	13.2
Other	2,760	11.4	2,887	11.5
TOTAL	24,236	100.0	25,053	100.0

[1] Based on assumption that oil/gas capable units burn gas 95 percent of the year and thus 95 percent of their capacity is included in the gas category and 5 percent in the oil category.

[2] Including pumped storage.

Source: NEPOOL, 1992

generation that is of interest. Since the existing generating facilities are designed to meet the current loads and many of the existing facilities would be retired by 2010, the design year for the Amtrak electrification, it is likely that the demand posed by the Amtrakelectrification would be met by use of new generating capacity. This new generating capacity would not include a facility or facilities dedicated to serving Amtrak's electrical demand, but a portion of the new facilities' capacity would be used by Amtrak.

Table 6-9 shows the currently planned expansions of generating capacity for the three utilities affected by the Amtrak electrification. The vast majority of this new capacity is fueled by natural gas, with one small hydroelectric project included. Thus, future capacity is currently anticipated to be mostly fueled by natural gas. Given the increasingly stringent regulations on air emissions and the relatively low emissions (compared with other fossil fuels) associated with natural gas, along with newly constructed natural gas pipelines in the New England area, this trend should be expected.

TABLE 6-9

CURRENT UTILITY CAPACITY EXPANSION PLANS, 1992-2008

Utility	Plant Type	Capacity (Mw)		Start Date	Status
		Summer	Winter		
New England Electric	combined cycle/ natural gas	307	355	1996	under construction
	hydro	22	22	1997	licensing
Boston Edison	combined cycle/ natural gas	306	306	1996	licensing
Northeast Utilities	combined cycle/ natural gas	193	231	2005	proposed
	combined cycle/ natural gas	193	231	2006	proposed
	combined cycle/ natural gas	193	231	2007	proposed

Another source of information regarding the likely mix of fuels for this incremental increase in electricity demand is a marginal fuel use study conducted by the New York State Energy Office (NYSEO) and cited in an analysis of air quality impacts of electric vehicles (Tennis, 1992). The NYSEO analysis examined the incremental fuel use (fuel use on the margin) if a major hydroelectric supply planned for the region became unavailable. While this analysis looked at replacing a much larger supply of electricity than the Amtrak electrification demand (1,000 Mw versus 100 to 200 Mw), the concept is the same. This study found that in 2010, the marginal fuel use to replace this lost capacity would be 45 percent No. 6 oil, 4 percent No. 2 oil, 46 percent natural gas, and 5 percent other.

NEPOOL does not prepare marginal fuel use analyses. Therefore, on the basis of the NYSEO analysis, it is assumed that the marginal fuel mix to satisfy the demand associated with the Amtrak electrification in 2010 will be 50 percent oil and 50 percent natural gas.

Since the air impacts associated with burning oil are generally greater than those associated with natural gas, a "conservative" estimate of fuel mixture is one which errs on the side of oil usage. This is the case for the 50 percent oil/50 percent natural gas assumption, since virtually all of the planned new generating facilities for the three affected utilities are natural gas-fired facilities. In addition, facilities designed to meet peak demands for electricity (the transitory nature of the Amtrak electrification generally fit in this category) are almost exclusively natural gas-fired as a result of the capabilities of gas-fired combustion turbines to be switched on and off easily.

For the purposes of this analysis, it will also be assumed that each of the three affected utilities will utilize the same fuel mix to supply this incremental electricity demand. Although there are significant differences in the current mix of fuels used for generating electricity at these three utilities, the marginal fuel use for an incremental demand is likely to be much more similar from utility-to-utility than the total current mix of fuels. Given this assumption and information on the efficiency of oil- and gas-burning facilities, the fuel use for each utility can be projected. This information is presented in Table 6-10.

The electricity generation data is taken from Table 6-5 and represents total electricity generated to meet the projected Amtrak demand, including transmission losses. This electricity generation is assumed to be met by an equal mixture of natural gas and oil firing, as discussed above. The conversion to quantities of fuel is based on data regarding the regional average efficiency for fossil-fuel fired power plants and the heat content of oil and natural gas in the three states in which the affected utilities reside. The efficiency (or heat rate) and heat content data is for 1990, and it is assumed that these values will be the same in 2010 as in 1990 because the heat content of fuels varies only slightly over time. Assuming that the efficiency of fossil-fueled power plants remains constant is conservative, as the efficiency of these facilities is continually improving. For instance, some gas-fired combustion turbine power plants have efficiency ratings 15 to 20 percent better than the average rate used in this analysis.

6.4.4 Comparison Between No-Build and Electrification Alternatives

Table 6-11 summarizes three key comparisons in the energy consumption of the no-build and electrification alternatives. These comparisons are done for the design year of 2010. The first comparison is on the basis of total energy consumed, regardless of the form in which the energy is supplied. This comparison uses Btu's as the unit of energy for comparison, and it can be seen that the total energy consumed in the electrification alternative is significantly higher than that in the no-build alternative. This is to be expected, as the number of passenger-miles travelled in the electrification alternative, and thus the schedule of trains is more extensive. The number of Btu's is calculated for the electrification alternative by multiplying the fuel consumption figures projected in Table 6-10 by the heat content of fuels noted in the footnotes to Table 6-10. The Btu consumption for oil and natural gas is summed to yield the projection of 2,069 billion Btu's per year.

Even taking into account the higher number of passenger-miles in the electrification alternative, the energy consumption in the electrification alternative is significantly higher than for the no-build alternative. In terms of Btu's per passenger-mile, the energy consumption of the

TABLE 6-10

PROJECTED FUEL USE TO GENERATE ELECTRICITY FOR AMTRAK ELECTRIFICATION IN 2010

Utility	Electricity Generated (MwH/yr)	Oil Usage (Gallons/yr)	Natural Gas Usage (cu. ft/yr)
Northeast Utilities	95,396	3,209,900	469,167,000
New England Power	54,400	1,837,000	267,028,200
Boston Edison	54,005	1,828,300	260,801,500
TOTALS	203,801	6,875,200	996,996,700

Key Assumptions and Data:

1. Electricity generation for electrification project is fueled 50 percent by oil and 50 percent by natural gas.

2. Heat rate (efficiency) of fossil-fueled electricity generating plants is 10,151 Btu net KwH (EEI, 1992).

3. Heat content of oil is 150,841 Btu/gallon in Connecticut (Northeast Utilities), 150,305 Btu/gallon in Rhode Island (New England Power), and 149,924 Btu/gallon in Massachusetts (Boston Edison); heat content of natural gas is 1032, 1034, and 1051 Btu per cu. ft. respectively. (EIA, 1992).

electrification alternative is approximately 2.3 times that for the no-build alternative. There are a number of reasons why the energy consumption per passenger-mile would be higher for the electrified rail-line than for the diesel-based system, including the following:

- Although an electric locomotive may be more efficient than a diesel locomotive, the electrified system has the inherent inefficiency of the electricity generating facilities, which do not play a role in the diesel-based system;

- There are transmission and distribution losses inherent in the electrified system (estimated at 8 percent in this analysis), while there are no such losses in the diesel-based system; and

- The electrified rail line is projected to travel at a higher speed than the current diesel-based system, which would result in higher energy consumption.

TABLE 6-11

COMPARISON BETWEEN ENERGY CONSUMPTION OF NO-BUILD AND ELECTRIFICATION ALTERNATIVES

	No-Build	Electrification
Total Btu's Consumed (Billion Btu's/yr)	416	2,069
Passenger-Miles	295,598,115	653,210,659
Btu's/Passenger Mile	1,406	3,167
Petroleum Consumption (gal/yr)	2,948,600	6,875,200

The last comparison shown in Table 6-11 is for petroleum use, and it can be seen that even though only 50 percent of the electricity generation required in the electrification alternative is assumed to come from oil, the petroleum-based fuel consumption is significantly higher in the electrification scenario than the no-build alternative. Again, this is partially due to the inherent inefficiencies of electricity generating facilities and transmission and distribution losses, as well as the conservative nature of the build alternative assumptions.

6.4.5 Changes in Energy Consumption of Non-Train Alternatives

As a result of the increased ridership projected for the electrified rail line, there are expected changes to the use of non-train alternatives. It is projected that some of the travel between Boston and New York, and locations in-between, that would be done via automobile or aircraft in the absence of the electrification project would be shifted to rail travel as a result of the decreased travel time that results from the electrification (and other improvements).

Intercity bus is not anticipated to shift to rail so this energy consumption was not calculated. These shifts in travel mode are described in the transportation and traffic report. The shifts in travel mode result in decreased energy consumption for these non-train alternatives, which is important to look at when analyzing the total energy impacts associated with the electrification project. Thus, the projections of changes in travel modes were combined with energy consumption information regarding automobiles and aircraft in order to determine changes in energy consumption for these non-train alternatives, as a result of the electrification project. The results of this analysis are shown in Table 6-12.

For diesel consumption, the aircraft consumption was based on the mix and number of aircraft types for the no-build and electrification alternatives. Fuel consumption for the various aircraft types was estimated based on data available regarding fuel consumed for trips between New

TABLE 6-12

COMPARISON OF ENERGY CONSUMPTION DUE TO MODAL SHIFTS

Alternative	Petroleum (million gal/yr)					Natural Gas (billion cu ft/yr)
	Train (Diesel)	Aircraft (Jet Fuel)	Power Plant (Fuel Oil)	Automobile (Gasoline)	Total Petroleum	
No-Build	2.95	38.72	0	71.89	113.56	0
Build	0	26.25	6.88	70.44	103.57	0.996
Difference (No Build to Build)	-2.95	-12.47	+6.88	-1.45	-9.99	+0.996

York and Boston and New York and Providence, which are the only two routes from which airplane travel is projected to be diverted to rail. It can be seen that aircraft fuel consumption is projected to decrease 12.47 million gallons per year as a result of the implementation of the electrification project. The diesel consumption for trains is projected to decrease 2.95 million gallons per year, as a result of elimination of diesel locomotives.

The fuel oil consumption is simply that projected for use in producing electricity for the build alternative (6.88 million gallons per year) and there is no such consumption in the no-build alternative. As a result, fuel oil consumption is projected to increase 6.88 million gallons per year as a result of the electrification project. For gasoline, automobile consumption is projected to decrease from 71.89 million gallons per year in the no-build alternative to 70.44 million gallons per year in the build alternative. This is based on an assumption that automobiles consume gasoline at the rate of 0.05 gallons per mile (20 miles to a gallon), and a projected decrease of 29 million miles in vehicle-miles-traveled. Adding up all of the petroleum use, it can be seen that total petroleum use is projected to decrease approximately 10 million gallons per year as a result of the electrification project. Natural gas usage is expected to increase about 1 billion cubic feet per year as a result of the project.

Since petroleum and natural gas supplies are fairly different in terms of their reliance on imports, this projected shift in energy use will have an impact on the amount of energy imported. The most recent comprehensive figures available indicate that in 1992, 41 percent of the petroleum supply in the United States was imported (DOE, 1993), while in 1991, 9 percent of the natural gas supply was imported (DOE, 1992). Assuming that these importation levels remain constant until 2010, the 9.99 million gallons per year reduction in petroleum use would result in a 4.1 million gallon per year reduction in petroleum imports. For natural gas, the increase of 0.996 billion cubic feet per year would increase imports by 89.7 million cubic feet. On a Btu basis, the net result of these changes is a 419 billion BTU per year decrease in energy imports.

6.4.6 Conclusions

As shown in Table 6-10, despite the fact that only half of the energy used to power the electric locomotives would come from petroleum (oil) powered generating plants, the electrification project would result in a petroleum consumption level double that of the no-build alternative, which is completely powered by petroleum (diesel). While this is primarily due to twice as many trips and the higher power requirements of high speed trains, it is also the result of the inherent inefficiency of the electric generating facilities and the estimated 8 percent loss inherent in electricity transmissions and distribution. These last three factors also account for much of the six-fold increase in annual Btu's consumed and the three-fold increase in Btu's per passenger mile, which are shown in Table 6-10.

As a result of shifts in travel mode resulting from the electrification project, total petroleum use is projected to decrease approximately 10 million gallons per year, while natural gas usage is projected to increase about 1 billion cubic feet per year, as is shown in Table 6-11. In addition, the net effect of the shift in energy use is to decrease energy imports on a heat content (Btu) basis, assuming current importation patterns remain the same.

References

Amtrak, 1993. Ridership projections transmitted to Roy F. Weston, Inc. by Paul McBride of DMJM/Harris in memorandum dated May 24, 1993.

Bolbrock, 1992. Richard J. Bolbrock. NEPOOL Forecast Report of Capacity, Energy, Loads and Transmission, 1992-2007. Holyoke, Massachusetts: New England Power Planning, April 1992.

EEI, 1992. Edison Electric Institute. Statistical Yearbook of the Electric Utility Industry 1990. 1992

EIA, 1992. Energy Information Administration. Electric Power Annual. January 1992.

Hill, 1993. Letter from Richard F. Hill of Amtrak to Matthew Goldman of Roy F. Weston, Inc. dated May 18, 1993.

MK/Comstock/Spie, 1993[a]. Table dated February 17, 1993 provided to Roy F. Weston, Inc. by DMJM/Harris.

MK/Comstock/Spie, 1993[b]. Table dated March 19, 1993 provided to Roy F. Weston, Inc. by DMJM/Harris.

NEPOOL, 1992. NEPOOL Load Forecasting Committee, NEPOOL Forecast of New England Electric Energy and Peak Load, Executive Summary, 1992-2007. Holyoke, Massachusetts: New England Power Planning, April 1992.

Popoff, 1992. Letter from John Popoff of Amtrak to Glen Goulet of Volpe National Transportation Systems Center, August 28, 1992.

Popoff, 1993. Telephone conversation between John Popoff of Amtrak and Matthew Goldman of Roy F. Weston, Inc. on May 17, 1993.

Tennis, 1992. Michael W. Tennis. Impact of Battery-Powered Electric Vehicles on Air Quality in the Northeast States. Boston: NESCAUM, July 1992.

U.S. DOE, 1992. Energy Information Administration, Office of Oil and Gas, U.S. Department of Energy. Natural Gas Annual 1991. Washington, D.C, October 1992.

U.S. DOE, 1993. Energy Information Administration, Office of Oil and Gas, U.S. Department of Energy. Petroleum Supply Annual 1992, Volume 1. Washington, D.C., May 1993.

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7.0 INTRODUCTION

The Northeast Corridor Improvement Project involves the electrification of the AMTRAK railroad between New Haven and Boston. To accomplish this task, the construction of switching stations, substations with feeder lines and easements, and paralleling stations is necessary. Additionally, bridges will be modified - either raised, lowered or removed - to accommodate the improvements. The new stations and bridge modifications will involve ground disturbance which may adversely affect buried significant archaeological sites. Under federal law, any project involving federal funding must include an archaeological survey to determine if archaeological sites which may be eligible for the National Register of Historic Places are present and subject to possible impact.

Each new station and bridge modification area varies in impact area size. The substations are expected to alter about 0.5 acres of land, but also have associated feeder lines and easements which will also disturb the ground. Paralleling stations will disturb about 0.15 acres. Switching stations consume about 0.25 acres. Bridge modification areas vary, depending on the type of action taken at each bridge.

In each state, the archaeological survey requirements varied, but the goals and actual tasks involved were essentially the same. The goal was to determine the potential of each site for yielding archaeological remains and the tasks were mainly site file and report research and walkover visual inspection. Each state is discussed below.

7.1 REGULATORY SETTING

Impacts may occur to historic properties (includes archaeological sites, standing structures, and landscape features) in the following areas:

- all locations for elements of the undertaking (i.e., borrow areas, wetland replication areas, etc.)

- all locations where the undertaking may result in disturbance to the ground

- all locations from which elements of the undertaking (e.g., structures, etc.) may be visible

- all locations where activity may result in changes in traffic patterns, land use, public access

Impacts may include the following:

- altering the characteristics of a property that may qualify it for the National Register of Historic Places

- altering features of a property's location, setting, or use that contribute to its significance

- physical destruction, damage, or alteration of all or part of a property

- introduction of visual, audible, or atmospheric elements that are out of character with the property or alter its setting

- neglect of a property resulting in its deterioration or destruction

- transfer, sale or lease of a property

- degradation resulting from natural forces or vandalism

- secondary or indirect impacts resulting from associated activities of the undertaking

(after 36 CFR 800.9(b) and Section 110(a)(2))

7.1.1 Federal Regulations

7.1.1.1 National Historic Preservation Act (NHPA) of 1966, as amended (16 USC 470). Section 101 of this act directs the Secretary of the Interior to maintain a National Register of Historic Places and establishes a State Historic Preservation Office within each state to initiate general preservation programs and carry out project review. The implementing regulations for this are 36 CFR 60.

Projects that are determined to be under the direct or indirect jurisdiction of a federal agency or licensed or assisted by a federal agency (an undertaking) must conform to Section 106 of the NHPA. These undertakings include new and continuing projects or programs not previously considered under Section 106. The Advisory Council on Historic Preservation (Council) has issued regulations (36 CFR 800) that define the procedures that federal agencies must follow to meet their responsibilities under NHPA, commonly referred to as the "Section 106 process".

Section 110 of the NHPA prescribes general and specific responsibilities to federal agencies in the identification, evaluation, registration, and protection of properties of historic, archaeological, architectural, engineering, or cultural significance. The US Department of the Interior, National Park Service, jointly with the Council, have published guidelines for implementing Section 110 (The Section 110 Guidelines: Guidelines for Federal Agency

Responsibilities under Section 110 of the National Historic Preservation Act). If any portions of the project are to be owned, acquired, leased or otherwise controlled by the federal government the Section 110 guidelines, in conjunction with the Section 106 process will have to be followed.

Section 201 of the NHPA established the Advisory Council on Historic Preservation Amendments in 1976 changed the status of the Council to an independent federal agency.

7.1.1.2 Section 106 Process. The steps to be taken during the Section 106 process, as regulated in 36 CFR 800 and 36 CFR 60 (Department of the Interior Regulations for the National Register of Historic Places) are:

- the identification and evaluation of historic properties.

The purpose of this step is to determine if any properties within the undertaking's area of potential effect are included in or are eligible to the National Register of Historic Places. If there are no properties that are on or eligible for the National Register and the Council, the Agency, and the SHPO agree, the undertaking proceeds as planned. If historic properties are found, the Agency continues to the next step in the process:

- assess the effects of the undertaking on the historic property.

The regulations define the criteria of effect in 36 CFR 800.9(a) and whether or not the effect is adverse in 36 CFR 800.9(b). If no effect is found, and the SHPO agrees, the undertaking may proceed. If an effect is found but it is not adverse and the SHPO concurs, documentation is sent to the Council. If the Council has no objection, the undertaking proceeds.

If an adverse effect is found, step 3 in the Section 106 process takes place:

- consultation, aimed at developing measures to enable the Agency to proceed with the undertaking by avoiding or mitigating the adverse effects to the historic property.

This stage of the process must involve consultation among the Agency, the SHPO, and any interested parties. The Council is notified but involvement at this point is optional. Once an action to reduce or avoid the adverse effects is agreed upon, generally formalized in a Memorandum of Agreement (MOA), the final stage of the process is initiated:

- seeking Council comment.

Following the Council's comments, the Agency considers them in reaching a final decision on the undertaking.

In general the Section 106 process is the standard procedure to follow for a federal undertaking. However, the regulations do provide for four alternatives to the case-by-case review. These are: the development of counterpart regulations by the Agency, in consultation with the Council, that can substitute for 36 CFR 800; the substitution of State review processes in lieu of the procedures in 36 CFR 800, also requiring Council approval; the substitution of a Native American Tribe for the SHPO when the undertaking affects its' lands; and the development of a Programmatic Agreement (PA), generally for a large, lengthy and complex undertaking. A PA is the most utilized alternate to the Section 106 review process.

While the NHPA is the most comprehensive act regarding historic properties and the cornerstone of the Federal preservation program, there is other federal legislation that bear on historic properties and federal actions. Below is a brief synopsis of each act.

7.1.1.3 Native American Graves Protection and Repatriation Act of 1990 (25 USC 3001-13). This act provides for the protection of Native American graves and regulates the intentional removal of Native American human remains and associated grave objects. It also defines ownership, sets standards for repatriation and actions to be taken in case of inadvertent discovery. It applies to federal and tribal lands. To date no implementing regulations have been published.

7.1.1.4 Native Environmental Policy Act of 1969, as amended (42 USC 4321-4347). Under the NEPA all agencies of the federal government have to consider an interdisciplinary approach that insures the integrated use of the natural and social sciences and the environmental design arts in planning any project that may have an impact on man's environment. This is widely interpreted as including historic properties.

7.1.1.5 Archaeological Resources Protection Act of 1979 (16 USC 470aa-470ll). The Archaeological Resources Protection Act (ARPA) allows for protection of archaeological resources and sites which are on public and Native American lands, and means to foster communication between government, professional archaeologists, and private individuals. Under the Act, these resources must be at least 100 years old to be treated as archaeological resources. Section 470cc deals with permitting individuals to excavate on public or Native American lands to remove archaeological resources, while sections 470ff-gg outline the civil penalties that may be addressed against violators of the Act and the enforcement of these penalties. ARPA also addresses the confidentiality of information relating to the nature and location of archaeological resources.

7.1.1.6 Archaeological and Historic Preservation Act of 1974 (16 USC 469-469c). This act allows for the appropriate federal actions to be taken for the preservation of significant archaeological data when any alteration of the terrain is caused as a result of any federally funded or licensed undertaking. This specifically includes an identification stage to locate any previously unknown resources.

7.1.1.7 Executive Order No. 11593 "Protection and Enhancement of the Cultural Environment" (3 CFR 154, 1971) (reprinted in 16 USC 470). This order directs federal agencies to take a leadership role in preserving, restoring and maintaining the historic and cultural environment of the nation. Federal agencies must locate, inventory and nominate to the National Register of Historic Places all historic properties under their jurisdiction or control. This order was codified when Section 110 was added to the NHPA in 1980.

7.1.1.8 Department of Transportation Act of 1966 (49 USC 303). Section 4(f) of this act directs the Secretary of Transportation to consult with, among others, the Secretary of the Interior, and to minimize any harm to historic properties that may result from transportation programs. Implementing regulations are 23 CFR 772.

7.1.1.9 Historic Sites Act of 1935. This act mandated the National Park Service to be the lead federal agency in historic preservation efforts. It also established three federal programs: the Historic American Building Survey (HABS), the Historic American Engineering Record (HAER), and the National Survey of Historic Sites and Buildings (Landmarks).

7.1.1.10 Antiquities Act of 1906 (16 USC 431-433). This act formed a basis for modern preservation legislation. It authorized the President to designate as National Monuments historic resources of national significance located on federally owned or controlled land. It was the first act to designate permitting powers to the Secretaries of the Interior, Agriculture and Defense. Implementing regulations are 43 CFR 3.

7.1.2 State Regulations

In general the federal legislation is the most stringent legislation when dealing with federal undertakings. However, the state have legislation that may require complementing actions. This legislation is reviewed below for the applicable states.

7.1.2.1 Connecticut

<u>Connecticut Public Act 81-177</u>

Amended The Environmental Policy Act by identifying the CHC as a mandated review agency for state-funded projects and cultural resources as important factors in project planning.

Applicable Connecticut standards and guidelines issued in 1987 include:

<u>Archaeological Report Standards</u>

<u>Guidelines: Collection Repository</u>

7.1.2.1 Massachusetts

Massachusetts General Law (MGL), Chapter 9, Sections 26-27c

This general law established the Massachusetts Historical Commission (MHC) and the Office of the State Archaeologist. It lists the duties and permitting powers of the State Archaeologist. It also mandates the MHC to administer the federal preservation program. Implementing regulations are found in 950 CMR 70 and 950 CMR 71.

Chapter 254 of the Acts of 1988

Chapter 254 amended MGL, Chapter 9, Sections 26-27c in several ways, most importantly by clarifying the historic review process administered by the MHC. It provides for review of an entire project, not just the portion of the project which requires state funding or licensing.

Massachusetts Unmarked Burial Law

The unmarked burial law requires individuals and entities who discover an unmarked human burial or skeletal remains to cease any activity upon the site which would deface, alter, destroy or otherwise impair the integrity of the site until the State Archaeologist has conducted a site evaluation.

References: MGL, Chapter 9, Section 27c (1988 ed)
Chapter 7, Section 38a (1988 ed)
Chapter 386 of the Acts of 1989

Massachusetts Underwater Archaeology Act, Chapter 989, Acts of 1973

This act established the Board of Underwater Archaeological Resources to protect and preserve historical, scientific and archaeological information about underwater archaeological resources located within the waters of the Commonwealth.

Massachusetts Environmental Policy Act (MEPA), Chapter 30 as amended by Chapter 947 of the Acts of 1977

MEPA requires evaluation of projects to assess their impacts on the natural and human environments, including historical and archaeological sites and structures, as such, the MHC is a participating review agency and can comment on the likelihood of a project to contain archaeological sites and/or historic structures.

7.1.3 Level/Requirements of Archaeological Study and Sites/Methodology

7.1.3.1 Connecticut. In Connecticut the minimum accepted level of archaeological survey is the assessment level survey. This level of survey does not actually locate archaeological sites in a given project area, but determines the potential of the project area for containing sites. The determination is based on a combination of background research and walkover visual inspection. The archaeological site files of the Connecticut Office of State Archaeology (COSA) and the Connecticut Historical Commission (CHC) contain information on sites reported to the state. There is no state law to report sites, so the files are not comprehensive or systematically collected, but nonetheless they offer important information on the number and kinds of sites all over the state. They are particularly useful for correlating prehistoric site location with environmental variables. Prehistoric sites, for example, are often found on relatively level ground near a fresh water source on well drained soils. This information helps predict the potential for prehistoric sites in areas with these environmental features, even if no sites have been reported in these areas (see Table 7-1). These site files were thoroughly researched for prehistoric and historic sites in or near the various study areas.

TABLE 7-1. Environmental Attributes Contributing to Prehistoric Archaeological Sensitivity Rankings.

CRITERIA	ARCHAEOLOGICAL SENSITIVITY (POTENTIAL FOR BURIED INTACT CULTURAL REMAINS)		
	HIGH	MODERATE	LOW
Distance to Water/Wetland	adjacent or < 150 meters	150 to 300 meters	> 300 meters
Slope	minimal 0 to 3%	moderate 3 to 15%	steep >15%
Soil Types	sandy, well-drained	gravelly, fair drainage	very gravelly, poor drainage

The National Register of Historic Places was also consulted to determine if any listed sites or structures are in the vicinity of the study areas. Also, the CHC keeps a list of archaeological sites and buildings which have been approved for nomination to the Register but haven't been actually nominated yet. This list was also consulted.

Published and unpublished archaeological reports were consulted which are relevant to the study areas for information on known or possible sites. These reports included contract archaeology survey reports, published papers, dissertations, and the NECIP report prepared by DeLeuw, Cather/Parsons in 1979 (DC/P 1979a). Although this report is out of date and the information within is vague, it is part of the requirement of an assessment level survey in Connecticut to review and include reports which are relevant to the project area. Because this report is so old, however, it must not be assumed, for example, that buildings and sites referred to in it are still standing or that archaeologically sensitive "zones" are still sensitive. Much identification of the landscape has occurred since 1979. Nevertheless, it was often found that DC/P's designation of an archaeologically sensitive area corresponded with ours. USGS topographic maps and USDA soil survey maps were reviewed for environmental information which may suggest archaeological sensitivity.

Lastly, each site was visited and walked it over, closely inspecting it and the surrounding environment for signs of disturbance and for environmental factors which are associated with prehistoric sites. Signs of historic period sites were looked for, such as wells or foundation remains; these features often have associated below-ground cultural remains. If an area was obviously severely disturbed by land modification, reduced its archaeological potential was reduced to low because intact cultural remains are probably nonexistent, having been destroyed by the ground disturbance. If environmental features associated with prehistoric occupation were present, especially if other prehistoric sites have been reported in the vicinity, and there were little signs of disturbance, an area was considered to have high potential for containing archaeological sites. If historic features were noted above the ground and little disturbance was observed, the area was ranked as having good archaeological potential (see Table 7-2).

TABLE 7-2. Locational Attributes Contributing to Historic Period Site Distribution

CRITERIA	ARCHAEOLOGICAL SENSITIVITY (POTENTIAL FOR BURIED INTACT CULTURAL REMAINS)		
	HIGH	MODERATE	LOW
Known historic sites in vicinity	known site adjacent or near	known site in general vicinity	no known sites in vicinity
Proximity to fresh water source	adjacent or < 100 meters	moderate 100 to 300 meters	distant >300 meters
Proximity to water power source	adjacent or < 50 meters	moderate 50 to 150 meters	distant >150 meters
Access to transportation network	excellent - < 200 meters	moderate 200 to 1500 meters	distant >1500 meters
Proximity to settlement concentration	adjacent or < 800 meters	moderate 800 to 1500 meters	distant >1500 meters
Proximity to agriculture	adjacent or < 100 meters	moderate 100 to 300 meters	distant >300 meters
Disturbance	none to minimal	minimal to moderate	moderate to severe

All of the work in Connecticut was done in accordance with appropriate state and federal regulations (see below) and in accordance with the Environmental Review Primer for Connecticut's Archaeological Resources (Poirier 1987). No permits were necessary because no subsurface testing was done and the project did not involve state property.

7.1.3.2 Rhode Island. In Rhode Island, the same assessment level of survey was required as for Connecticut. The methodology and tasks were exactly the same. The site files of the Rhode Island Historic Preservation Commission (RIHPC) were researched, the National Register was consulted and archaeological reports, including the 1979 NECIP report (DC/P 1979b) for Rhode Island. Topographic and soils maps were consulted and each project site was visually inspected for indications of archaeological potential. Permits were not required because no subsurface testing was conducted. In Rhode Island, if subsurface testing is to be conducted in the coastal zone, a permit is required for each site, whether on private or public property. Zones of the Northeast Corridor sites fell into the coastal zones, but did not require permits because of the current level of testing.

All of the archaeological work done in Rhode Island was performed in accordance with the RIHPC's Standards for Archaeological Survey (RIHPC 1982).

7.1.3.3 Massachusetts. In Massachusetts, the level of survey and requirements are different. Massachusetts required a permit, which involved the Massachusetts Historical Commission (MHC) first reviewing the project plans and determining what level survey was required. The MHC determined that a comprehensive cultural resources reconnaissance survey (950 CMR 70) be conducted and included in the Draft Environmental Impact Statement/Report (DEIS/R). This survey was in compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (36 CFR 800) and Massachusetts General Laws, Chapter 9, Sections 26-27C, as amended by Chapter 254 of the Acts of 1988 (950 CMR 71). Although in Massachusetts the survey is called a reconnaissance survey, its goal is essentially the same as the assessment level survey in Connecticut and Rhode Island: to identify and evaluate the archaeological sensitivity of a given project area. The methods are basically the same - background site file and report research, map and environmental research, and field site inspection. Massachusetts, however, adds limited subsurface testing to the field research in this survey level, if the sensitivity of a parcel is not obvious from visual inspection.

The archaeological reconnaissance survey was conducted under MHC Permit Number 1285, issued by the Massachusetts State Archaeologist. MHC site files, the National Register of Historic Places, archaeological survey reports, maps and environmental documentation were reviewed for information about known and potential sites in or near the project areas. The 1979 NECIP report for Massachusetts (DC/P 1979c) was included in the document review. Each project site was visited and examined for signs of disturbance or archaeological sensitivity. No subsurface testing was possible because the ground was frozen.

7.2 ARCHAEOLOGICAL OVERVIEW OF PREHISTORY

This section provides a summary overview of prehistory for four distinct regions within the Northeast corridor: coastal Connecticut, southern Rhode Island, southeastern Massachusetts and the Boston area. Table 7-3 provides a description of the various periods of prehistory that are referenced in the discussions below.

7.2.1 Prehistory of Coastal Connecticut

The regional prehistory of coastal Connecticut is fairly well known from numerous site excavations and archaeological surveys within and immediately adjacent to coastal areas. The information obtained from these single-site excavations and archaeological surveys document an unbroken record of human occupation in the region dating back at least 8,000 years. Archaeologically, Connecticut traditionally focused on single site-excavations of large coastal and riverine sites because of their accessibility, visibility and the high densities of artifacts (Coffin 1937, 1938, 1940, 1946, 1951; Glynn 1953; Lavin 1988; Praus 1942; Russell 1942). Important coastal sites located in the general vicinity of the project area that have greatly contributed to the understanding of the coastal prehistory of the region include Grannis Island in New Haven Harbor (Glynn 1953; Lavin 1988), the Old Lyme Shell Heap in Old Lyme (Lavin 1988), Mago Point in Waterford (McBride 1984b; McBride and Dewar 1987), Fort Shantok and Shantok Cove in Montville (Salwen 1966; Salwen and Ottesen 1972; Williams 1972), the Thomas Site in Groton (Butler 1946), and the Davis Farm Site in Stonington (Griffin 1946). A number of regional archaeological surveys have also been conducted in coastal regions of Connecticut, and have provided a great deal of information on the nature and distribution of archaeological sites in these areas (McBride 1984b; Public Archaeology Survey Team, Inc. 1987).

Studies conducted by professional archaeologists over the past two decades have greatly increased the understanding of the region's prehistory. These studies have been conducted in the Connecticut Valley and northeastern highlands of Connecticut (McBride 1984b; McBride and Soulsby 1989), in the Thames River Valley (Juli 1981), the Lower Connecticut River Valley and other coastal and estuarine locales (McBride and Dewar 1987; Public Archaeology Survey Team, Inc. 1987).

The earliest archaeological evidence for human occupation in the region dates from the Paleo-Indian Period (12,500-10,000 B.P.). Following the retreat of the last Wisconsin glacier, the environment underwent a transition from tundra to open spruce woodland, dominated be scrub birch and alder (Funk 1972). Small, highly mobile bands of hunter-gatherers moved into the Northeast at this time, roaming over large territories and exploiting a wide range of food

Table 7-3. Prehistoric Cultural Chronology for Southern New England.

General Period	Identified Temporal Subdivisions*	Cultural Aspects
Paleoindian 12,500-10,000 B.P.** (10,500-8,000 B.C.)	(1) Eastern Clovis (2) Plano	Hunting of migratory game animals by small groups with a specialized, sophisticated lithic technology was the rule for highly mobile bands of hunter-gatherers.
Early Archaic 10,000-7500 B.P. (8000-5500 B.C.)	(1) Bifurcate-Base Point Assemblage	Few sites are known, possibly because of problems with archaeological recognition. This period represents a transition from specialized hunting strategies to the beginnings of a more generalized hunting and gathering adaptation due to changing environmental circumstances.
Middle Archaic 7500-5000 B.P. (5500-3000 B.C.)	(1) Neville (2) Stark (3) Merrimack Creek (4) Otter (5) Vosburg	Regular harvesting of anadromous fish and various plant resources is combined with generalized hunting. Major sites are located at falls & rapids along major river drainages. Ground stone technology is first utilized. There is a reliance on local lithic materials for a variety of bifacial and unifacial tools.
Late Archaic 5000-3000 B.P. (3000-1000 B.C.)	(1) Brewerton (2) Squibnocket (3) Small-Stemmed Point Assemblage	Intensive hunting and gathering was the rule in diverse environments. Evidence for regularized shellfish exploitation is first seen during this period. An abundance of sites suggests increasing populations, with specialized adaptations to particular resource zones. Notable differences between coastal and interior assemblages are seen.
Transitional 3600-2500 B.P. (1600-500 B.C.)	(1) Atlantic (2) Watertown (3) Coburn (4) Orient	Same economy as the earlier periods, but there may have been groups migrating into New England, or local groups developing technologies strikingly different from those previously used. Trade in soapstone became important. Evidence for complex mortuary rituals is frequently encountered.
Early Woodland 3000-1600 B.P. (1000 B.C.-300 A.D.)	(1) Meadowood (2) Lagoon	A scarcity of sites suggests population decline. Pottery was first (?) made. Little is known of social organization or economy, although evidence for complex mortuary rituals is present. Influences from the mid-western Adena culture are seen in some areas.
Middle Woodland 1650-1000 B.P. (300-950 A.D.)	(1) Fox Creek (2) Jack's Reef	Economy focused on coastal resources. Horticulture may have appeared late in period. Hunting and gathering was still important. Population may have increased from the previous low in the Early Woodland. Extensive interaction between groups throughout the northeast is seen in the widespread distribution of exotic lithics and other materials.
Late Woodland 1000-450 B.P. (950-1500 A.D.)	(1) Levanna	Horticulture was established in some areas. Coastal areas seem to be preferred. Large groups some times lived in fortified villages, and may have been organized in complicated political alliances. Some groups may still have relied solely on hunting and gathering.
ProtoHistoric & Contact 450-300 B.P. (1500-1650 A.D.)	(1) Algonquian groups	Groups such as the Wampanoag, Narragansett, and Nipmuck were settled in the area. Political, social, and economic organizations were relatively complex, but underwent rapid change during European Colonization.

* Termed Phases or Complexes ** Before Present

resources such as pleistocene megafauna as well as smaller game, marine resources, and seasonally available wild plant food (Dragoo 1976). Sites from this period are characterized by distinctive fluted projectile points and flaked stone tool assemblages (e.g., scrapers, gravers, drills).

Few intact cultural depositions from this period have been recorded in Connecticut; most of the known sites consist of surface finds from plowed fields (Curran and Dincauze 1977). One site, however, was recently discovered on a ridge overlooking the Thames River Valley in Groton. This site (Baldwin Ridge) yielded the base of a fluted point, end scrapers, and a resharpening flake. The stone tool assemblage indicated that the site represents a special-purpose location at which animal resources may have been hunted and processed (Soulsby et al 1981). This site represents one of the two intact Paleo-Indian sites recorded in Connecticut, the other being the Templeton Site, 6-LF-21, in Washington (Moeller 1980).

The Early Archaic Period (10,000-7500 B.P.) was characterized by a warmer and drier climate, dominated by a mixed pine-hardwood forest. This type of paleoenvironment would have made seasonally available natural food resources more predictable and abundant, allowing populations to exploit a wide range of territories. Populations probably increased during this period, although Early Archaic sites are not well-represented in the regional archaeological record. This low site count could be due in part to changing environmental conditions which may have deeply buried or destroyed many early sites by erosion or archaeological inability to recognize Early Archaic assemblages.

Stone tool assemblages dating to the Early Archaic Period have been recovered at several sites in Connecticut, although none are immediately adjacent to coastal areas. These assemblages indicate that in Connecticut this period is characterized by a quartz cobble lithic industry and bifurcate-based projectile points (McBride 1984 a and b). The Dill Farm Site (Site 41-50) in East Haddam represents one of the best-documented Early Archaic sites in eastern Connecticut. Archaeological investigations identified cooking/refuse features, quartz debitage, retouched tools, and bifurcate-based projectile points. Further excavations at the site have produced additional bifurcate-based points, hearth areas, refuse pits, stone tool workshops, and subsistence remains (charred nuts, mammal bone) as well as radiocarbon date of 8560 +/- 270 B.P.

Evidence of Middle Archaic Period (7500-5000 B.P.) occupation in Connecticut is more widely documented than for the preceding periods. The distribution and somewhat higher density of Middle Archaic sites suggest that a multi-site seasonal settlement system was established in the region by this time. Occupations are located within a variety of ecozones, with an emphasis toward interior wetlands. The archaeological assemblages of this period are characterized by a quartz cobble industry and Stark and Neville projectile point types. One of the best documented Middle Archaic sites in the region is the Dill Farm Site, Locus One (Site 41-50), in East Haddam. This locus yielded Neville projectile points, basin-shaped hearths, post molds, pit features, nuts and mammal bone, caches of quarry blocks, and lithic debitage as well as two radiocarbon dates of 7720 +/- 260 B.P. and 7305 +/- 280 B.P. These depositions have been interpreted to represent seasonal reuse of this local over a long period of time (McBride 1984 a and b).

Late Archaic Period (5000-3000 B.P.) settlement in eastern Connecticut has been documented at numerous coastal and interior upland locations. This period constitutes one of the best-known temporal sequences in southern New England. It is represented by three major cultural traditions (the Laurentian, Narrow-stemmed, Susquehanna), all of which are represented at sites throughout eastern coastal Connecticut. The Late Archaic Period is characterized by an essentially modern distribution of plant and animal populations, with an increase in human population, development of more complex settlement and subsistence systems, and the development of long-distance exchange networks (Snow 1980).

The regional manifestation of the Laurentian Tradition in eastern Connecticut has been identified as the Golet Phase (4600-4300 B.P.) on the basis of several distinct aspects of material culture and settlement patterns (McBride 1984 a and b). The principal diagnostic aspects of this tradition/phase include Brewerton type projectile points, ground stone tools (ulu or semi-lunar slate knives), and a preference for non-quartz lithic materials. The data collected from the numerous sites in eastern Connecticut with Golet Phase deposits indicate that occupations are distributed across a wide range of microenvironments and most likely represent small groups of hunter-gatherers utilizing a variety of upland resources on a seasonal basis (McBride 1984 a and b).

Several sites in coastal Connecticut have been assigned to the Narrow-stemmed Tradition (4300-3500 B.P.). This tradition is characterized by small- or narrow-stemmed projectile points, regional variants of which include Squibnocket, Sylvan Lake, Lamoka, Bone Island, Wading River, and Poplar Island projectile point forms (Ritchie 1971; Snow 1980). Narrow-stemmed settlement patterns are characterized by seasonal camps along rivers, interior wetlands, lakes and uplands. Numerous temporary and task-specific sites are distributed across a wide variety of ecozones. Larger base camps have also been discovered along major rivers, indicating long-term seasonal reuse of some locales over long periods of time as well as a degree of stability and territoriality not previously documented in the region. The more notable Narrow-stemmed sites in coastal zones include the Archaic Midden Site in Haddam and the Grannis Island Site in New Haven. The Archaic Midden Site has been partially submerged by rising sea levels and is only visible at low tide. This may be typical of many Late Archaic sites in the region, indicating the potential of encountering sites under salt marshes or in coves and bays.

The Susquehanna Tradition (3900-2700 B.P.) of the Late/Terminal Archaic Period is also well-represented in coastal Connecticut. Sites assigned to this tradition are characterized by projectile point forms such as Snook Kill, Susquehanna Broad, and Orient Fishtail, as well as by occasional ceramics, ground stone tools (atlatl weights, grooved axes and adzes), and carved steatite (soapstone) bowls. The larger sites in the region have been found to be oriented toward coastal and riverine locales (Dincauze 1975; Pagoulatos 1986; Pfeiffer 1983; Snow 1980). A number of coastal sites have yielded Susquehanna assemblages, some of them in submerged conditions.

The Woodland Period (3000-450 B.P.) in southern New England is characterized by the introduction of cultigens (maize, beans, squash and sunflowers) and an increased use of ceramic vessels. Site size and complexity increase during this period, suggesting a trend toward increased sedentism and social complexity in coastal areas (McBride 1984b). The Woodland Period has been traditionally subdivided into Early (3000-1600 B.P.), Middle (1650-1000 B.P.), and Late (1000-450 B.P.) periods on the basis of ceramic styles, subsistence and settlement patterns, and political and social developments (Ritchie 1969; Snow 1980). Early Woodland sites in coastal Connecticut are characterized by a quartz cobble lithic industry, Lagoon, Meadowood and Rossville projectile point types and thick, grit-tempered, cord-marked ceramics. Settlement patterns are generally oriented to riverine and coastal locales. The frequency, size and complexity of Early Woodland sites increase significantly from the Late Archaic Period, particularly in coastal areas. This shift in settlement patterns and subsistence practices appears to be linked to developing tidal marshes in coastal zones beginning about 2500 B.P. (McBride 1984 a and b). Food remains from Early Woodland sites along the coast indicate the increasing importance of marine resources in the diet, including shellfish, shallow and deep water fish, marine mammals such as seal, and a variety of waterfowl such as ducks and geese.

While most of the recorded sites containing Early Woodland components are situated along the coast or at the mouths of major rivers such as the Quinnipiac, Connecticut, Thames and Mystic Rivers, a number of interior upland locations have been documented. Important Early Woodland coastal sites include Grannis Island in New Haven (Lavin 1988), Waldo-Hennessey in Branford (McBride 1984b), Old Lyme Shell Heap in Old Lyme (Lavin 1988), and Broeder Point in Old Lyme (McBride 1984b).

Numerous Middle Woodland Period occupations in coastal areas of Connecticut have been identified. These sites are characterized by increased size and complexity over their Early Woodland counterparts, and are also characterized by a wider diversity of ceramic styles and forms and lithic material types. Middle Woodland occupations in coastal areas are believed to represent year-round villages based on recovered faunal and botanical assemblages and the presence of storage facilities. The nature and distribution of Middle Woodland period sites in coastal areas clearly indicate increased aggregation and sedentism along coastal and estuarine settings. An increase in temporary and task-specific sites in upland/interior zones has also been identified coincidental with an absence of any large upland seasonal camps.

Late Woodland period occupations are common in coastal areas of Connecticut, reflecting both increased size and therefore visibility as well as an actual increase in Late Woodland populations. The majority of the Late Woodland sites in eastern Connecticut are located in coastal/estuarine locales or along interior flood plains. Late Woodland coastal sites are characterized by increased diversity of ceramic styles and forms and a high percentage of non-local lithics. Coastal Late Woodland sites are large and relatively complex. Identified features/structures in coastal villages include numerous houses, hearths, storage pits, and small household middens as well as extensive middens adjacent to the villages. Cemeteries are frequently identified associated with the large coastal village sites. Recovered faunal and botanical remains indicate that a wide range of marine, estuarine and terrestrial resources are being exploited. Both shallow and deep water resources are present, including shellfish, tautog, shark, cod, sturgeon and bass as well as marine mammals such as seal and dolphin. Terrestrial animals include raccoon, squirrel, and rabbit (McBride 1984b). Tropical cultigens have also been recovered from coastal Late Woodland sites, although these plants were likely not an important part of the diet (McBride and Dewar 1987). Important Late Woodland sites that have been identified within the general project area include the Old Lyme Shell Heap, Mago Point, and the Davis Farm Site (McBride 1984b; McBride and Dewar 1987). A number of Late Woodland task-specific and temporary sites have also been identified in both coastal and interior/upland settings. Based on current understanding of the nature and distribution of Late Woodland sites, the most intensively used areas are coastal zones such as coves, bays and estuaries.

7.2.2 Prehistory of Southern Rhode Island

7.2.2.1 Western Narragansett Basin and Southern Rhode Island. The topography of this area is heterogeneous. The shoreline along Narragansett Bay consists of low-lying coastal marshes interrupted with occasional areas of bedrock outcrops. Along Rhode Island Sound is a series of salt ponds dispersed over the extent of the coastal plain. North of the coastal plain is the Charlestown Moraine. The terrain of the upland interior is hilly, with pockets of boulder outcrops and many small lakes and ponds (e.g., Ponagansett and Tarbox Ponds). The major river systems dissecting the upland and low-lying interior include the Pawtucket, Hunt, Pawtuxet, Blackstone and Moosup Rivers.

The prehistoric sites that are located within the western Narragansett basin and southern Rhode Island suggest that this region has been occupied for as long as 9,000 years. Site reports indicate that specific topographically defined areas in the upland interior and low-lying riverine settings (now Narragansett Bay) were repeatedly used from the Middle Archaic to Late Woodland times (7500-450 B.P.) with a variety of on-site activities being performed. Less desirable settings such as the Charlestown Moraine were part of the regional land use pattern, but probably occupied for a short period of time while task groups were on route to a specific destination. Other areas such as the Oaklawn Quarry were frequented with the intention of extracting specific resources (e.g., Plainfield Formation quartzite, steatite).

Much of the work that has been conducted on "early" prehistoric sites is useful in terms of identifying the cultural assemblage and the locations or environments of where prehistoric people lived (Fowler 1962; Leveillee and Van Couyghen 1990). The difficulty arises, however, in the interpretive function of early prehistoric sites. Early interpretations often lumped components from several different periods into one occupation, making it difficult to sort out the components and interpret the activities that took place on the site during a specific time.

Another difficulty in formulating early prehistoric land use patterns concerns coastal versus interior settlement. Coastal sites that were probably occupied prior to the stabilizing of sea water are now under Rhode Island Sound. Consequently, the evidence of coastal adaptation prior to the Late Archaic Period is extremely scant. Nevertheless, the following is a general cultural chronology for this region.

To date, Paleo-Indian (12,500-10,000 B.P.) occupations have been reported on Mill Creek (Leveillee and Van Couyghen 1990) and the West River at the Twin Rivers Site (Fowler 1954). Both occupations were identified by fluted projectile points. The fluted point recovered from Twin Rivers was made from a local quartzite and associated with two stone hearths. Fowler interpreted this site as a small hunting camp. A third fluted point was found along the shore of Chapman Pond just beyond the western terminus of the Charlestown Moraine (Turnbaugh and Turnbaugh 1980). This point is made of material which visually is similar to Normanskill Chert. All of the points were found in upland riverine (Twin Rivers) and glacial lake (South Wind Site, Chapman Pond) settings with a distance of over 30 miles between them.

Early Archaic occupations, with the exception of the Bouchard Site, have been identified by the presence of bifurcate-base points. Bifurcate points have been recovered from the South Wind Site along Wickford Harbor (Leveillee and Van Couyghen 1990) and from Sweet Meadowbrook in Apponaug (Fowler 1956). During occupation both of these site areas were part of low-lying riverine environments. Bifurcate-base points have also been identified in collections from the Pawcatuck River drainage (Turnbaugh and Turnbaugh 1980). The Bouchard Site, also within the Pawcatuck River drainage, yielded a radiocarbon date 8,510 B.P. from charcoal that was associated with one quartz flake, suggesting an Early Archaic occupation (Davin 1985).

Middle Archaic (7500-5000 B.P.) sites are found more frequently and in a variety of settings, including the upland interior of the Moosup drainage and Woonasquatucket drainage, a low-lying riverine which is present-day Narragansett Bay, the Great Swamp, and even in seemingly less desirable places such as the Charlestown Moraine. While examining artifact collections from the Pawcatuck River drainage, Turnbaugh and Turnbaugh (1980) found a number of Middle Archaic projectile points (Stark and Neville variants). Quartzite, felsite and rhyolite were the raw materials most often represented in the collections. Many Middle Archaic sites were repeatedly occupied from about 7500 to 450 years before present with the Middle Archaic occupation being the most ephemeral. As in the previous periods, interpretations of activities are often limited to hunting and/or fishing. An exception is RI 1153, an upland site with a radiocarbon date of 5J00 +/- 150 B.P. (McBride 1984a); this interior site is interpreted as a residential camp.

Occupation appears to increase during the Late Archaic Period (5000-3000 B.P.) as indicated by the frequency of reported sites. Most of the temporally identifiable sites that were located during the Big River Survey (Ritchie 1986) dated to the Late or Transitional Archaic Periods. Sites range in size and activity from small, temporary hunting camps (Wilcox Site) to larger occupations, where activities suggest intention to return (Flat River). Temporally sensitive projectile points such as Brewerton's have been recovered from the Pawcatuck drainage (Bouchard Site), Pawtuxet drainage (RI 1528, Rattlesnake Rockshelter), coastal islands (Joyner), and upland interior (RI 1169 and Wilcox Site).

Intensive occupation during the Transitional Archaic Period (3600-2500 B.P.) is evident by the widespread locations of diagnostic artifacts such as Susquehanna and Orient Fishtail type projectile points and steatite bowls. Also diagnostic of this period are secondary cremation burials. Shellfish exploitation begins during this period, which is probably concurrent with estuarine development in some areas. Occasionally, locales were frequented primarily for the purpose of resource extraction; the Oaklawn Quarry Site is an example (Fowler 1967). Steatite extracted from this quarry was used to make bowls, platters, cups and pipes. Steatite objects and sherds have been found along the salt ponds, Narragansett Bay, and the low-lying interiors of the Flat and Big Rivers.

Cremation burials have been reported in Charlestown (Fowler 1964), on the Flat River (Fowler 1968) and on Conanicut Island (Simmons 1970). Four cremation burials were excavated at the Flat River Site; a radiocarbon date of 3430 +/- 100 B.P. was obtained from one of the interments. Fowler made an association between the burials, stone hearths, cache blade features and Susquehanna Tradition projectile points. Orient Fishtail and Coburn points were also recovered from this site.

This region, along with southern New England as a whole, shows an increasing focus on coastal resources. Several considerations should be taken into account when considering the degree to which this shift in settlement took place. First, coastal sites occupied prior to the stability in sea level rise are omitted from the archaeological record because they are now inundated. This explains, in part, why coastal adaptation in this area only dates between the Transitional Archaic through Contact Periods. Secondly, historically, most archaeological surveys that have taken place in Rhode Island have been conducted along the coast. This locational bias, along with the presence of middens created during shellfish exploitation, makes coastal sites highly visible. Compared to the Archaic Period (10,000-3000 B.P.), sites dating to the Woodland Period (3000-450 B.P.) are slightly less frequent in the interior but are still represented.

There is an apparent scarcity of Early Woodland (3000-1600 B.P.) sites in this region. The lack of sites could be attributed to few diagnostic artifact types which date to this period or to population decline. Artifacts that are diagnostic of this period include Meadowood and Lagoon projectile points and certain cord-impressed pottery. Early Woodland occupations are evident along the bay, salt ponds, the low-lying interior, and the upland interior. A radiocarbon date of 1700 +/- 110 B.P. was obtained from a feature at the Wilcox Site in the upland interior, but the major occupation of this site was during the Late Archaic Period (Davin 1987). The Bouchard Site within the Pawcatuck River drainage was a fishing or hunting camp that was occupied for a short time (Davin 1985). Camp maintenance activities (trash disposal) and faunal processing took place on the site. Two radiocarbon dates (2080 +/- 50 B.P. and 1950 +/- 130 B.P.) indicate a strong Early Woodland association.

Middle Woodland (1650-1000 B.P.) sites are better-represented than those of the previous period. Non-local lithics (chert, jasper and hornfels) were used by prehistoric people during this period, suggesting extensive trade. A relatively high percentage of Middle Woodland sites are located in the vicinity of the Lambert Farm and display various degrees of shellfish exploitation from trash pits to middens.

In the upland interior, a few sites identified as residential camps were occupied during the Middle Woodland Period. RI 1152 was located during an archaeological reconnaissance survey (McBride 1984a). A radiocarbon date of 1120 +/- 110 B.P. was obtained from a feature; however, related activities were not noted. The Breezy Hill Site, located in Foster, yielded a radiocarbon date of 1230 +/- 200 B.P. along with dentate stamped ceramics (Wilbur Smith Associates 1984).

The Late Woodland Period (1000-450 B.P.) is strongly documented along Narragansett Bay and Rhode Island Sound and, to a much lesser degree, in the interior. Levanna projectile points are often associated with this time period, but are not restricted to it. Late Woodland occupations are located along the Big River, Flat River, at the Oaklawn Quarry Site, on Tarbox Pond, in the Wickaboxet State Forest, on Ponagansett Lake, and in the interior upland.

7.2.2.2 Eastern Narragansett Bay. Land forms included in this discussion on local prehistory are Aquidneck and Prudence Islands, the Sakonnet River area, and the East Bay and Mount Hope Bay. Temporally diagnostic artifacts from local sites suggest human occupation for at least 8,000 years and possibly longer. The most intensive occupation dates to the Late Woodland/Contact Period (1000-300 B.P.).

The highest site density in the northeast section of the Bay is located along Bristol Neck and Kickamuit Narrows. Sapowett Marsh, in Tiverton, is an eastern focal point. Site types include burials, villages (Rider 1904), multicomponent camp sites, shell middens, and chipping stations. Many of these sites have been repeatedly occupied over a long span of time.

The only suggestion of Paleo-Indian (12,000-10,000 B.P.) activity along the eastern bay is a fluted projectile point collected on the Noble Farm property located near the Nayatt section of Barrington (Duncan Ritchie, personal communication 1989). Though a single artifact does not confirm Paleo-Indian occupation, it does indicate a presence. This projectile point is made of yellow chert and displays basal grinding on the lateral sides. Artifacts from the Noble Farm property are part of the Edward A. Smith Collection, housed at the Barrington Historical Society (Suzanne Glover, personal communication 1989).

Early (8000-7500 B.P.) and Middle (7500-5000 B.P.) Archaic projectile points have been identified on Prudence Island (Kerber and Ueki 1981), at the Burr's Hill Site in Warren (Ritchie 1980), and at the Read Farm Site in Swansea, Massachusetts. Both the Burr's Hill Site and Read Farm Site contain artifacts dating from the Early Archaic through Late Woodland/Contact Periods. The Eastover Site on Aquidneck Island was occupied during the entire Archaic Period (8000-3600 B.P.), with reoccupation during the Late Woodland Period. To date, one Early Archaic projectile point (Kirk type) and 15 Middle Archaic projectile points have been recovered during the ongoing Phase III investigation at the Eastover Site (PAL Management Memorandum 1989). A preference for argillite and felsite during the Middle Archaic Period is evident at this site by the Stark and Neville projectile points as well as by associated chipping debris. During this time, the Eastover Site would have overlooked a fresh water river. Aquidneck was not an island and was barely separated from the mainland by what was the southern extension of the Taunton River (McMaster 1983).

Late Archaic sites are traditionally found in a variety of settings and exemplify varying degrees and types of activities, from special-purpose to broad based uses. Late Archaic occupations are often identified by projectile point types, including Brewerton (Kerber and Ueki 1981) and Squibnocket (Loparto et al 1977). A Late Archaic fishing camp site is located along the Palmer River.

The Peckham Farm Site, within the Eastern Sapowit marsh core area on the east bank of the Sakonnet River, contains a shell midden component which yielded a radiocarbon date of 4000 +/- 110 B.P. (Leveillee and Thorbahn 1984). To date, this is the earliest evidence of shellfish exploitation within Narragansett Bay. Cultural material associated with the Peckham Farm Site (mostly surface-collected) includes Squibnocket Triangle, Small-stemmed, and Levanna projectile points, as well as cores, scrapers, preforms, bifaces, chipping debris and one net sinker.

The Transitional Archaic Period (3600-2500 B.P.) is characterized by soapstone technology, Susquehanna Tradition-style projectile points, cremation burials, and a preference for felsite lithic material. This period is well-represented in the East Bay. The most common Susquehanna Tradition projectile point in this region is the Orient Fishtail style. Orient Fishtail projectile points have been recovered from the east bank of the Sakonnet River (Leveillee and Thorbahn 1984) and other sites, including the Burr's Hill Site (Ritchie 1980).

Site RI 1755 is a small (50- x 50-meter) prehistoric site discovered in north Bristol during a Phase I survey (Morenon 1988). Preliminary information from this site indicates that soapstone bowl fragments and a cache of rhyolite bifaces, as well as a charcoal feature, carbonized nut seeds, and aboriginal pottery were recovered during excavation (Morenon 1988). In addition, a human bone fragment was exposed during bulldozing activity. This cultural assemblage suggests that RI 1755 was occupied during two separate time periods. The soapstone vessel, together with the rhyolite cache, is indicative of a Transitional Archaic occupation. If these objects are associated with the human bone fragment, then this assemblage may represent a cremation burial. Similar situations have been cited in Riverside about 10 km north of the project area (Dincauze 1968).

The Blaeser Site (RI 297) is located adjacent to the One Hundred Acre Cove in Barrington (Mowchan 1989). Cultural and faunal material recovered from this site include an Orient Fishtail projectile point, bifaces, scrapers, chipping debris (mostly felsite), shell and bone fragments. The bone fragments recovered from this site are possibly deer, and the shell is either oyster or quahog. This assemblage suggests that prehistoric people were hunting, fishing and processing animal remains during the Transitional Archaic Period.

The Woodland Periods (3000-450 B.P.) were strongly associated with coastal adaptation, the use of aboriginal pottery, increasing diversification of food sources, and the advent of horticulture

(Snow 1980; Bernstein 1987). During archaeological investigations at Potowomut Neck in East Greenwich, Kerber (1984) noted that prehistoric coastal utilization paralleled development of salt marsh estuaries. Although Kerber's survey was conducted in the West Bay, a similar pattern most likely occurred along the East Bay.

The Johannis Peninsula Site (RI 1716), located on the Palmer River, was occupied during the Early Woodland Period (3000-1600 B.P.), as suggested by Vinette I-type aboriginal pottery (Mowchan 1987). The presence of a hearth, as well as aboriginal pottery, calcined bone, a small amount of quahog, chipping debris, a core, and a biface suggests that prehistoric people were processing food and manufacturing stone tools at this camp site.

The Weaver Cove Site (RI 1745) is located along the Eastern Passage on Aquidneck Island. This site was most likely occupied during the Early and Middle Woodland Periods (3000-1000 B.P.), as suggested by recovered projectile points. A chert Meadowood preform and jasper Jack's Reef corner-notched projectile points were recovered during a Phase I survey (Van Couyghen and Leveillee 1988). Two chert Jack's Reef-type projectile points are included in the Burr's Hill collection as well (Ritchie 1980). A Middle to Late Woodland Period (1150-450 B.P.) occupation was identified by Fowler (1976) at the Squantum Woods shell midden in East Providence.

Late Woodland (1000-450 B.P.) occupations are well-represented in this region. Traditionally, Levanna projectile points are affiliated with this period, though they may have been associated with radiocarbon dates spanning from the Middle Woodland to Contact Periods (1650-300 B.P.). Late Woodland components are reported at the Read Farm Site, Eastover Site, RI 1755 (Morenon personal communication 1989), and Kickamuit Spring Site, as well as along the Sakonnet River (Leveillee and Thorbahn 1984) and Mount Hope Bay (Kerber and Ueki 1981). Most of these components are associated with shellfish exploitation to varying degrees.

A Late Woodland deposition was identified at the Kettle Point Site (Pagoulatos and Ritchie 1987) during a Phase II survey along the Providence River. Three radiocarbon dates of 520 +/- 80 B.P., 450 +/- 80 B.P. and 400 +/- 70 B.P. were obtained from a hearth and a trash pit feature. A variety of shellfish and seed species, as well as mammal bone, were recovered from the site. Associated cultural material includes incised and plain bodied ceramics, a Levanna projectile point, and tool maintenance debitage.

During the Contact Period, three Wampanoag villages were located in this region. Sowams was the main village and home of Massasoit, chief sachem of the Wampanoags (Munro 1880). The nearby Burr's Hill Site is best known for its Contact Period burial ground, and is thought to be associated with the village at Sowams (Gibson 1980). In 1913, Burr's Hill was systematically excavated by Charles Read Carr. Of the 52 burials located, the majority were in a flexed posture, positioned on their right side, and facing a southerly direction, similar to interments excavated at both RI 1000 in North Kingstown and the West Ferry Site (RI 84) in Jamestown.

Many of the individuals at Burr's Hill were wrapped in matting or blankets. Some of the interments were multiple, and a wide variation existed in the quantity and type of associated grave goods. The amount of grave goods may have been a reflection of an individual's social status (Gibson 1980). Most of the artifacts were of European influence, dating to the late 1600s. In fact, some objects postdate King Philip's War (1675/6), suggesting a continuation in mortuary practices despite cultural disruption.

In summary, the East Bay area was inhabited throughout much of prehistory, with the most intense occupation dating to the Late Woodland/Contact Periods (Burr's Hill Site). The majority of prehistoric sites are situated in close proximity to Kickamuit River (RIHPC 1981). Land use patterns along the East Bay are similar to those found elsewhere along New England's coastline with respect to temporal affiliation, frequent reoccupation, and gradual increase in shellfish exploitation.

7.2.3 Prehistory of the Southeastern Massachusetts Area

The Narragansett Basin system encompasses the Taunton, Seekonk, Ten Mile, Seven Mile, Palmer, and Runnins river drainages. Archaeological research along these riverine/coastal drainages indicated that this region of southern New England was utilized by prehistoric populations (Dincauze 1974; Dincauze and Mulholland 1977; Snow 1980). In particular, the distribution of certain lithic materials from known source areas and the resource exploitation patterns it represents suggest that group territories were related in some way to drainage systems.

Archaeological investigations in the Attleboro section of the Narragansett Basin system have identified focal points of prehistoric subsistence and settlement activities during the past 10,000 years. Attleboro is the location of a source of lithic raw material, known as Attleboro red felsite, which was quarried by prehistoric populations for raw material to manufacture stone tools. Known outcrops of Attleboro red felsite are located in North Attleboro and Attleboro at the headwaters of the Ten Mile River. Site types in the area include "satellite" sites where lithic manufacturing was the primary activity. These sites are generally located in relatively close proximity to an outcrop or quarry location and usually contain several small lithic workshops in which moderate to high concentrations of chipping debris, bifaces, and other tool types are present. The Knoll 1 Site in Attleboro is typical of a small satellite site located within several hundred meters of a known quarry and which contained evidence of only one type of activity, lithic manufacturing (Davin and Miller 1991).

Narragansett Bay was inundated following the retreat of the Wisconsin glaciation, approximately 12,000 years ago. The post-glacial environment was initially inhabited during the Paleo-Indian Period, traditionally interpreted as a time in which small groups of highly mobile people traversed the region subsisting primarily on Pleistocene game animals such as mammoths and mastodons, bear, bison, elk, caribou, and musk ox. However, this perception of Paleo-Indian hunter-gatherers is currently being challenged. Nicholas (1988: 263) states "Much of this archaeology has been done on the basis of assumptions of resource-poor landscapes, mobile and egalitarian populations, and limited site types that characterized the literature on the early post-glacial environments." Paleo-Indian populations were probably heavily dependent upon marine resources as well. Nonetheless, prehistoric sites dating to the Paleo-Indian Period (ca. 12,500 to 10,000 B.P.) in this region are uncommon. The sites which are characteristic of this period have been known to contain lithic tool assemblages which include fluted-type projectile points, gravers, scrapers, and channel flakes.

The paleoecological setting for sites of this period within southern New England would have been located on post-glacial river valleys comprised of broad terraces of sandy outwash plains. A site of this type (Wapanucket #8) was located within the Taunton River drainage, in Middleborough, Massachusetts (MHC 1982). Avocational archaeologists have located complete fluted projectile points and point fragments within the upper Narragansett Basin region in East Providence. Given the comparatively small number of Paleo-Indian sites identified in coastal zones of the Narragansett Basin, archaeologists working in this region have recognized the potential effects of rising sea levels and isostatic rebound that are characteristic of the post-glacial physical environment of this area. The gradual rise in sea level with the retreating/melting glaciers formed the Narragansett Basin, bringing about increased and diversified floral, faunal, and marine resources. Archaeologists have therefore recognized that the coastal regions were inundated and therefore evidence for probable Paleo-Indian sites has diminished (Thorbahn 1982; MHC 1982).

The gradual development of adaptive strategies oriented to mixed deciduous/coniferous forests rather than the earlier, post-glacial boreal forest provides the basis for the beginning of the Archaic Period approximately 10,000 years ago. During the Early Archaic Period (ca. 10,000 to 7500 B.P.), prehistoric subsistence focused on a wider resource base than that of the preceding period. These changes probably occurred in a gradual continuum over a few thousand years, as climatic fluctuations influenced the nature of available resources for human exploitation. While known Early Archaic Period sites are more numerous than Paleo-Indian depositions, only a few have been identified in southeastern Massachusetts and nearby Rhode Island. Bifurcate-base projectile points are diagnostic of this period, with artifact assemblages including ground stone tools, drills, anvil stones, choppers, and scrapers (Snow 1980: 172).

Sites containing bifurcate-based points have been identified within a wide variety of environmental settings. The largest Early Archaic assemblage in the Narragansett Basin is from the complex multicomponent Read Farm Site (19-BR-75) located in South Seekonk, Massachusetts. The Read Farm property is situated on a terrace overlooking the Runnins River and associated tidal marshes to the south. Eight bifurcate-base projectile points were identified among the 721 total points recovered from this site. More recently, the Seekonk 2 Site (19-BR-72), situated on a terrace of the Ten Mile River, yielded a bifurcate-base point, broken into two pieces (tip, base/midsection fragments) (Rainey and Cox, in preparation). This point was made from a felsic volcanic rock of the Mattapan/Lynn Formation.

The distribution and frequency of known Middle Archaic Period (ca. 7500 to 5000 BP) sites in the Narragansett Basin system reflect the development of a more complex, localized land use strategy when compared to the preceding cultural periods. Middle Archaic depositions have been found in a wide variety of environmental settings, including the edges of bogs, swamps, lakes, ponds, and rivers. Middle Archaic sites also tend to be located on high ground characterized by well-drained sandy soils (Barber 1979; Simon and Gallagher 1981). These sites vary greatly in size and in the types of activities performed. Some are large, repeatedly-used base camps on riverine wetlands; others are smaller, temporary camps or small loci which contain specific tools for processing food or manufacturing/maintaining stone tools. The distribution and frequencies of Middle Archaic sites also suggest an increase in population and utilization of diverse natural resources. The seasonal pursuit of anadromous fish and waterfowl may have developed during this period (MHC 1982; Dincauze and Mulholland 1977; Snow 1980). Lithic technologies attributed to this period are typically identified from Neville and Stark varieties of projectile points, commonly made from lithic materials such as nonlocal, Boston Basin felsites as well as locally available shales and argillites (Leveillee and Ritchie 1982).

Neville and Stark points are included in the Richardson collection from the Ten Mile River drainage. John Richardson, of Attleboro, was responsible for identifying many of the known prehistoric sites in the Ten Mile River drainage (Anthony et al. 1980). His collection of approximately 20,000 artifacts, located at the Maurice Robbins Archaeological Museum in Middleborough, Massachusetts, represents prehistoric sites distributed along major tributaries within this drainage.

The increasing frequency of sites in southern New England during the Late Archaic Period (ca. 5000 to 3000 B.P.) has been interpreted as either a growth increase in population and/or intensified exploitation of diverse ecozones (Barber 1979: 213). The Late Archaic Period is divided into three traditions which reflect both time periods and/or changing lithic technologies. The earliest of these is the Laurentian Tradition, which appears to have a strong association with interior resources and settlement and more sporadic use of coastal resources. Diagnostic projectile points attributed to the Laurentian include Otter Creek, Vosburg, and Brewerton styles, all of which have been found in the upper Narragansett Basin region.

Artifacts diagnostic of the Small-stemmed Tradition of the Late Archaic are the most frequently found in southern New England. The Ledge Road Site yielded one quartz Small-stemmed projectile point, numerous flakes, a biface, and two pieces of shatter, all composed of quartz. Seventeen Small-stemmed points were located at the Seekonk 2 Site located along the Ten Mile River. Small-stemmed components were also found at the Seekonk 3 Site (Rainey and Cox, in preparation) and the Fram (RI 59) and Fram North (RI 932) sites as well as the Walker Point (Bluff Section, North Terrace) site in East Providence, near the mouth of the Ten Mile River (Rainey and Ritchie 1992). The Read Farm Site contained several points characteristic of this tradition. The presence of these cultural components indicates that this section of the Narragansett Basin was exploited by Late Archaic hunter/gatherers of the Small-stemmed Point Tradition. In particular, there are many examples of small, low-density sites, indicating settlement patterns that included broad-based foraging strategies in use from approximately 4500 to 3000 years ago.

The third tradition of the Late Archaic Period is also represented at sites in the vicinity. Two quartz Squibnocket Tradition projectile points were found at the Ledge Road, Seekonk 2, and the Walker Point sites. These sites reflect a variety of subsistence activities (food procurement and processing, stone tool manufacture/maintenance) oriented to the exploitation of freshwater riverine marsh and/or wetland environments.

The Transitional Period (ca. 3600 to 2500 B.P.) between the Archaic and Woodland periods is characterized by the strong presence of the Susquehanna Tradition and the continuation of the Small-stemmed Point assemblages. Subregional syntheses of prehistoric settlement patterns have noted an increase in the use of coastal zone/estuarine site locations during this period (Dincauze 1974; Snow 1980). At this time the Narragansett Bay basin region included numerous tidal/estuarine environments which supported diversified natural resources. Significant use of this type of environment is suggested by the number of sites which have Transitional Archaic components. Early forms of pottery, and the introduction of steatite or soapstone vessels, are affiliated with the Transitional Period.

The Maurice Robbins Archaeological Museum contains a large assemblage of Susquehanna Tradition projectile points collected from the Narragansett Race Track site in East Providence. A variety of stylistically-related Transitional Archaic projectile points (i.e., Orient Fishtail, Coburn, Wayland Notched) and a steatite bowl were recovered from a site at Fort Hill, located at the confluence of the Seekonk and Providence Rivers in East Providence. This collection of artifacts resembles the contents of Transitional Archaic burials identified in southeastern Massachusetts and Rhode Island (Lord 1962; Simmons 1970). The Walker Point-North Terrace Site, located at the mouth of the Ten Mile River, contained over 500 pieces of Attleboro red felsite within a probable Transitional Archaic component. This increasing volume of archaeological data indicates that during the Late/Transitional Archaic temporal range, intensive land use strategies were in place within the Narragansett Basin region of southern New England.

The following cultural episode, the Woodland Period (3000 to 450 B.P.), is generally recognized by a shift in subsistence and land use strategies from inland areas to more coastal zones (Dincauze 1974: 51; Snow 1980: 283-285). Subregional overviews of Woodland Period subsistence/settlement patterns in this area of southern New England recognize an apparent scarcity of Early Woodland (3000 to 1600 B.P.) sites and a steady increase in the number of sites through the Middle (1600 to 1000 B.P.) and the Late Woodland (1000 to 450 B.P.) Periods. Horticulture was introduced into this region approximately 1000 years ago, although hunting/gathering remained as a substantial subsistence mode for Native Americans. Therefore, it is suggested that Late Woodland populations may have practiced a combined economy consisting of hunting, plant gathering, shellfish collecting, fishing, and plant cultivation. Complex social organizations involving territories and horticulture probably occurred among Late Woodland populations (Mulholland 1988). Mulholland elaborates on the complicated political alliances in which foraging horticulturists competed for and defended arable lands.

The Early Woodland Period is identified by grit- and shell-tempered, incised/cord-marked ceramics, as well as Meadowood, Lagoon, and Rossville point types. Middle Woodland sites often contain assemblages which include dentate-stamped ceramics along with Jack's Reef and Fox Creek point varieties. Components assigned to the Middle Woodland usually yield a high percentage of raw materials from outlying sources, probably indicating long-distance exchange networks (Dragoo 1976; Snow 1980). Late Woodland material culture includes fine, thin ceramic wares and Levanna projectile points (Snow 1980).

The Ledge Road Site yielded an Early to Middle Woodland grit-tempered dentate-stamped ceramic sherd. The Fairbanks Farm Site (19-BR-69), Indian Bluff Farm Site (19-BR-70), and Site 19-BR-71 are all situated along Coles Brook; these sites were located by members of the Massachusetts Archaeological Society from the 1930s to the 1940s. Steatite and aboriginal ceramics were located at these sites. Indications of Middle Woodland Period activity has been identified at several sites within the Ten Mile River drainage. The Walker Point Site produced two Jack's Reef projectile points, grit-tempered ceramic sherds, and jasper and hornfels chipping debris.

Many of the Woodland Period sites investigated by avocational archaeologists contain coastal shell midden features, indicating an intensive exploitation of various marine/estuarine resources. Diagnostic cultural materials recovered from shell middens include a smoking pipe (possibly constructed from an antler), a biface/knife of jasper, bone awls, antler tine flaking tools and projectile points, and shell- or mineral-tempered ceramics with incised line (chevron) decoration (Fowler 1976).

7.2.4 Prehistoric Land Use and Settlement in the Boston Area.

The Boston area is unusual in comparison to other urban areas because early collections of prehistoric material have been preserved from sites that have been destroyed by development and landscape modification. Collections assembled in the late 19th century from sites along the lower Charles and Mystic River drainages are valuable sources of prehistoric data. Prehistoric sites located at the confluence of various streams with the Charles River near Magazine Beach and Mt. Auburn Hospital in Cambridge, as well as the Watertown Arsenal and the Perkins School for the Blind in Watertown, were visited by 19th-century collectors during the development and construction of these establishments. An important locus of prehistoric activity at the confluence of the Mystic River and Alewife Brook in Arlington was the source of at least one large collection. The Boylston Street fish weir was first discovered during subway construction in 1913.

A survey of archaeological resources in the greater Boston area conducted in 1967-1968 was the first large-scale inventory and assessment of prehistoric sites (Dincauze 1974: 39). This survey included the Boston Harbor islands, revealing the important research potential of the sites located in the harbor district. A later investigation of 12 harbor islands was the first archaeological survey to focus specifically on the islands. An important product of this survey was a model of how prehistoric land use/settlement patterns changed between the Late Archaic and Late Woodland Periods (Luedtke 1975, 1980).

More recent cultural research has provided new information about prehistoric sites in Charlestown (Shaw 1984; Ritchie 1987), Watertown (Barfield and Barber 1982), and in the Boston Harbor district (Ritchie and Gallagher 1984; Jones and Seasholes 1988). The largest and best-preserved concentration of prehistoric sites in the metropolitan area is contained within the Boston Harbor Islands National Register District, which includes 34 sites distributed among 21 islands with evidence for occupation from the Early Archaic to Late Woodland Periods.

A sequence of prehistoric settlement and land use covering at least 9,000 years can be documented with the inventory of known sites in the Boston area (Table 7-3). A small Paleo-Indian Period component on the Saugus Quarry Site, north of Boston, is the earliest site in the area. Paleo-Indian hunter-gatherers were the first to exploit the fine-grained, red-pink lithic material (Saugus jasper) outcropping in a section of the Lynn Volcanic formation, near the Saugus River. A diagnostic fluted projectile point, point preforms, and some other Paleo-Indian tools were collected from this site before it was destroyed by recent development (Grimes 1984).

The discovery of a potential Early Archaic component on a Long Island site provided first evidence of prehistoric occupation within the Boston Harbor district before about 7,000 B.P. (Luedtke 1984). This site is particularly important because the other coastal locations used around 8,500 to 8,000 B.P. are under Boston Harbor. A few sites representing other aspects of Early Archaic settlement patterns in the Boston area are located on large riverine systems draining into coastal waters. A large terrace of glacial outwash sand/gravel above the Charles River in East Watertown was apparently occupied by Early Archaic groups: a single bifurcate base projectile point was collected there in the late 19th century (Dincauze 1973: 32). Several other bifurcate base point find spots representing temporary camps used by Early Archaic hunter/gatherers have been recorded in the three major river drainages (Mystic, Charles and Neponset) emptying into Boston Harbor (Dincauze 1974: 45).

Marine transgression and the creation of Boston Harbor drowned most of the sites located near the coastal/estuarine environmental settings of 7,500 to 6,000 years before present. The available information on Middle Archaic Period settlement patterns and other activities in the harbor district is limited in comparison to adjacent, inland sections of the Boston Basin. One of the prehistoric sites located on the southern end of Long Island yielded a broken Neville point. If this large non-midden site does contain more Middle Archaic material, it could be an important source of information needed to reconstruct settlement and resource use patterns in the harbor around 7,000 years before present. Earlier survey work in the Boston Basin suggested that the majority of Middle Archaic sites not under shallow, offshore waters are in three general environmental settings: adjacent to a river, in lakes and rivers, or in bogs (Dincauze 1974: 45).

Examples of Middle Archaic sites or components in these settings are known from different parts of the Boston area. Along the lower sections of all three of the major river drainages entering Boston Harbor, Middle Archaic components occur in multi-component sites. An example of this is the Watertown Arsenal Site located on the lower Charles River. Sites on the shores of several large ponds (for example, Spy Pond in Arlington and Fresh Pond in Cambridge) were also occupied during the Middle Archaic, forming some of the earliest depositions in what would later become important base camps during the Late Archaic and Woodland Periods.

The prehistoric component of the Dillway/Thomas House Site within the Roxbury Heritage State Park also appears to include a Middle Archaic Period deposition. The location of this camp on elevated terrain above the Stoney Brook drainage contrasts with most of the other contemporaneous sites in the Boston area and adds to the range of site locations known for this time period. The occupants of the site were using felsite obtained from quarries in the Mattapan area (Mattapan Volcanic Complex) and rhyolite from the Blue Hills to manufacture chipped stone tools. Many sites around the perimeter of these quarries were used as temporary workshops.

Relatively high numbers of Late Archaic Period sites have been recorded in the Boston metropolitan area. The Boylston Street fish weir was constructed early in this period (ca. 4,500 years B.P.) in the recently formed Charles River estuary. This wood and brush facility for trapping fish in the intertidal zone appears to have been maintained/repaired on a seasonal basis by hunter/gatherers of the Small-stemmed Point tradition. Several sites along the Charles River in Cambridge with Small-stemmed components were located near the position of the intertidal zone around 4,000 years B.P. (Dincauze 1973). Other sites such as the Water Street Site in Charlestown suggest that Small-stemmed tradition settlement and subsistence was based on the exploitation of resources from a variety of estuarine locates (Shaw 1984). Investigations of a shell midden on Peddock's Island in Boston Harbor uncovered a very unusual Archaic inhumation burial under the midden deposit. A radiocarbon date of 4135 +/- 225 years B.P. (GX-2528) indicates that it was probably affiliated with a Small-stemmed deposition, predating the formation of the midden (Dincauze 1974: 48).

Other Late Archaic populations, particularly those affiliated with the Susquehanna tradition, were active on the Boston Harbor islands and at many locations along the Charles River estuary. One of the sites (Hull-11) was apparently used by Susquehanna tradition people. The Calf Island Site in the outer harbor probably contained a fairly substantial Late Archaic deposition that was mostly destroyed by rising sea level and subsequent erosion. One of the subsistence-related activities carried out by Late Archaic hunter/gatherers may have been the construction and operation of a fish trap or weir between Calf Island and the Brewster Islands.

About 4,000 years B.P., some large sites near ponds and the Charles River estuary seem to have been important base camps for Susquehanna tradition hunter/gatherer populations. The Watertown Arsenal, Cassidy Farm and Perkins School Sites on the lower Charles River and the Spy Pond indicate numerous occupations took place through three successive phases (Atlantic, Watertown. Coburn) of the Susquehanna tradition between about 4,100 and 3,200 years B.P. (Dincauze 1973).

By around 3,000 years B.P., Terminal Archaic populations were still using some of the same site locations that had been parts of earlier Archaic settlement patterns in the harbor district and Charles River estuary. The largest sites, possibly representing the cores of Terminal Archaic

(Orient complex) and Early Woodland settlement patterns in some coastal drainages, are near the head of estuaries along the Mystic and Charles Rivers (Dincauze 1973, 1974: 50). Several examples of small, temporary camps occupied by Early Woodland Period hunter/gatherers have been found near the mouth of the Charles River in Charlestown. Activities carried out at or near these sites include the manufacture of stone tools from locally available felsites, rhyolite, and argillite, and the processing of some type of resource, such as plant material or fish. The Water Street and Town Dock Pottery Sites are both good examples of prehistoric sites located near the former estuary zone, subsequently buried under deposits of historic period fill. The Town Dock Wharf Site, a small, temporary camp/lithic workshop, was sealed under a deposit of marine (salt marsh) peat that was created about 2,000 to 3,000 years B.P., just prior to the stabilization of the shoreline in Boston Harbor (Shaw 1984; Ritchie 1987).

The Early Woodland and first half of the Middle Woodland Periods mark an important shift in prehistoric settlement and resource use in the southern New England region. Exploitation of several species of shellfish (soft shell clam, scallop, oyster, quahog) intensified rapidly during the Middle Woodland Period in response to the stabilization of sea levels and establishment of suitable habitat (tidal flats) for the formation of shellfish beds. Some large shell midden sites were created in the Boston Harbor district, and they have a much wider distribution across the islands than sites of most preceding time periods. Both midden and non-midden Middle Woodland sites are located near estuarine environments along the shore of the harbor and at the estuary head base camps used by previous Terminal Archaic and Early Woodland groups in the Charles and Mystic River drainages (Braun 1974: 589-591; Dincauze 1974: 51).

The concentration of settlement/subsistence activities in the coastal/estuarine and offshore island environments of the harbor district continued into the Late Woodland Period, after about 1,000 years before present. During the Late Woodland and succeeding Contact Period, two concentrations or core areas of settlement appear to have developed within the Boston basin. These core areas were centered on the ecologically diverse environments found within the Mystic and Neponset River estuaries on the north and south edges of the Boston Harbor district. From the estuaries, the Neponset and Mystic cores extended inland along these river drainages into the adjacent uplands to include some of the major ponds and tributary stream systems. These islands in the Boston Harbor district in close proximity to the Mystic and Neponset estuaries were also apparently part of the core areas of Late Woodland and Contact Period activity (MHC 1982: 28-29).

Certain inner harbor islands were used for intensive shellfish processing and probably for farming (Long Island, Peddocks Island, Thompson Island, etc.) and could have been important parts of the territories of groups based in the Charles, Mystic, Neponset or other river basins. Outer harbor islands such as Calf Island and the Brewster Islands would have been occupied on brief, seasonal trips for exploiting specific marine resources (i.e., fish, shellfish, sea birds) (Dincauze 1974: 53; Luedtke 1980: 72-73).

Within the Neponset core area, a base camp or semipermanent village was located at the Massachusetts Hummock in Squantum. This site, near the mouth of the Neponset estuary, was allegedly the village occupied by Chickatawbut, a Massachusett sachem. The elevated peninsula, in what is now south Boston, was a part of this Neponset core or territory known as Mattapanock in the early 17th century. A Contact Period grave uncovered at Savin Hill Park in Dorchester during the 19th century contained the remains of an individual buried with large numbers of sheet copper beads and several iron tools (axe, fishhook, fish spear) (Sweetser 1883; Willoughby 1973).

From the preceding review of available information, it is clear that the Boston area was occupied during the entire span of the prehistoric period. The coastal estuarine environment, with its high natural resource potential, was clearly a focal point of settlement and subsistence during the Archaic and Woodland Periods.

7.3 SITE SURVEYS

To assess the historic and prehistoric period archaeological sensitivity of the substation and utility corridors, switching station areas, parallelling station areas, and areas where bridges would be raised an archaeological assessment was conducted, which consisted of background research and visual inspection of selected areas. The results of this assessment are described in this section and summarized in Tables 7-4 through 7-7. Information on previously known or reported archaeological sites was obtained from the site files of the Connecticut Historical Commission (CHC), Connecticut Office of State Archaeology (COSA), the Rhode Island Historical Preservation Commission (RIHPC) and the Massachusetts Historic Commission. In addition, the National Register of Historic Places was consulted to identify any National Register-listed sites within or immediately adjacent to the project areas. The original archaeological assessment reports for the Northeast Corridor project prepared by DeLeuw, Cather/Parsons for the United States Department of Transportation Federal Railroad Administration (FRA) were also consulted (DC/P 1979a, b and c). These reports identified historic districts, historic structures and prehistoric and historic period archaeological sites as well as areas of potential historic or prehistoric sensitivity.

TABLE 7-4. Archaeological Sensitivity of Substation Sites and Utility Corridors.

SUBSTATION	LOCATION	MILE POST	ARCHAEOLOGICAL SENSITIVITY
Branford	Branford, CT	79.26	Substation - low; Corridor - low to moderate
New London	New London, CT	123.55	Substation - low; Corridor - high along 4th Street otherwise low
Warwick	Warwick, RI	176.91	Substation - low; Corridor - low
Roxbury Crossing	Boston, MA	226.02	Substation - moderate; Corridor - low

TABLE 7-5. Archaeological Sensitivity of Switching Station Sites.

SWITCHING STATIONS	LOCATION	MILEPOST	ARCHAEOLOGICAL SENSITIVITY
Westbrook	Westbrook, CT	103.53	Low
Richmond	Richmond, RI	150.35	Low
Norton	Attleboro, MA	198.99	Low

TABLE 7-6. Archaeological Sensitivity of Paralleling Station Sites.

PARALLELING STATION	LOCATION	MILEPOST	ARCHAEOLOGICAL SENSITIVITY
Leetes Island	Guilford, CT	85.99	Moderate to high
Madison	Madison, CT	92.41	High
Grove Beach	Westbrook, CT	99.11	Low
Old Lyme	Old Lyme, CT	109.50	High
Millstone	Waterford, CT	117.56	Low
Noank	Groton, CT	129.46	Low
Stonington	Stonington, CT	134.65	High
State Line	Stonington, CT	139.93	Moderate
Bradford	Westerly, RI	145.19	Low
Kingstown	South Kingstown, RI	157.11	Low in right-of-way Moderate in accessway
Exeter	Exeter, RI	161.78	Low
East Greenwich	North Kingstown, RI	169.80	Low
Elmwood	Providence, RI	181.70	Moderate to high
Providence	Pawtucket, RI	187.55	Low
Attleboro	Attleboro, MA	193.40	Moderate to high
East Foxboro	Foxboro, MA	205.70	Moderate to high
Canton	Sharon, MA	212.40	Low
Readville	Boston, MA	219.10	Low

TABLE 7-7. Archaeological Sensitivity at Bridges to be Modified.

BRIDGE NAME	LOCATION	MILEPOST	ARCHAEOLOGICAL SENSITIVITY
Johnnycake Hill Road	Old Lyme, CT	108.51	Moderate to high
Millstone Point Road	Waterford, CT	117.31	Low
Burdickville Road	Charlestown, RI	148.41	Moderate
Kenyon School Road	Richmond, RI	154.04	Low
RI Route 138	South Kingstown, RI	158.32	Low
Pettaconsett Avenue	Warwick, RI	178.46	Low
Park Avenue	Cranston, RI	180.29	Low
Depot Street	Sharon, MA	211.04	Low
Maskwonicut Street	Sharon, MA	211.62	Low

In areas identified as having moderate or high potential for the presence of intact buried cultural remains (or designated of moderate or high sensitivity), the FRA will determine in consultation with the appropriate SHPO, what if any additional action is necessary. In areas designated as having low or no potential for the presence of buried archaeological remains (low sensitivity), no additional action is recommended, and the SHPOs comments on these recommendations will be solicited as well.

Under Amtrak's proposal, no substations and transmission lines, switching stations, and parallelling stations areas would be sited and no bridges would be modified in the following communities: New Haven, East Haven, Clinton, East Lyme and the City of Groton, CT; Greenwich and Central Falls, RI; and Mansfield, Canton, Westwood and Dedham, MA. Figures refered to in this section can be found in Appendix A.

7.3.1 Branford, CT

Branford Substation. The Branford substation (Milepost 79.26) is located on the site of a former toll station along Interstate Route 95. The toll station and associated support facilities were removed within the last five years. A visual inspection of the proposed substation site indicates it has been extensively disturbed by activities related to the original construction of the toll station and its subsequent removal. The Branford substation site is therefore not considered to have any potential for prehistoric or historic period archaeological resources.

The proposed 115kv aerial transmission line to the Branford substation originates from an existing 115kv transmission line 1200 feet north of the proposed substation. A 25kv underground feeder will connect the substation to the catenary at the rail line and will run underneath Hosley Avenue to the rail line. The proposed 1200-foot 115kv and 400-foot 25kv feeders generally traverse an upland environment. Neither line impacts a wetland or stream nor runs within 200 meters of a wetland or stream until the termination of the 25kv line at the existing rail line. At this point the 25kv line ends adjacent to a small unnamed stream where it empties into Lake Saltonstall. This area appears to have been disturbed by activities related to the original construction of the rail line. The utility corridors, including both the 115kv and 25kv feeders, is considered to have low to moderate sensitivity with respect to both prehistoric and historic archaeological sites.

The site files of the COSA and the CHC list only two known prehistoric sites in the general vicinity of the Branford project areas. Sites 14-11 and 14-18 are both located along Lake Saltonstall north of the substation. The NECIP report (DC/P 1979a) identified a prehistoric archaeological zone (#141) in the Lake Saltonstall area and three structures of historic importance (#s 142-144) (see Figure 1 in Appendix A). None of these sites will be impacted by the project.

7.3.2 Guilford, CT

Leetes Island Paralleling Station. The proposed location of the Leetes Island paralleling station (Milepost 85.99) appears to have been disturbed, at least surficially, by previous rail and road construction. Tidal marshes and wetlands surround the right-of-way in this area. COSA and CHC site files list two known archaeological sites in the general area (Sites 60-2 and 60-11) (see Figure 2). In addition, the NECIP report (DC/P 1979a) included this area in prehistoric archaeological zone #150 and noted historic structures in the area, none of which will be impacted (see Figure 2). The location of this paralleling station is therefore considered archaeologically sensitive due to the abundance of resources associated with coastal wetland regions and the presence of known sites in the vicinity.

7.3.3 Madison, CT

Madison Paralleling Station. The Madison paralleling station (Milepost 92.41) is located in an area of both prehistoric and historic period archaeological potential. Visual inspection and soil map review indicate the soils outside of the right-of-way are relatively undisturbed. Approximately 10 meters outside of the right-of-way are a well and foundation, suggesting a historic period site in the vicinity. The site files of the COSA and the CHC list no known prehistoric or historic sites in the general vicinity of the Madison paralleling station (see Figure 3). The NECIP report (DC/P 1979a) lists no sites or structures in the immediate vicinity of the station. However, due to nearby wetlands and fresh water ponds there is a high potential for prehistoric archaeological sites in this area. Across the Hammonassett River in Clinton, systematic archaeological survey has revealed a number of sites. The same density of sites can be reasonably expected for the area of the Madison paralleling station.

7.3.4 Westbrook, CT

Grove Beach Paralleling Station. The proposed Grove Beach paralleling station (Milepost 99.11) site has been stripped and is being used for dumping of rock and gravel debris. COSA and CHC site files list several archaeological sites in the Grove Beach station area (see Figure

4). The NECIP report (DC/P 1979a) designated a prehistoric archaeological zone in the area (#183), which is very close to the station, and also noted historic structures in the area, outside of the impact area (see Figure 4). However, the disturbance of the station area probably severely limits the potential for finding intact cultural archaeological materials.

Westbrook Switching Station. The proposed location of the Westbrook switching station (Milepost 103.53) is at the junction of Old Rock Road and the Amtrak right-of-way (Figure 5). This area has been heavily disturbed by railway construction and is therefore unlikely to yield intact archaeological materials. The NECIP report (DC/P 1979a) listed two areas of archaeological importance: prehistoric archaeological zone #199 and historic period zone #198 (see Figure 5). The switching station lies within both zones. COSA and CHC site files list numerous archaeological sites in the general area, but none will be impacted by the switching station construction.

7.3.5 Old Lyme, CT

Johnnycake Hill Road Bridge. The proposed improvements to the Johnnycake Hill Road bridge (Milepost 108.51) intend to minimize deviation from the existing conditions. The immediate area surrounding the bridge is disturbed by rail construction. The Old Lyme Country Club golf course is to the northwest of the bridge. COSA and CHC files list many known sites in the general area, none of which will be directly impacted by the proposed construction (see Figure 6). The NECIP report (DC/P 1979a) designated a five-mile area, which includes this bridge, as prehistoric archaeological zone #210 (see Figure 6). The bridge area is therefore considered to be moderately archaeologically sensitive based on known site information as well as nearby wetland, riverine and coastal resources.

Old Lyme Paralleling Station. The location of the Old Lyme paralleling station (Milepost 109.50) is on a small triangle of land between the right-of-way and Buttonball Road which may have remained undisturbed by previous construction. COSA and CHC site files list a number of archaeological sites in the general area (see Figure 7), none of which will be affected by the proposed station. The NECIP report (DC/P 1979a) included the station area in the five-mile prehistoric archaeological zone #210 (see Figure 7), thus the station area should be considered highly archaeologically sensitive.

7.3.6 Waterford, CT

Millstone Point Road Bridge. The proposed improvements to the Millstone Point Road bridge (Milepost 117.31) will be primarily confined to the bridge superstructure. Prior road, rail and power plant construction has heavily disturbed this area. There is one known archaeological site listed in the COSA and CHC site files near the bridge: Site 152-13, an undated prehistoric site (see Figure 8). The NECIP report (DC/P 1979a) lists areas of both historic archaeological sensitivity (#218) and prehistoric archaeological sensitivity (#219) in the vicinity (see Figure 8). These sites and zones will not be impacted. The bridge area has since been heavily disturbed by construction, thus the proposed bridge improvements are unlikely to impact intact archaeological remains.

<u>Millstone Paralleling Station.</u> The proposed Millstone paralleling station (Milepost 117.56) is located adjacent to an electrical substation for the nuclear power plant. A visual inspection of the location indicated that this area has been heavily disturbed by previous construction activities. The COSA and CHC site files list several prehistoric sites in the vicinity, but none will be impacted by the paralleling station construction (Figure 8). Abundant fresh and saltwater resources probably attracted prehistoric peoples to the project area; however, the power plant construction has, unfortunately, obliterated any archaeological sites in the immediate vicinity of the paralleling station. The NECIP report (DC/P 1979a) identified one prehistoric archaeological zone (#219) and one historic archaeological zone (#218) in the area. Plus, the Niantic River Bridge (#217) was identified as a historic rail structure. None of these zones or structures will be affected by the paralleling station construction. There is little or no potential for encountering intact historic or prehistoric archaeological sites at this location.

7.3.7 New London, CT

<u>New London Substation.</u> The New London substation (Milepost 123.55) is located between several existing rail lines and bridges north of the State Pier, and is an area that has been extensively disturbed by industrial/commercial construction (Figure 9). The potential for encountering intact prehistoric or historic period archaeological resources in the substation area is therefore considered to be low.

The proposed 4800-foot 115kv underground feeder will run from the CL&P Williams Street Substation via existing streets (90%) and the CL&P right-of-way (10%) for a distance of 4800 feet to the substation. Although this line runs underground, previous archaeological investigations in downtown New London (DC/P 1979a) indicated a high potential for historic period archaeological sites in the waterfront area. As a result, the 115kv utility corridor along Fourth Street is considered to have moderate potential with respect to historic period archaeological sites.

The 25kv line to the catenary at the rail line will consist of aerial feeders to the existing rail bridges and submarine cables. These areas have also been extensively disturbed and are considered to have low prehistoric and historic period archaeological sensitivity.

The New London substation and transmission lines are all located within the New London Historic District (#224) (Figure 9), which is listed in the National Register of Historic Places. None of the contributing structures in the district are located immediately adjacent to the proposed substation or transmission lines. The NECIP report (DC/P 1979a) lists numerous structures of historic importance (#s 221-233) and a prehistoric archaeological zone (#220) in the area, and the Connecticut state site files list four historic sites (95-7, 95-8, 95-11, 95-12) (Figure 9). None of these sites or structures will be impacted.

7.3.8 City and Town of Groton, CT

Noank Paralleling Station. The proposed location of the Noank paralleling station (Milepost 129.46) has been severely impacted by rail construction activities. There is a small stream that parallels the right-of-way to the south in addition to the location's proximity to coastal waters. The surrounding area is archaeologically rich due to abundant coastal resources. COSA and CHC site files list many archaeological sites in the area (see Figure 10). However, the severity of the disturbance at the proposed paralleling station location reduces its archaeological sensitivity to low. The NECIP report (DC/P 1979a) listed historic archaeological district #242 (Figure 10), the location of the original Noank settlement, but it is at some distance from the paralleling station and will not be impacted. Two properties on the National Register are listed in the area, but will not be affected by construction of the paralleling station: the Edward Yeoman House (Cove Nook Farm) and the Noank Historic District (Route 215 Noank Peninsula) (Figure 10).

7.3.9 Stonington, CT

Stonington Paralleling Station. The original Stonington paralleling station site (Milepost 134.65) appeared relatively undisturbed and to have the potential for prehistoric archaeological remains due to its close proximity to inland wetlands. The historic period archaeological potential also appeared high because the eastern edge of the paralleling station area nearly abutted the corner of a 19th-century cemetery. As a result, the paralleling station location was shifted to a location near mile post 134.87 to avoid the cemetery. Due to the presence of old stone walls parallel to each side of the right-of-way at this new location, historic period archaeological potential is still high at this site. The Connecticut state site files show no archaeological sites in the immediate area of the Stonington paralleling station; however, fresh and saltwater resources suggest a high potential for prehistoric archaeological sites. The NECIP report (DC/P 1979a) does not address this area (Figure 11).

State Line Parallelling Station. The proposed State Line paralleling station (Milepost 139.93) is located behind the Lehigh Oil Company and appears to have been somewhat disturbed by both rail and commercial construction. However, the NECIP reports (DC/P 1979a and b) list the area as archaeological zone #251, dating from the early historic period (see Figure 12). No other known archaeological sites or structures are listed in the state site files or National Register, but no systematic work has been done in the area.

7.3.10 Westerly, RI

Bradford Paralleling Station. The proposed locations of the Bradford paralleling station (Milepost 145.19) and the accessway are both heavily disturbed by rail construction activity and have very low archaeological potential. RIHPC has recognized the Bradford historic district, to the northeast, and has recommended it for the National Register of Historic Places (see Figure 13). The proposed station construction will have no adverse effect on the district. No other sites or structures are known in the area.

7.3.11 Charlestown, RI

Burdickville Road Bridge. The proposed improvements to the Burdickville Road bridge (Milepost 148.41) include widening the existing roadway to two 10-foot lanes with 6-foot wide paved shoulders. While road and rail construction has previously disturbed this area, significant widening of the existing road may encounter archaeologically sensitive soils. The bridge is in between two areas which were designated as prehistoric archaeological zones (#s 272 and 273) by NECIP (DC/P 1979b) (see Figure 14), and sites have been reported in the area. Although none of these resources will be directly affected, the prehistoric sites and the existence of wetlands and rivers nearby the bridge suggest archaeological sensitivity.

7.3.12 Richmond, RI

Richmond Switching Station. The Richmond switching station (Milepost 150.35) is located on the west bank of the Pawcatuck River near Wood River Junction (see Figure 15). The riverine location would make the area very sensitive were it not for much previous disturbance from railway and industrial development. The NECIP report (DC/P 1979b) identified three prehistoric archaeological zones in the area (#s 273, 275, 277). The Wood River Junction Historic District is to the west, identified by the RIHPC (and by the NECIP report as Site 276) (see Figure 15). The RIHPC site files show archaeological site RI 159 south of the District. Neither the District nor RI 159 will be impacted by the Richmond switching station construction.

Kenyon School Road Bridge. The proposed improvement to the Kenyon School Road bridge (Milepost 154.04) has low potential for disturbing archaeological sites. While there are wetlands flags on each side of the bridge, indicating environmental resources, previous rail, bridge and road construction has adversely impacted any potential for encountering intact archaeological remains. The NECIP report (DC/P 1979b) noted two designated prehistoric archaeological zones (#s 278 and 279) as well as the Narragansett Indian Reservation (#277) in the general vicinity (see Figure 16). Also listed are the Kenyon (#282) and Shannock (#280) Historic Districts and the Kenyon Arch Bridge, which are listed on the National Register of Historic Places (see Figure 16). The bridge is in the Kenyon Historic District.

While none of the above sites or structures will be directly impacted by the proposed improvements and previous construction has disturbed the area immediately adjacent to the bridge, there exists a low potential for encountering archaeological sites if the construction will involve disturbance at any distance from the existing bridge superstructure.

7.3.13 South Kingstown, RI

Kingstown Paralleling Station. The proposed location of the Kingstown paralleling station (Milepost 157.11) lies within the Great Swamp Wildlife Reservation. While the area immediately adjacent to the right-of-way has been disturbed by previous construction, the approximately 80-foot accessway between Great Neck Road and the right-of-way is potentially archaeologically sensitive due to the extensive resources afforded by the surrounding Great Swamp.

RIHPC site files show no known sites for the area. However, the proposed paralleling station location is included in prehistoric archaeological zone 285 in the NECIP report (see Figure 17) (DC/P 1979b). Two sites in the area are on the National Register of Historic Places: the Kingstown Station (#286) and the Ministorial Road Site (RI 781) (see Figure 17). Neither of these listed sites will be impacted by the Kingstown paralleling station.

Rhode Island Route 138 Bridge. The proposed improvements to the Main Street (RI Route 138) bridge (Milepost 158.32) will not disturb any potential archaeological resources due to previous disturbance by rail and lumberyard construction.

There are no known archaeological sites in the vicinity. The nearby Great Swamp area has been designated as a prehistoric archaeological zone (#285) in the NECIP report (DC/P 1979b) (see Figure 17). Several structures of historic importance are in the immediate area, including the National Register-listed Kingstown Railroad Station (#286), and Buildings #287-290, on the State Register, none of which will be impacted by the proposed improvements (Figure 17). In addition, RI 781, the Ministorial Road Site, is on the National Register of Historic Places, but also will not be impacted (see Figure 17).

7.3.14 Exeter, RI

Exeter Paralleling Station. The Exeter paralleling station (Milepost 161.78), previously named the Slocum station, appears to have been heavily disturbed by previous industrial/commercial construction and has virtually no archaeological potential. The site files of the RIHPC do not list any prehistoric sites within or adjacent to the project area. The National Register-listed Slocum House is south of the station and will not be impacted (Figure 18). The station is within a district associated with the Dorsett Mill/Yawgoo Manufacturing Company, which the RIHPC has been asked to consider for nomination to the National Register. The station is also included within the Slocum Agricultural Historic District (#293) identified in the NECIP report (DC/P 1979b) (Figure 18).

7.3.15 North Kingstown, RI

East Greenwich Paralleling Station The proposed location of the East Greenwich paralleling station (Milepost 169.80) has been severely disturbed by previous rail construction. Similarly, the accessway from Austin Road has been completely stripped. Rhode Island Historic Cemetery #4, dating from the early 19th century, is approximately 250 feet south of the proposed paralleling station, adjacent to the right-of-way (Figure 19). The cemetery will not be impacted by the proposed action. No known archaeological sites are listed for the area. Because of the extensive disturbance, the proposed location of this paralleling station is not archaeologically sensitive.

7.3.16 Warwick, RI

Warwick Substation. The Warwick substation (Milepost 176.91) is located between the Amtrak right-of-way and Interstate Route 95. The site files of the RIHPC do not list any known prehistoric or historic period archaeological sites within or immediately adjacent to the project area, but the NECIP report (DC/P 1979b) shows a historic archaeological zone (#329) to the south (see Figure 20); it will not be impacted. The substation site has been severely impacted by both rail and commercial construction. The RIHPC site files show no prehistoric or historic archaeological sites reported in the vicinity. The area is unlikely to yield intact archaeological materials.

Pettaconsett Avenue Bridge. The proposed improvements to the Pettaconsett Avenue bridge (Milepost 178.46) poses no threat to potential archaeological sites as previous rail and industrial construction have disturbed the area. There are no known prehistoric or historic archaeological sites in the area. The NECIP report (DC/P 1979b) listed only one structure of historic importance in the area (#332), the H.C. Budlong House, a mid-19th-century structure approximately 400 feet from the right-of-way (Figure 21). The proposed action poses no threat to this building.

7.3.17 Cranston, RI

Park Avenue Bridge. The proposed improvements to the Park Avenue Bridge (Milepost 180.29) are confined within areas previously disturbed by rail and commercial construction. No known archaeological sites are listed in the area. The NECIP report (DC/P 1979b) lists three structures of historic importance in the area (#s 337-339); however, none will be impacted by the proposed action (see Figure 21).

7.3.18 Providence, RI

Elmwood Paralleling Station. The proposed location of the Elmwood paralleling station (Milepost 181.70) is an abandoned paved lot within 250 feet of Mashapaug Pond. Access to this station is via a paved road and parking lot from the Gorham Plant Complex to Reservoir Avenue (Route 2); access therefore poses no impact to potential archaeological resources. However, the RIHPC considers Mashapaug Pond and adjacent areas to be archaeologically sensitive. The RIHPC site files list a burial discovered at the northern end of Mashapaug (RI 1351) and an undated prehistoric site near the southern end (RI 262) (see Figures 21 and 22). The planned Elmwood paralleling station is therefore considered to be in a moderately to highly archaeologically sensitive area.

In addition, the NECIP report (DC/P 1979b) lists several structures of historic importance in the area, including the Elmwood Station (#363) which has been recommended to the National Register of Historic Places (see Figure 22). The Gorham Manufacturing Company building at 333 Adelaide Avenue was also noted in the NECIP report (#362) (DC/P 1979b) (Figure 22); it has been reviewed by RIHPC and deemed possibly eligible for the National Register of Historic

Places. The Elmwood Historic District, east of the paralleling station, has been recommended for the National Register of Historic Places by the RIHPC (Figure 22). None of these structures or districts will be impacted by the paralleling station.

7.3.19 Pawtucket, RI

Providence Paralleling Station. The Providence paralleling station area (Milepost 187.55) has been extensively disturbed by previous industrial and/or commercial construction; its archaeological potential is very limited. The site files of the RIHPC do not list any known prehistoric or historic period archaeological sites within or immediately adjacent to the project area. The NECIP report (DC/P 1979b) identified several areas of historic industrial archaeological potential in the general vicinity of the project area (Figure 23), but none will be impacted. Due to the disturbance, this area has low potential for archaeological sensitivity.

7.3.20 Attleboro, MA

Attleboro Paralleling Station. The designated Attleboro paralleling station (Milepost 193.40) is located within the southern limits of the city, near the Seekonk corporate boundary (Figure 24). This specific parcel is privately owned and is adjacent to the MBTA/Amtrak right-of-way. The Ten Mile River is located approximately 200 feet east of the proposed parcel.

The Attleboro paralleling station site exhibits a moderate to high sensitivity for the presence of prehistoric cultural resources. Environmental attributes of the project area include location less than 150 meters from the western strand of the Seven Mile River, slope of 0-5%, and a predominantly open field with mixed vegetation. The soils are characteristically sandy, indicating good drainage. Two known prehistoric sites are less than one kilometer from the project area, with numerous sites north and east of this area (see Figure 24). The NECIP report (DC/P 1979c) indicated many historic structures in the area, none of which will be directly impacted. Archaeological potential appears high.

Norton Switching Station. The proposed Norton switching station site (Milepost 198.99) is located adjacent to an existing Massachusetts Bay Transit Authority (MBTA) railroad easement and a Massachusetts Electric right-of-way in Attleboro, Massachusetts (Figure 25). The proposed station site is situated on an upland terrace consisting of well-drained soils associated with the Paxton soil series. The environmental setting in and around the project area, including wetlands, indicates a moderate to high potential for prehistoric and historic period archaeological sites. Although the MHC site files do not list any known prehistoric or historic resources within the project area, a number of archaeological sites, containing a record of more than 7000 years of occupation, have been located by PAL, Inc. in similar environmental settings in Attleboro (Davin and Thorbahn 1983; Davin 1987; Holstein and Davin 1987; Davin and Holstein 1988; Fitts 1988; Gallagher 1989; Davin and Miller 1991; Leveillee 1987; Miller 1992). However, a majority of the substation parcel was found to have been disturbed by removal of large quantities of soil. Intact cultural deposits are not likely; this area has a low potential for archaeological sensitivity.

7.3.21 Foxboro, MA

__East Foxboro Paralleling Station.__ The proposed location for the paralleling station (Milepost 205.70) is just north of the Mansfield town boundary and west of the Sharon town boundary (Figure 26). This parcel of land is situated on private property, and is adjacent to and southeast of the existing MBTA right-of-way.

Amtrak's proposed action for the paralleling station parcel will have an impact on possible subsurface cultural resources. The presence of known prehistoric sites (Figure 26), the location of the Rumford and Canoe Rivers, and the Glue Factory and Beaumont Ponds, are within close proximity to the project area. In addition, the proposed parcel is elevated, with a 0-5% slope, contributing to the areas level of moderate to high archaeological sensitivity. The NECIP report (DC/P 1979c) shows a prehistoric zone in the area (#530) (see Figure 26). This area has high potential for prehistoric cultural resources.

7.3.22 Sharon, MA

__Depot Street Bridge.__ The Depot Street bridge (Milepost 211.04) is to be replaced by Amtrak. Three prehistoric sites have been located in the vicinity of the Depot Street bridge (Figure 27). As with the Maskwonicut Street bridge (below), the closest of the three sites to the Depot Street bridge is the Geissler Farm Site. This multicomponent site dates from the Middle Archaic through to the Late Woodland Periods. In addition, a possible Susquehanna Tradition burial may have been in this area (MHC site files). The remaining two sites (19-NF-59 and 19-NF-60) are situated along the eastern and southern shores of Massapoag Lake, respectively, and are discussed above. Due to extensive ground disturbance in the area, there is low potential for intact buried cultural remains.

__Maskwonicut Street Bridge.__ Amtrak proposes to raise the Maskwonicut Street bridge (Milepost 211.62). Three prehistoric sites have been located in the vicinity of the Maskwonicut Street bridge (Figure 28). The closest of the three sites is the Geissler Farm Site, situated adjacent to Devils Brook and northeast of Massapoag Lake. This multicomponent site dates from the Middle Archaic through to the Late Woodland Periods. Various projectile points (Laurentian, Small-stemmed, Susquehanna, and Orient) were found in this area, from the 1880s through to the early 1900s, by Jacob Geissler. In addition, a possible Susquehanna Tradition burial may have been in this area (MHC site files).

The remaining two sites (19-NF-59 and 19-NF-60) are situated along the eastern and southern shores of Massapoag Lake, respectively. These sites were located in the 1940s by members of the Massachusetts Archaeological Society. There is no detailed information available regarding these sites, although the MHC site files indicate that Site 19-NF-59 was possibly a very large village site. The area around the existing Maskwonicut Street bridge has been severely disturbed and is unlikely to yield intact cultural materials.

Canton Paralleling Station. The Canton paralleling station (Milepost 212.40) is located in the northeastern periphery of the town of Sharon, Massachusetts, near the Canton border (Figure 29). The proposed station is situated within the Massachusetts Bay Transit Authority/AMTRAK railroad easement and right-of-way. A gravel road traverses this parcel. Numerous wetlands, brooks, and ponds are located in close proximity to the switching station location, including the Neponset River, an environmental setting indicating a moderate to high potential for prehistoric archaeological resources. Although the site files at the MHC do not list any known prehistoric or historic period resources within the above-mentioned parcel, many prehistoric sites have been identified in the Canton vicinity which contain evidence of Middle (1600-1000 B.P.) and Late Woodland (1000-450 B.P.) components. Within the Neponset River drainage, the same site areas appeared to have been utilized from the Late Archaic (5000-3000 B.P.) on through to at least the Middle Woodland Periods (see Ritchie 1983, 1984, 1987; Ritchie and Feigher 1990; Davin and Doucette 1993; Edens and Roberts 1991; Carty 1984; Leveillee and Davin 1987; Martin 1977; Parker 1974; Rosser 1980). The station is just outside of a prehistoric zone (#542) designated in the NECIP report (DC/P 1979c) (Figure 29). An inspection of the property, however, indicated much disturbance, with the signs of recent grading and landscaping. Intact archaeological remains are unlikely.

7.3.23 Boston, MA

Readville Paralleling Station. The Readville paralleling station (Milepost 219.10) is within the Hyde Park section of the city, adjacent to the westernmost periphery of the town of Milton (Figure 30). The parcel is entirely on MBTA property and within its right-of-way. The selected site is located adjacent to railroad tracks which are currently abandoned, and has been highly disturbed by major cutting, grading, and filling. Evidence of gravel piles apparently brought in and placed alongside the abandoned tracks was found. Modern trash was dumped in many areas, including the project location. No evidence of possible significant cultural remains were located within or in close proximity to the project area. As a result of the disturbance noted in the walkover inspection, the site has low archaeological sensitivity.

Roxbury Crossing Substation. The Roxbury Crossing substation (Milepost 226.02) (Figure 31) is located in an urban area occupied by several warehouses on MBTA property. Large quantities of building-related debris are on the property. The area appears to have been somewhat disturbed by construction/land modification activities, but historical research suggests a long history of habitation, from the 17th century. Undisturbed historic sites may be present, but currently unaccessible because of the fill. Due to the identification in the NECIP report (DC/P 1979c) identified several historic bridges and structures in the immediate vicinity of the project area, this site is considered moderately sensitive.

The proposed 115kv aerial feeder utility corridor will traverse 300 feet over existing MBTA tracks to the catenary at the Amtrak rail line. This area appears to have been previously disturbed and is considered to have low archaeological potential.

7.4 RESULTS AND CONCLUSIONS

Archaeological surveys of 34 areas to be affected by the NECIP were conducted. These areas included four substation sites (plus associated utility corridors), three switching station sites, 18 paralleling station sites, and nine bridge-modification sites. These sites are in three states: Connecticut, Rhode Island and Massachusetts. In each state the archaeological survey was conducted according to varying state regulations, but the methods and goals of the survey were the same: to assess the archaeological sensitivity of each project site (i.e., each site's potential for containing buried cultural remains) through document research and field inspection. The results of the survey are summarized in Tables 7-4 through 7-7.

Of the four substations and associated utility corridors surveyed, three were found to be archaeologically sensitive. In Connecticut, the Branford substation site was found to have low potential for archaeological remains, but its associated corridor was found to have low to moderate archaeological sensitivity. At the New London substation, archaeological sensitivity was found to be low overall, but high along the Fourth Street portion of the associated corridor. In Rhode Island, the Warwick substation and corridor were both determined to have low potential for yielding archaeological sites. In Massachusetts, the Roxbury Crossing substation in Boston was found to have moderate archaeological potential, but its associated utility corridor is not sensitive.

Of the three switching stations studied, none appear to have the potential for containing intact cultural remains.

Eighteen paralleling station sites were studied; nine were found to be archaeologically sensitive. These sensitive stations include the Leetes Island, Madison, Old Lyme, Stonington and State Line stations in Guilford, Madison, Old Lyme and Stonington, Connecticut, respectively. In Rhode Island, the sensitive stations include Kingstown and Elmwood in South Kingstown and Providence. The Attleboro and East Foxboro paralleling stations in Attleboro and Foxboro, Massachusetts, are also sensitive.

Of the nine bridge-modification areas, only three were suspected of having moderate or high archaeological potential. These include the Johnnycake Hill Road bridge in Old Lyme, Connecticut, and the Burdickville Road and Kenyon School Road bridges in Rhode Island.

REFERENCES

Anthony, David, Frederick Carty and Linda Towle 1980. State Reconnaissance Survey Interim Report. Massachusetts Historical Commission, Boston, MA.

Barber, Russell 1979. A Summary of Cultural Resource Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras, Volume II, Archaeology and Paleontology. Institute for Conservation Archaeology, Peabody Museum, Harvard University, Cambridge, MA.

Barfield, Thomas and Russell Barber 1982. The Amphitheater Site: A Late Archaic Settlement in Watertown, Massachusetts. Institute for Conservation Archaeology, Harvard University, Cambridge, MA.

Bernstein, David 1987. Prehistoric Subsistence at Greenwich Cove, Rhode Island. Unpublished Ph.D. dissertation, Department of Anthropology, State University of New York at Binghamton.

Braun, David 1974. Explanatory Models for the Evolution of Coastal Adaptation in Prehistoric Eastern New England. American Antiquity 39: 582-596.

Butler, E. 1946. The Brush or Stone Memorial Heaps of Southern New England. ASCB 19: 3-12. New Haven, CT.

Cameron, Barry editor. Geology of Southeastern New England. Department of Geology, Boston University, Boston, MA.

Coffin, Claude 1937. A Prehistoric Shell Heap at the Mouth of the Housatonic. ASCB 5: 10-19.

Coffin, Claude 1938. An Indian Village at Cedar Ridge, Upper White Hills, Shelton, Connecticut. ASCB 7: 9-11.

Coffin, Claude 1940. Excavations in Southwest Connecticut. ASCB 10: 33-50.

Coffin, Claude 1946. Final Work at the Eagle Hill Site 1937-43. ASCB 19: 18-36.

Coffin, Claude 1951. The Eagle Hill Ridge Site - Laurel Beach, Milford. ASCB 25: 25-54.

Curran, Mary Lou and Dena Dincauze 1977. Paleo-Indians and Paleo-Lakes: New Data from the Drainage. Amerinds and their Paleoenvironments in Northeastern North America, edited by W.S. Newman and B. Salwen, pp. 333-348. New York Academy of Sciences, NY, NY.

Davin, Ann 1985. Archaeological Investigations at the Bouchard Site (RI 1025) Usquepaug, Rhode Island. The Public Archaeology Laboratory, Inc. Report No. 54-1. Submitted to Farmers Home Administration, Amherst, MA.

Davin, Ann 1987. Intensive Archaeological Survey of the Locust Valley Country Club Project Area, Attleboro, Massachusetts. The Public Archaeology Laboratory, Inc. Report No. 157. Submitted to the Fafard Companies, Ashland, MA.

Davin, Ann and Beth Miller 1991. Results of the Site Examination of the Knoll I Site, Orr's Pond Rehabilitation Project Area, Attleboro, Massachusetts. The Public Archaeology Laboratory, Inc. Report No. 356. Submitted to Camp, Dresser and McKee, Inc., Cambridge, MA.

DeLeuw, Cather/Parsons 1979a. Northeast Corridor Improvement Project Task 110: Historic and Archaeological Resources of the Northeast Corridor: Connecticut. Prepared for the US Department of Transportation. Washington: DeLeuw, Cather/Parsons.

DC/P 1979b. Northeast Corridor Improvement Project Task 110: Historic and Archaeological Resources of the Northeast Corridor: Rhode Island. Prepared for the US Department of Transportation. Washington: DeLeuw, Cather/Parsons.

DC/P 1979c. Northeast Corridor Improvement Project Task 110: Historical and Archaeological Resources of the Northeast Corridor: Massachusetts. Prepared for the US Department of Transportation. Washington: DeLeuw, Cather/Parsons.

Dincauze, Dena 1968. Cremation Cemeteries in Eastern Massachusetts. Papers of the Peabody Museum of Archaeology and Ethnology, Harvard University, Vol. 59, No. 1. Peabody Museum, Cambridge, MA.

Dincauze, Dena 1973. Prehistoric Occupation of the Charles River Estuary: A Paleographic Study. Archaeological Society of Connecticut Bulletin 38: 25-39.

Dincauze, Dena 1974. An Introduction to the Archaeology of the Greater Boston Area. Archaeology of Eastern North America 2(11): 39-67.

Dincauze, Dena 1975. The Late Archaic Period in Southern New England. Arctic Anthropology 12(2): 3-14.

Dincauze, Dena and Mitchell Mulholland 1977. Early and Middle Archaic Site Distributions and Habitats in Southern New England. Amerinds and Their Paleoenvironments, edited by W.S. Newman and B. Salwen. Annals of the New York Academy of Sciences 288: 439-456.

Dragoo, Don 1976. Some Aspects of Eastern North American Prehistory: A Review 1975. American Antiquity 41: 3-27.

Fowler, William 1954. Rhode Island Prehistory at the Green Point Site. Bulletin of the Massachusetts Archaeological Society 15(4): 66-97.

Fowler, William 1956. Sweet Meadow Brook, A Pottery Site in Rhode Island. Bulletin of the Massachusetts Archaeological Society 18: 1-23.

Fowler, William 1962. Rattlesnake Rockshelter. Bulletin of the Massachusetts Archaeological Society 24(1).

Fowler, William 1964. A Birdstone Recovery in Rhode Island. Bulletin of the Massachusetts Archaeological Society 26: 37-43.

Fowler, William 1967. Oaklawn Quarry: Stone Bowl and Pipe Making. Bulletin of the Massachusetts Archaeological Society 26: 39-43.

Fowler, William 1968. Archaic Discoveries at Flat River. Bulletin of the Massachusetts Archaeological Society 29(2).

Fowler, William 1976. A Rare Pipe Discovery. Bulletin of the Massachusetts Archaeological Society 37(3-4): 42-45.

Funk, Robert 1972. Early Man in the Northeast and the Late Glacial Environment. Man in the Northeast 4: 7-39.

Gibson, Susan editor 1980. Burr's Hill, a 17th-Century Wampanoag Burial Ground in Warren, Rhode Island. Haffenreffer Museum of Anthropology, Brown University, Providence, RI.

Glover, Suzanne 1990. Report of Phase I Archaeological Reconnaissance Survey of the Greenbriar Riding Club in Ledyard, Connecticut. Pawtucket: PAL, Inc. Prepared for Daystar Development Company.

Glynn, F. 1953. The Pilot's Point Submerged Sites. ASCB 27: 11-29.

Griffin, J. 1946. Cultural Change and Continuity in Archaeology. Man in Northeastern North America. Papers of the R.S. Peabody Foundation for Archaeology, Col. 3. Andover, MA.

Grimes, John, W. Eldridge, B.G. Grimes, A. Vaccaro, F. Vaccaro, J. Vaccaro, N. Vaccaro, and A. Orsini 1984. Bull Brook II. Archaeology of Eastern North America 12: 159-183.

Jones, Donna and Nancy Seasholes 1988. Intensive Archaeological Survey of Spectacle Island in Boston Harbor. Office of Public Archaeology, Boston University, Boston, MA.

Juli, Harold 1981. An Archaeological Survey of the Thames River Valley, New London County: A Descriptive Report for Study and Preservation of the Prehistoric Cultural Heritage of Southeastern Connecticut. Connecticut Historical Commission Survey and Planning Grant-in-Aid. On file at the Connecticut Historical Commission, Hartford, CT.

Kerber, Jordan 1984. Prehistoric Human Occupation and Changing Environment of Potowomut Neck, Warwick, Rhode Island: An Interdisciplinary Approach. Unpublished Ph.D. dissertation, Department of Anthropology, Brown University, Providence, RI.

Kerber, Jordan and Takeshi Ueki 1981. Prehistoric Site Verification in the Coastal Zone: The East Side of Narragansett Bay, Rhode Island. Ms. on file at the Rhode Island Historical Preservation Commission, Providence, RI.

Lavin, Lucianne 1988. Coastal Adaptations in Southern New England and Southern New York. Archaeology of Eastern North America 16: 101-120. Dennis Curry, editor.

Leveillee, Alan and Duncan Ritchie 1982. Site Examination of the Site #16 within the Hale Reservation, Dover, Massachusetts. The Public Archaeology Laboratory, Department of Anthropology, Brown University, Providence, Rhode Island. Submitted to Boston Edison Company, Boston, MA.

Leveillee, Alan and Peter Thorbahn 1984. An Archaeological Assessment of the Sakonnet River. The Public Archaeology Laboratory, Inc. Report No. 46. Submitted to the Rhode Island Historic Preservation Commission, Providence, RI.

Leveillee, Alan and Renee Van Couyghen 1990. The Hoskins Park and South Wind Sites: A Program of Archaeological Data Recovery in Rhode Island's Coastal Zone. The Public Archaeology Laboratory, Inc. Report No. 163-1. On file at The Public Archaeology Laboratory, Inc, Pawtucket, RI.

Leveillee, Alan and Renee Van Couyghen 1991. An Environmental and Cultural Context for Prehistoric Utilization of the Narragansett Bay Area. Pawtucket: PAL, Inc. Occasional Papers of the Education Department, #2.

Loparto, Leonard, Steven Mrozowski and Peter Thorbahn 1977. Archaeological Evaluations of the Kickamuit Springs Site, Warren, Bristol County, Rhode Island. Public Archaeology Laboratory, Brown University Report. Submitted to the town of Warren, RI.

Lord, Arthur 1962. The Hawes Site: A Burial Stone Bowl Complex. Bulletin of the Massachusetts Archaeological Society 23(3-4): 21-23.

Luedtke, Barbara 1975. Final Report on the Archaeological and Paleobotanical Resources of the Twelve Islands in Boston Harbor. Submitted to Massachusetts Department of Environmental Management, Boston, MA.

Luedtke, B. 1980. The Calf Island and the Late Prehistoric Period in Boston Harbor. Man in the Northeast 20: 25-76.

Luedtke, B. 1984. Preliminary Report on an Archaeological Survey of the Southern Half of Long Island, Massachusetts. University of Massachusetts, Boston, MA.

Massachusetts Historical Commission 1982. Historic and Archaeological Resources of the Boston Area: A Framework for Preservation Decisions. Massachusetts Historical Commission, Boston, MA.

McBride, Kevin 1984A. Middle and Late Archaic Periods in the Connecticut River Valley: A Re-examination. Archaeological Society Bulletin 47: 55-71.

McBride, Kevin 1984B. Prehistory of the Lower Connecticut River Valley. Ph.D. dissertation, University of Connecticut, Storrs, CT.

McBride, Kevin 1990. The Historical Archaeology of the Mashantucket Pequots, 1637-1900: A Preliminary Analysis. The Pequots in Southern New England - The Rise and Fall of an American Indian Nation, Lawrence Hauptman and James Wherry, editors. University of Oklahoma Press: Norman, OK.

McBride, Kevin and Robert Dewar 1987. Agriculture and Cultural Evolution: Causes and effects in the Lower Connecticut River Valley. In Emergent Horticultural Economies of the Eastern Woodlands, W. Keenan, editor. Center for Archaeological Investigations: 305-328. Carbondale, Illinois (with Robert Dewar).

McBride, Kevin and Mary Soulsby 1989. Prehistory of Eastern Connecticut: Phase I, II and III Archaeological Surveys of the Relocation of Route 6/I-84 Project. Prepared for CONNDOT. Storrs, CT: PAST, Inc.

McBride, Kevin, William Wadleigh, Robert Dewar and Mary Soulsby 1980. Prehistoric Settlement in Eastern Connecticut: The North-Central Lowlands and Northeastern Highlands Surveys: 1979. Archaeological Research Monograph No. 15. University of Connecticut, Storrs, CT.

McMaster, Robert 1983. A 9,000 Year View of Narragansett Bay. Maritimes 27: 7-10.

Moeller, Roger 1980. 6-LF-21, A Paleo-Indian Site in Western Connecticut. American Indian Archaeological Institute Occasional Paper No. 2.

Morenon, Pierre 1988. Management Memorandum: An Archaeological Study of the Harding Estates in Bristol, Rhode Island: Results from a Phase I through Phase III Study. Occasional Papers in Archaeology #48, Public Archaeology Program, Department of Anthropology, Rhode Island College, Providence, RI.

Mowchan, Denise 1987. A Phase I Archaeological Survey of the Johannis Property, Barrington, Rhode Island. The Public Archaeology Laboratory, Inc. Report No. 177. Submitted to Robert E. Johannis, Barrington, RI.

Mowchan, Denise 1989 Investigations of the Blaeser Property, Barrington, Rhode Island. Ms. on file at The Public Archaeology Laboratory, Inc., Pawtucket, RI.

Mulholland, Mitchell 1988. Territoriality and Horticulture: A Perspective for Prehistoric Southern New England. Holocene Human Ecology in Northeastern North America, edited by George Nicholas, pp. 137-164. NY: Plenum Press.

Munro, Wilfred 1880. The History of Bristol, Rhode Island, A Story of the Mount Hope Lands. J.A. and R.A. Reid Printers and Publishers. Providence, RI.

Nicholas, George 1988. Ecological Leveling: The Archaeology and Environmental Dynamics of Early Postglacial Land Use. Holocene Ecology in Northeastern North America, edited by George Nicholas, pp. 257-296. NY: Plenum Press.

Olsen, Stephen, Donald Robadue and Virginia Lee 1980. An Interpretive Atlas of Narragansett Bay. Marine Bulletin 40. Coastal Resources Center, University of Rhode Island, Kingstown, RI.

Pagoulatos, Peter 1986. Terminal Archaic Settlement and Subsistence in the Connecticut River Valley. Ph.D. dissertation, Department of Anthropology, University of Connecticut, Storrs, CT.

Pagoulatos, Peter and Duncan Ritchie 1987. Phase II Archaeological Survey Kettle Point Project, East Providence, Rhode Island. The Public Archaeology Laboratory, Inc. Report No. 149. Submitted to Transcontinental Development Corporation, Boston, MA.

Pfeiffer, John 1983. Preliminary Reports: Chadwick, Murdock, Broeder and Tolle Road Sites. Occasional Papers in Northeastern Anthropology.

Praus, Alexis 1942. Excavations at the Old Lyme Shell Heap. ASCB 13: 3-66.

Public Archaeology Laboratory, Inc. 1989. Management Summary/Compilation Memorandum Site Examinations on Three Sites (19-NF-98, 19-NF-140, 19-NF-158) within the Gill Farm Archaeological District, Randolph, Massachusetts. Submitted to Gill Farm Realty Trust, Marshfield, MA.

Public Archaeology Survey Team, Inc. 1987. Report: FY 1987 Historic Restoration Fund Grant. Storrs, CT: PAST, Inc. Prepared for the Connecticut Historical Commission and the Mashantucket Pequot Tribe.

Rainey, Mary Lynne and Deborah Cox in press . A Data Recovery Program for the Seekonk 2 and Seekonk 3 Prehistoric Sites. The Public Archaeology Laboratory, Inc. Report. Submitted to Algonquin Gas Transmission Company, Boston, MA.

Rainey, Mary Lynne and Duncan Ritchie 1992. Supplemental Phase II Site Examinations of the Walker Point Site (RI 653), East Providence Industrial Highway Project, East Providence, Rhode Island. The Public Archaeology Laboratory, Inc. Report No. 459. Submitted to Maguire Group and the Rhode Island Department of Transportation, Providence, RI.

Rhode Island Historical Preservation Commission 1981. Historic and Architectural Resources of Charlestown, Rhode Island: A Preliminary Survey Report. The Rhode Island Historical Preservation Commission, Providence.

Rider, Sidney 1904. The Lands of Rhode Island as They Were Known to Caunounicus and Miantunnomu When Roger Williams Came in 1636. An Indian Map of the Principal Locations Known to the Nahigansetts and Elaborate Historical Notes. Providence, RI.

Ritchie, Duncan 1980. Prehistoric Cultural Resources in the Suburban Fringe: A Preliminary Assessment of the Sudbury/Assabet Drainage. Widening Horizons, edited by C. Hoffman, Attleboro, MA.

Ritchie, Duncan 1983. A Review of Past and Current Research in the Sudbury/Assabet River Drainage. Man in the Northeast 23: 83-93.

Ritchie, Duncan 1986. Management Summary, Phase I Archaeological Survey of the Big River Reservoir. Archaeological Laboratory, Inc. Submitted to Ronald M. Ash Associates, Inc., Pawtucket, RI.

Ritchie, Duncan 1987. Site Clearance Memorandum, Archaeological Data Recovery Program, Town Dock Pottery Prehistoric Component, Central Artery North Reconstruction Project, Charlestown, Massachusetts. The Public Archaeology Laboratory, Inc. Submitted to Massachusetts Department of Public Works, Boston, MA.

Ritchie, Duncan and Joan Gallagher 1984. Intensive Level Archaeological Survey of the Hariu Cranberry Bog, Plympton, Massachusetts. The Public Archaeology Laboratory, Inc. Report No. 49. Submitted to Gilmore Associates, South Carver, MA.

Ritchie, William 1969. The Archaeology of New York State. Revised edition. The Natural History Press, Garden City, NY.

Ritchie, William 1971. A Typology and Nomenclature for New York Projectile Points. Revised edition. New York State Museum and Science Service Bulletin 384, Albany, NY.

Russell, Lyent 1942. The Menunketisuck Site, Westbrook, Connecticut. ASCB 14: 4-57.

Salwen, Bert 1966. European Trade Goods and the Chronology of the Fort Shantok Site. ASCB 34.

Salwen, Bert and Ann Ottesen 1972. Radiocarbon Dates for a Windsor Occupation at the Shantok Cove Site. Man in the Northeast 3: 8-19.

Simon, Brona and Joan Gallagher 1981. Phase I Archaeological Survey of the East Providence Industrial Highway. The Public Archaeology Laboratory, Department of Anthropology, Brown University, Providence, RI. Submitted to CE Maguire, Inc., Providence, RI.

Shaw, Leslie 1984. Archaeological Survey and Testing on Thompson Island, Boston Harbor: The 1983 Field Season. Ms. on file at the Thompson Island Education Center, Boston, MA.

Simmons, William 1970. Cautantowwit's House. Brown University Press, Providence, RI.

Snow, Dean 1980. The Archaeology of New England. Academic Press, NY.

Soulsby, Mary, Robert Gradie and Kevin McBride 1981. Phase II Archaeological Survey, U.S. Navy Housing Project, Groton, Connecticut. Public Archaeology Survey Team, Inc. Submitted to the U.S. Department of the Navy. On file at the Connecticut Historical Commission, Hartford, CT.

Sweetser, M.F. 1883. King's Handbook of Boston Harbor. Moses King, Cambridge, MA.

Thorbahn, Peter 1982. The Prehistoric Settlement Systems in Southern New England. Final Report of the Interstate Highway 495 Archaeological Data Recovery Program, Volume 1. Department of Anthropology, Brown University, Providence, RI.

Turnbaugh, Sarah and William Turnbaugh 1980. Rhode Island's Prehistoric Past. University of Rhode Island, Kingstown, RI.

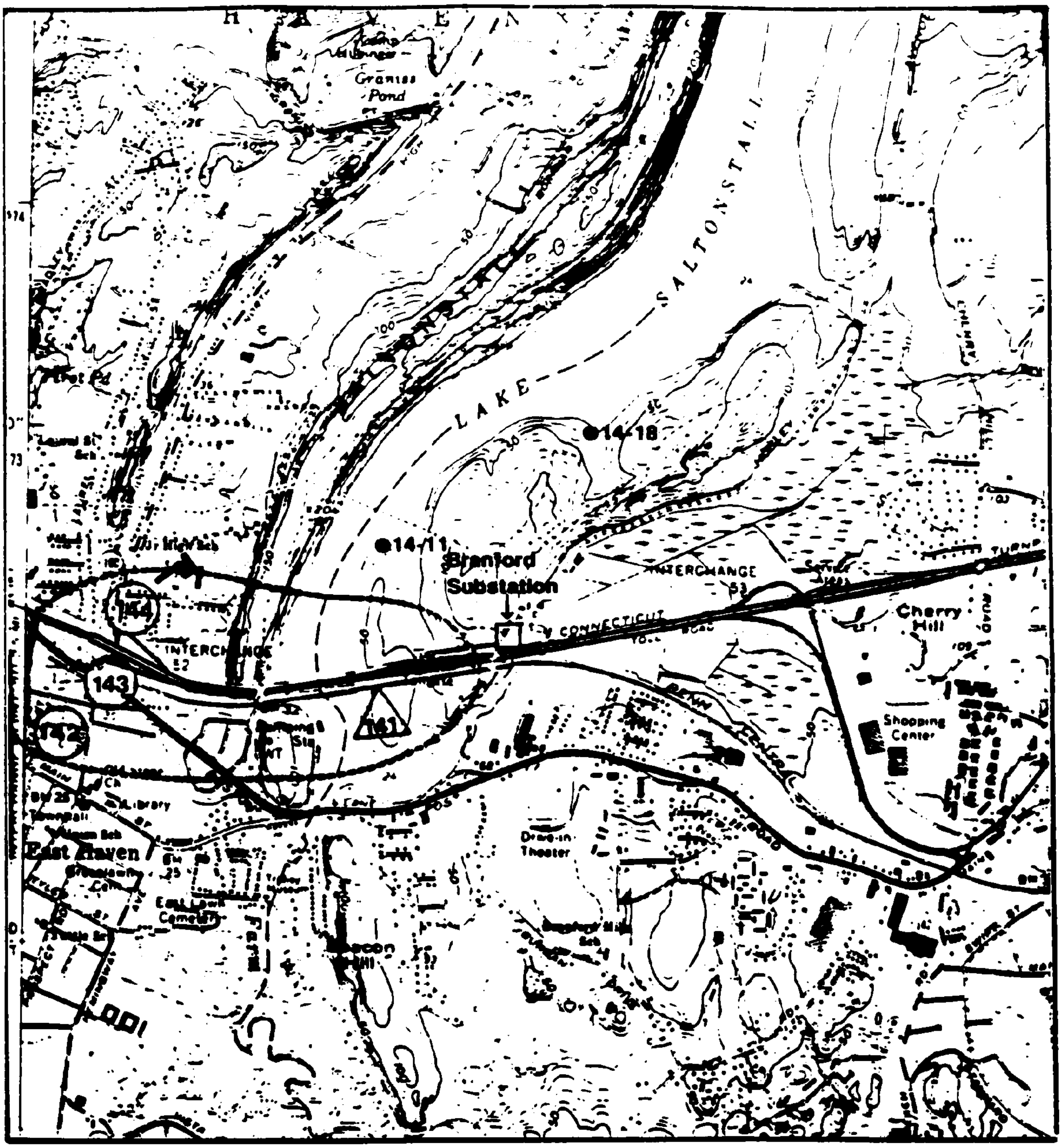
Van Couyghen, Renee and Alan Leveillee 1988. A Phase I Intensive Archaeological Survey of the Wickford Condominium Project Area, North Kingstown, Rhode Island. The Public Archaeology Laboratory, Inc. Report No. 169. Submitted to Marshall Realty Co., Wickford, RI.

Wilbur Smith and Associates 1984. Phase II Archaeological Investigations Part I: Prehistoric Sites, Route 6 Upgrade EIS. Prepared for the Rhode Island Department of Transportation, Providence, RI.

Williams, Lorraine 1972. Fort Shantok and Fort Corchaug: A Comparative Study of 17th Century Culture Contact in the Long Island Sound Area. Ph.D. dissertation. New York University.

Willoughby, Charles 1935. Antiquities of the New England Indians. Peabody Museum, Cambridge, MA.

APPENDIX A
Figures



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: BRANFORD, CT

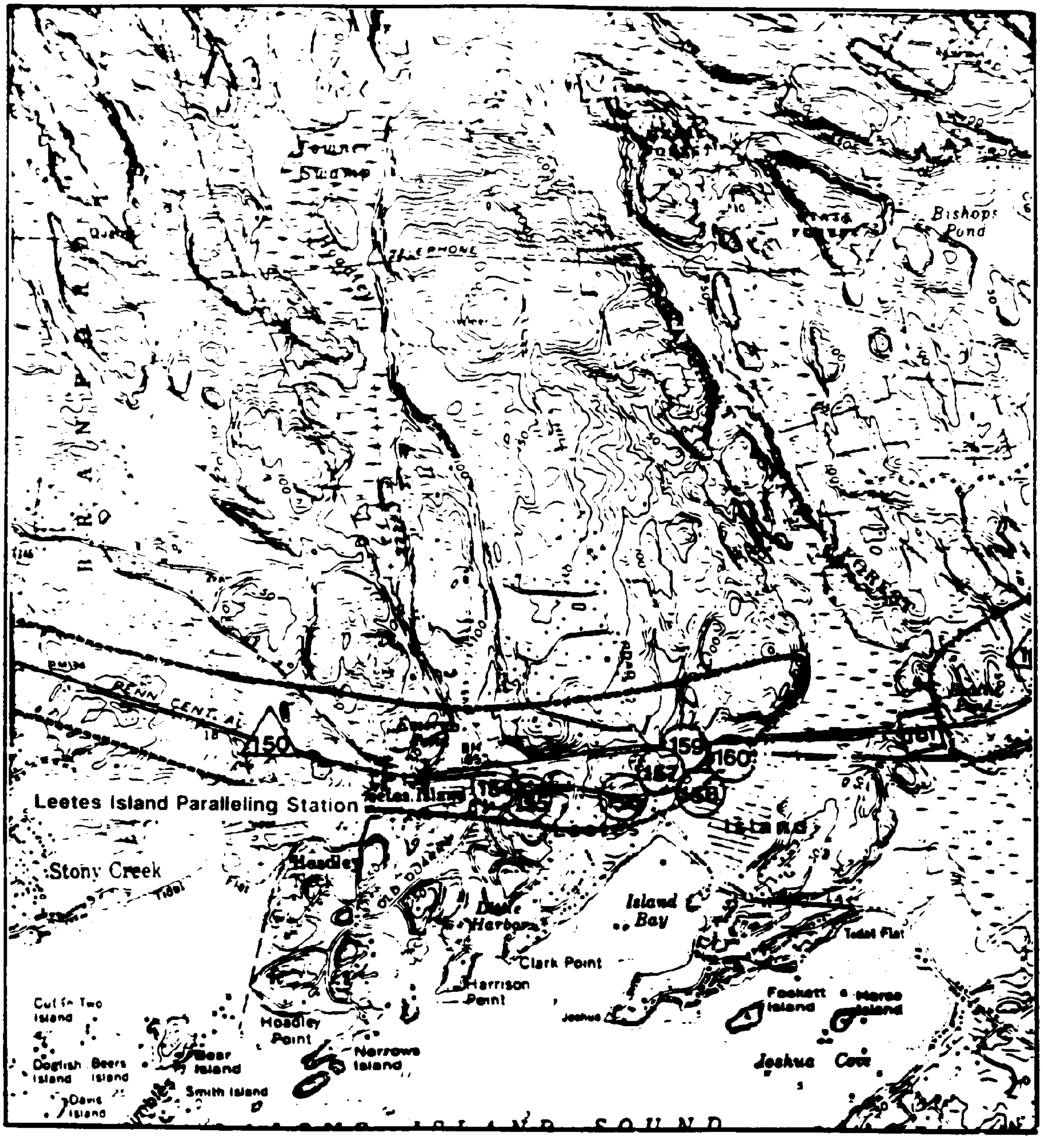
SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 1

From, DeLeuw, Cather/Parsons 1979 A

Cultural Resources



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: GUILFORD, CT

SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 2

From DeLeuw, Cather/Parsons 1979 A

Cultural Resources

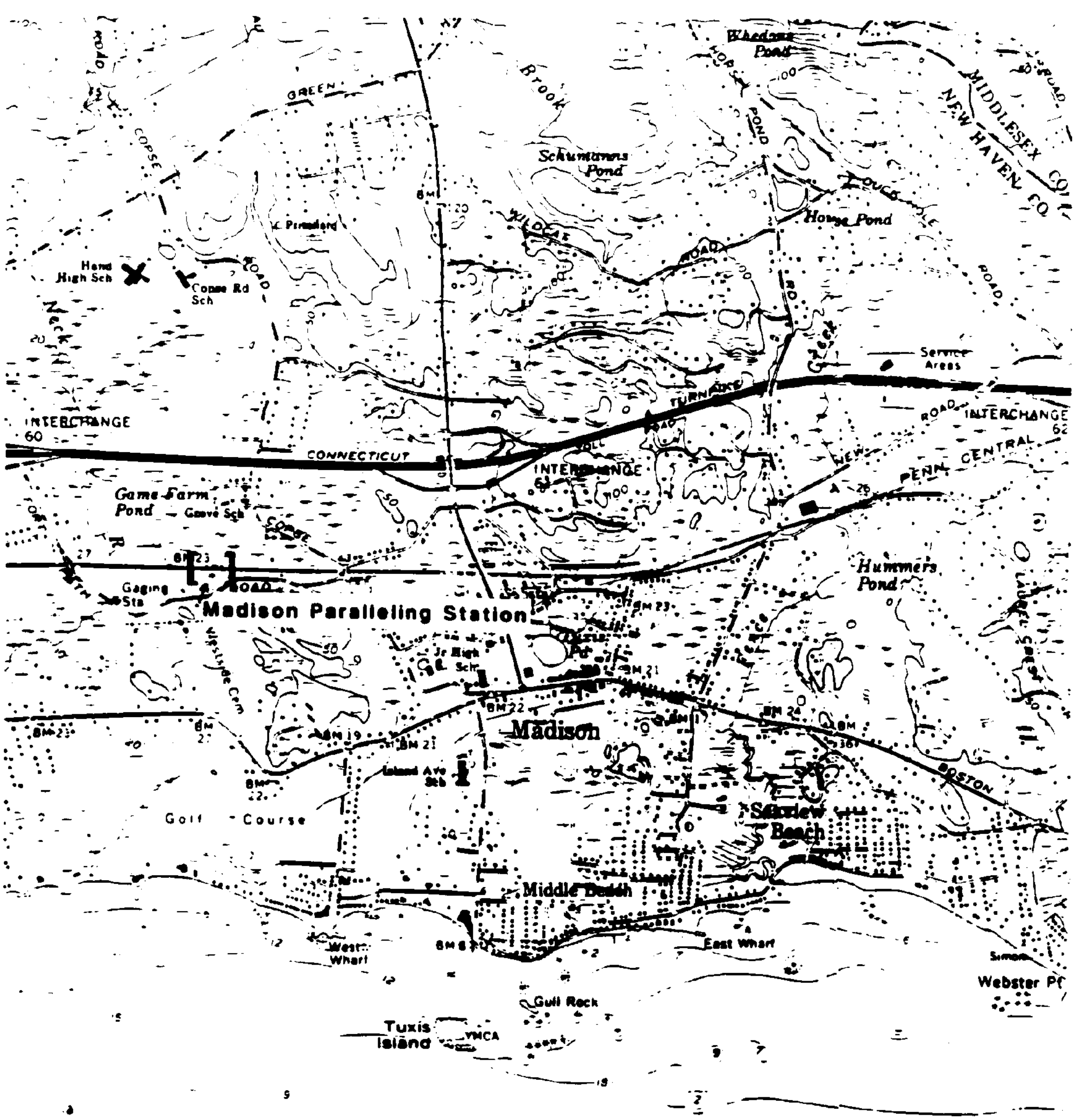
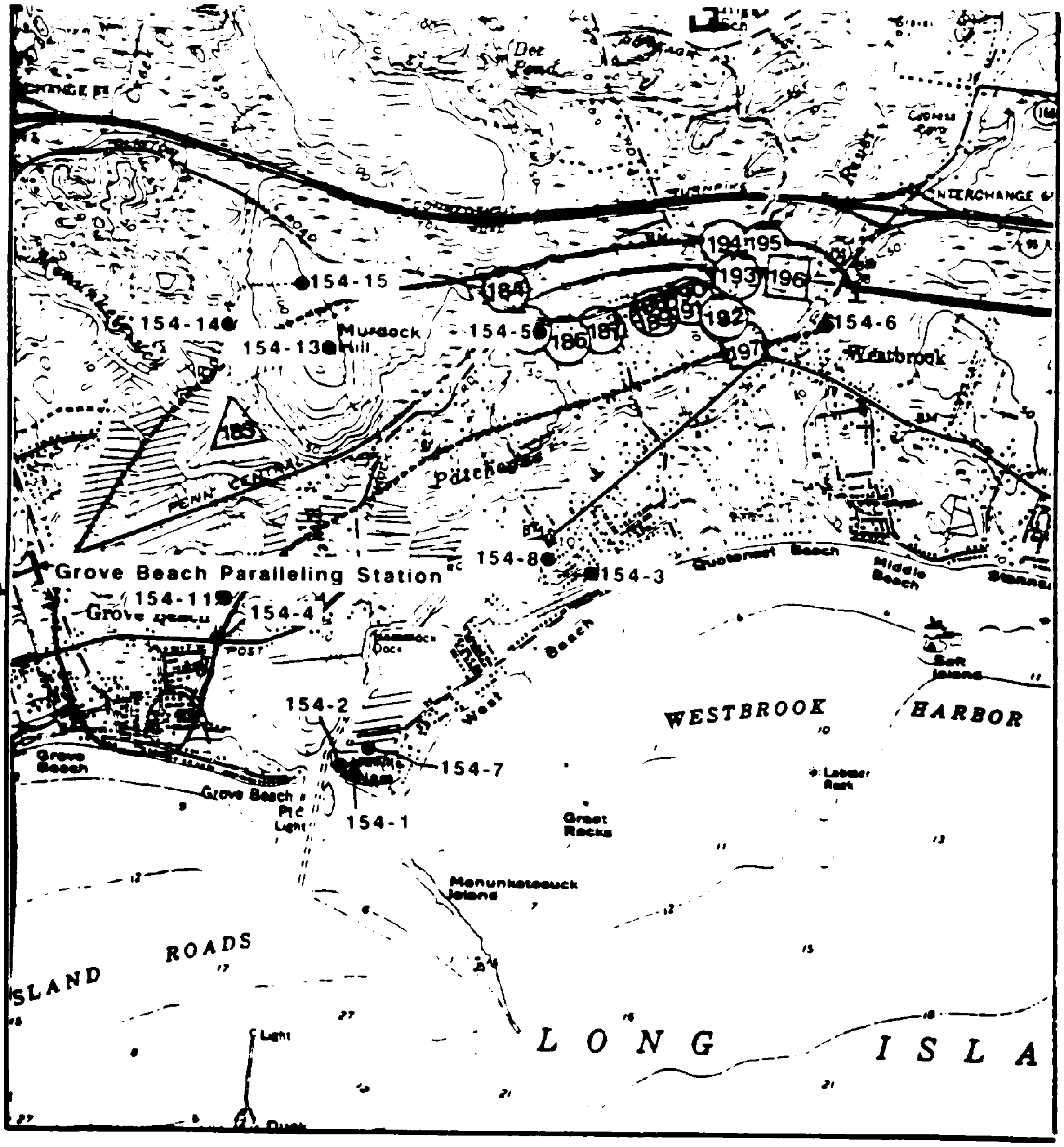


FIGURE 3

USGS Topographic Map
Clinton Quadrangle

N



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: ESSEX, CT

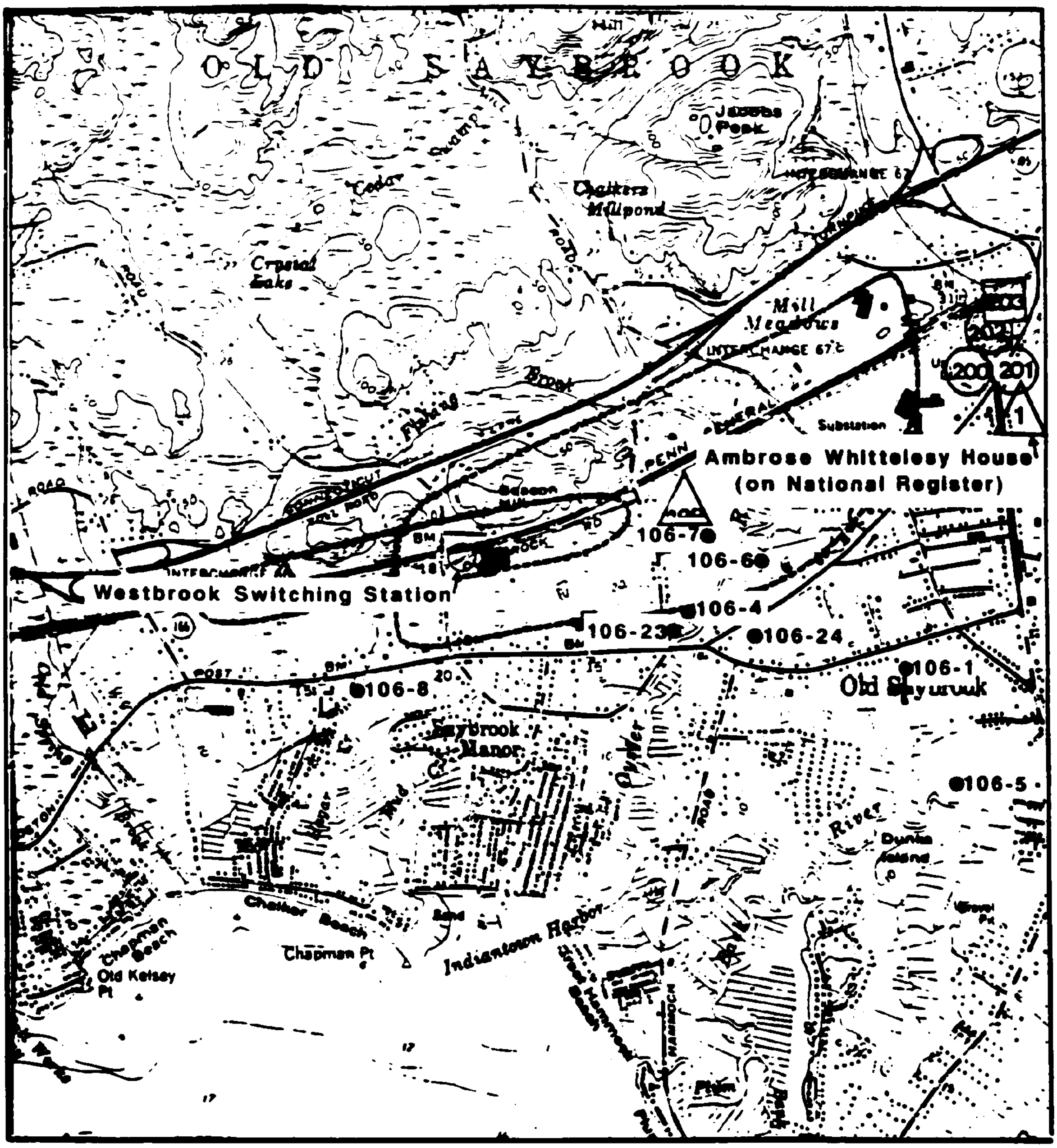
SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 4

From DeLeuw, Cather/Parsons 1979 A

Cultural Resources



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: ESSEX, CT

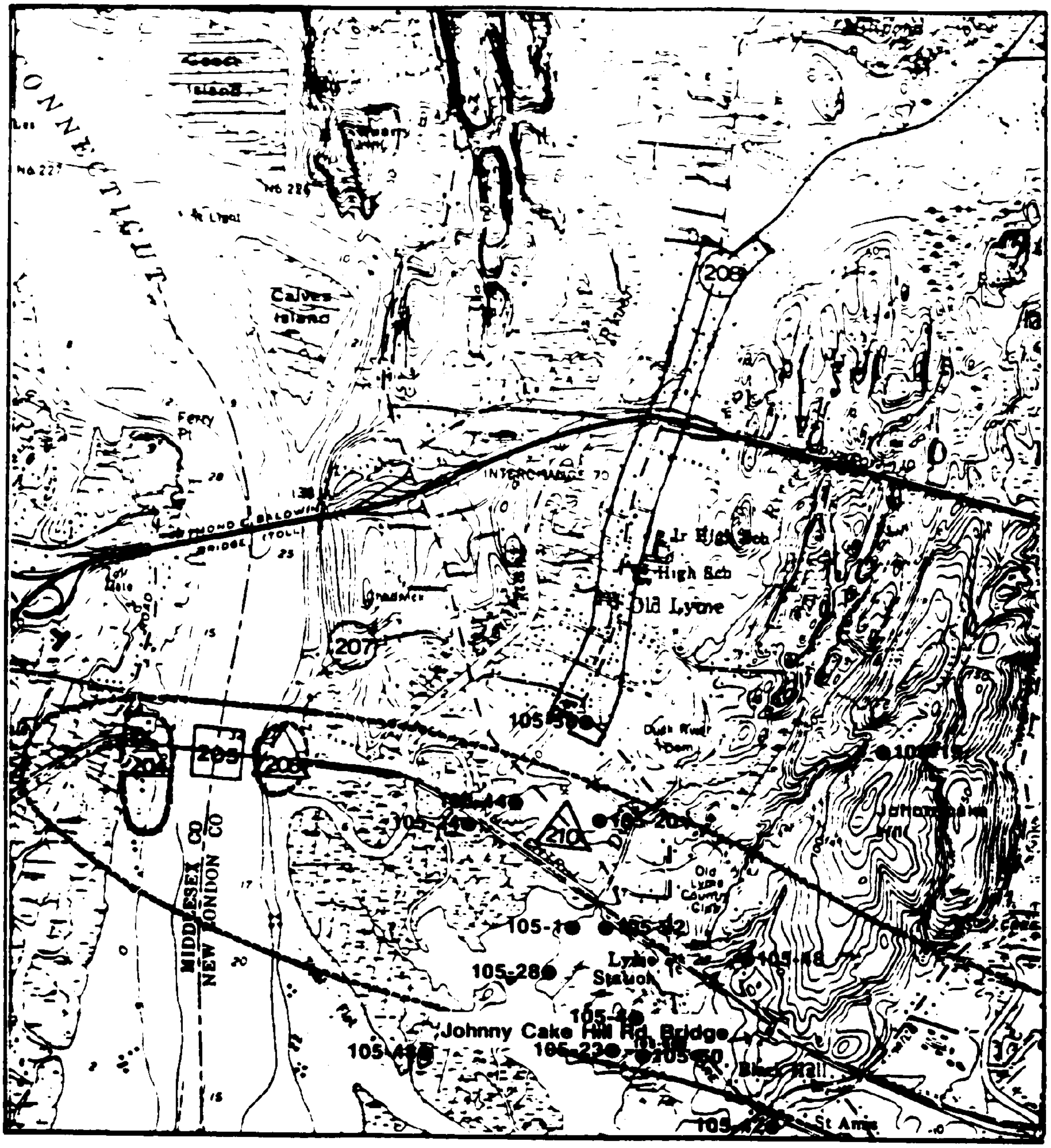
SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 5

From DeLeuw, Cather/Parsons 1979 A

Cultural Resources



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: OLD LYME, CT

SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 6

From DeLeuw, Cather/Parsons 1979 A

Cultural Resources

LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: OLD LYME, CT

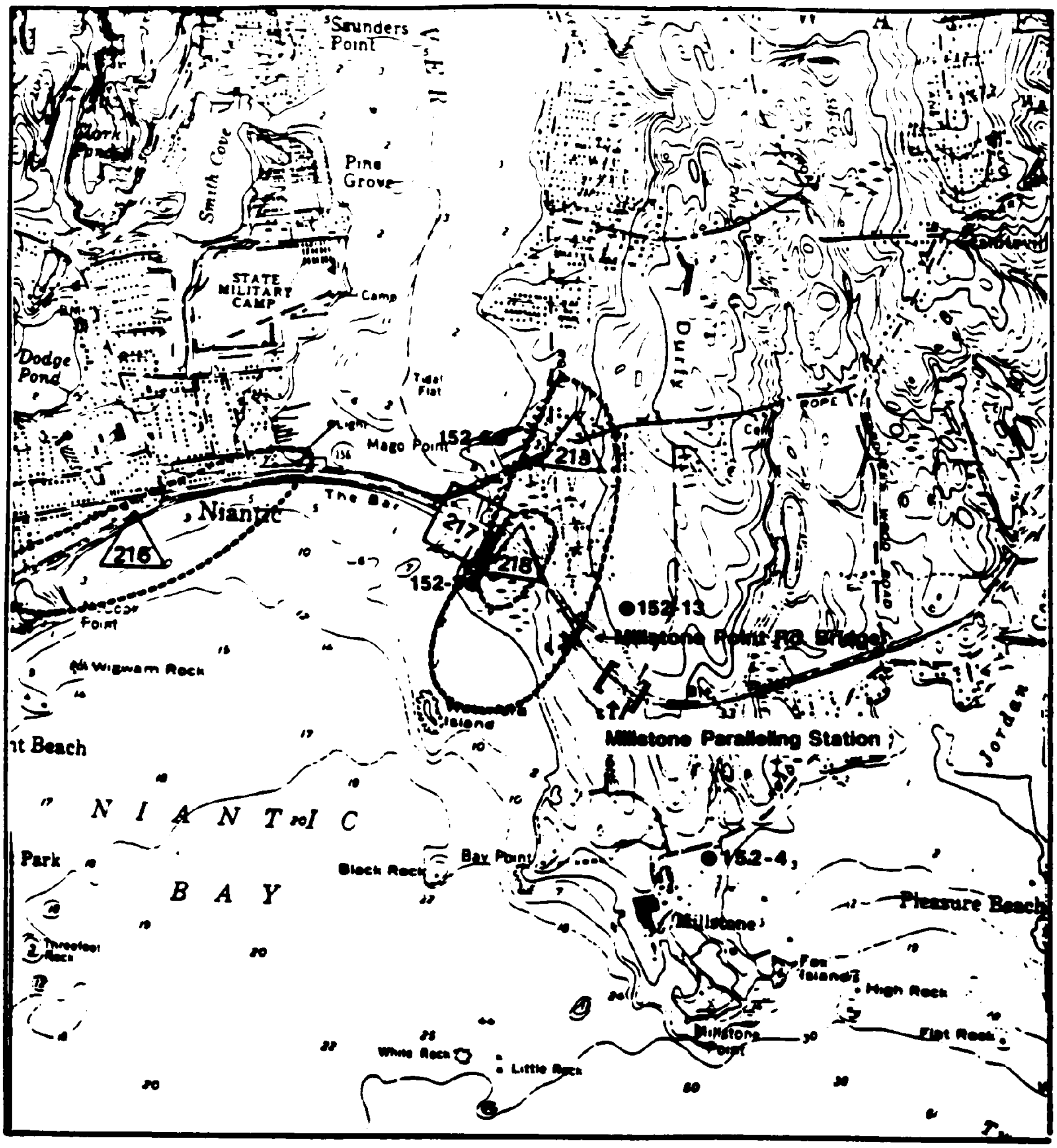
SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 7

From DeLeuw, Cather/Parsons 1979 A

Cultural Resources



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: NIANTIC, CT

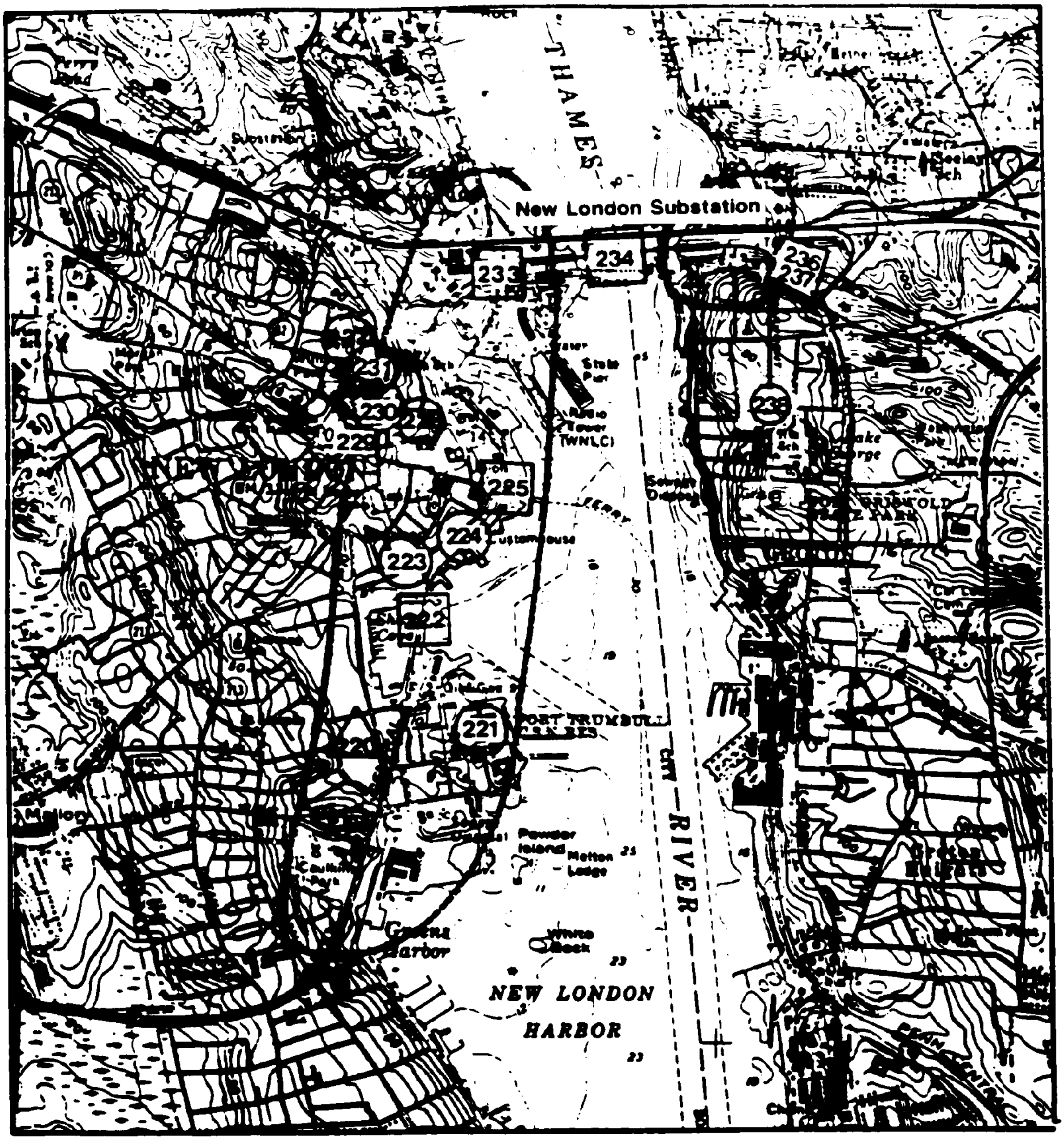
SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 8

From DeLeuw, Cather/Parsons 1979 A

Cultural Resources



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: NEW LONDON, CT

SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 9

From, DeLeuw, Cather/Parsons 1979 A

Cultural Resources

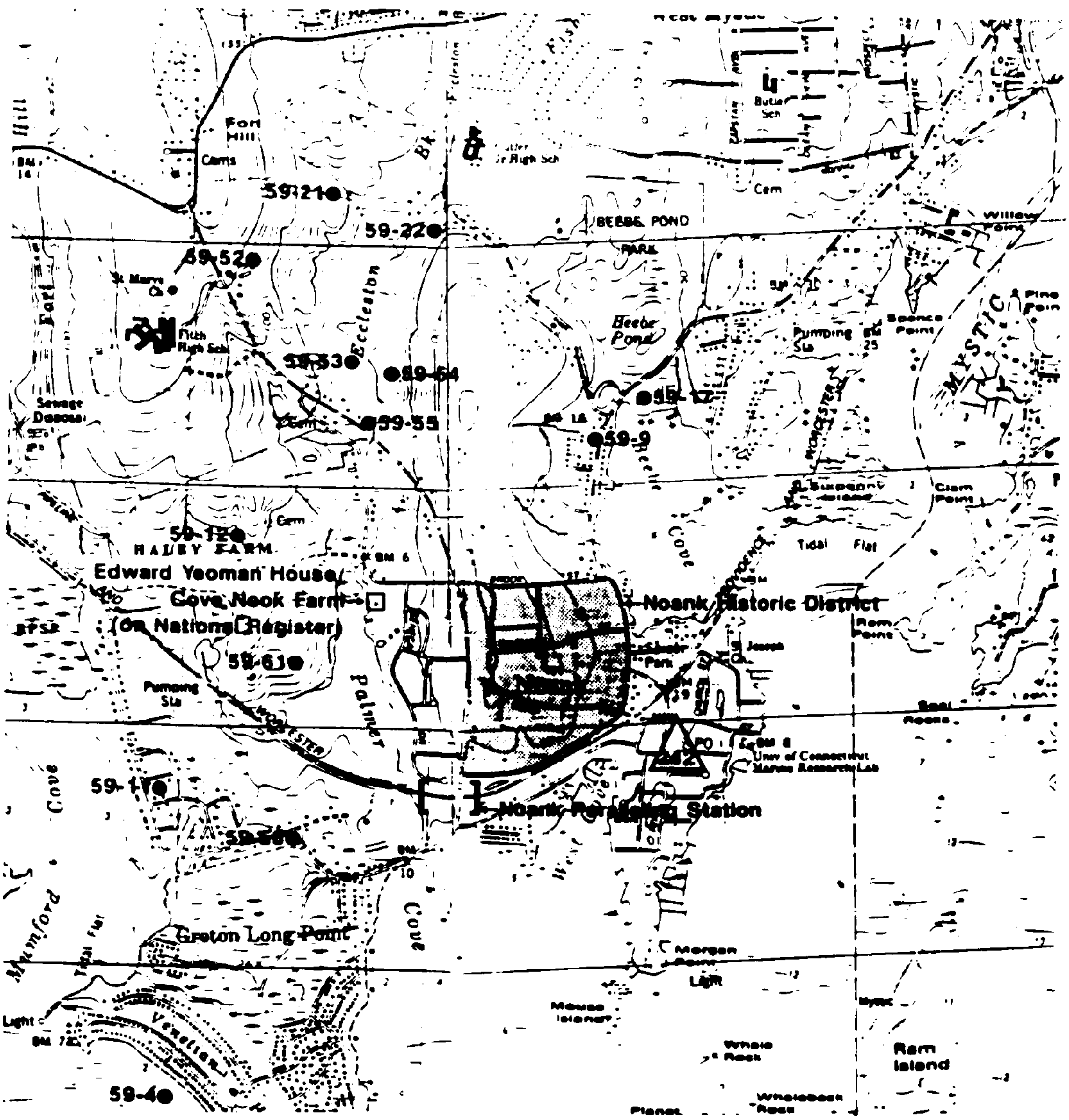
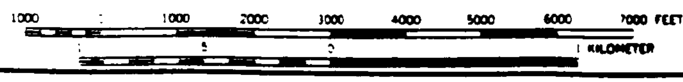


FIGURE 10

USGS Topographic Map
Mystic and New London Quadrangles



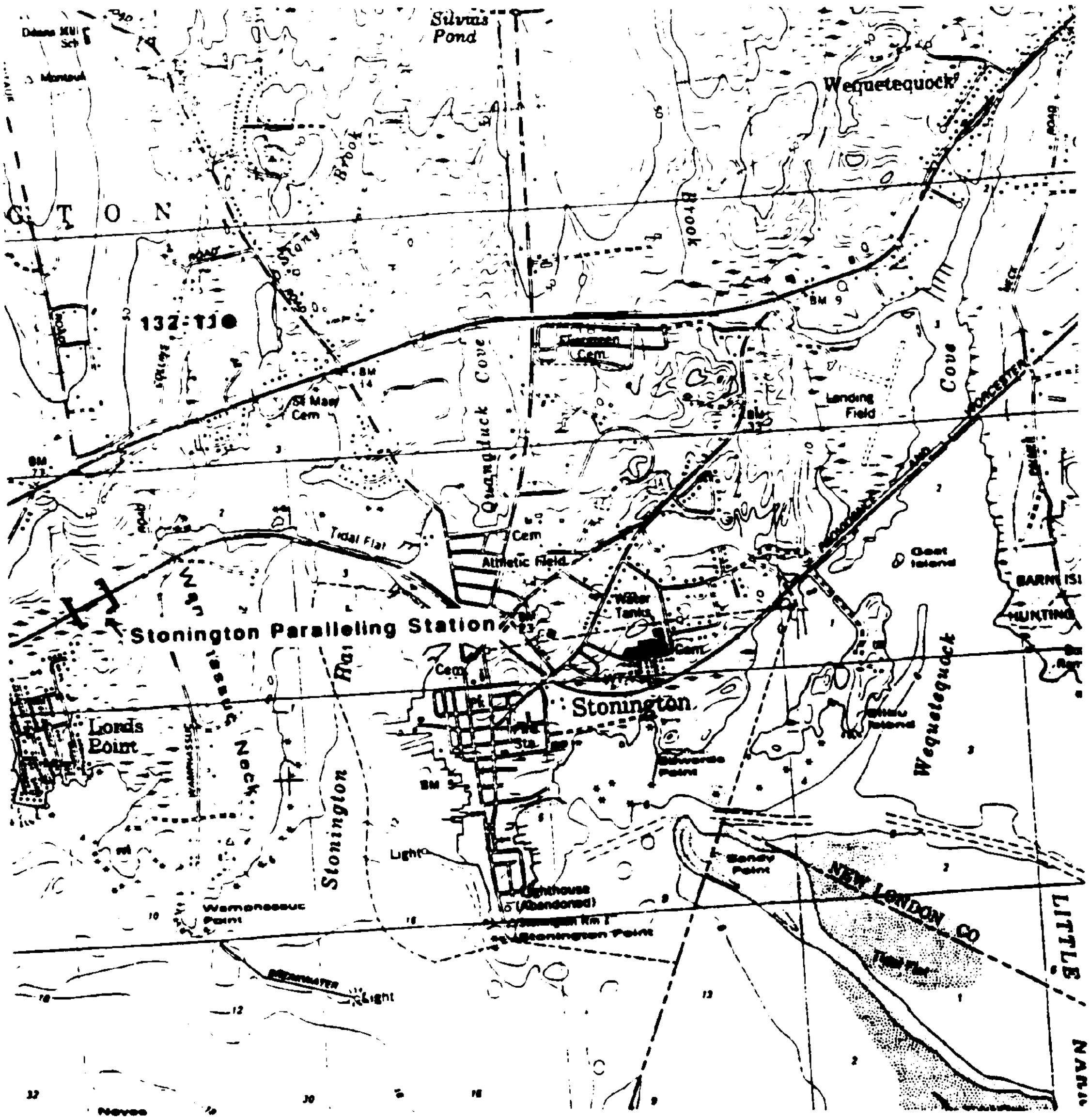
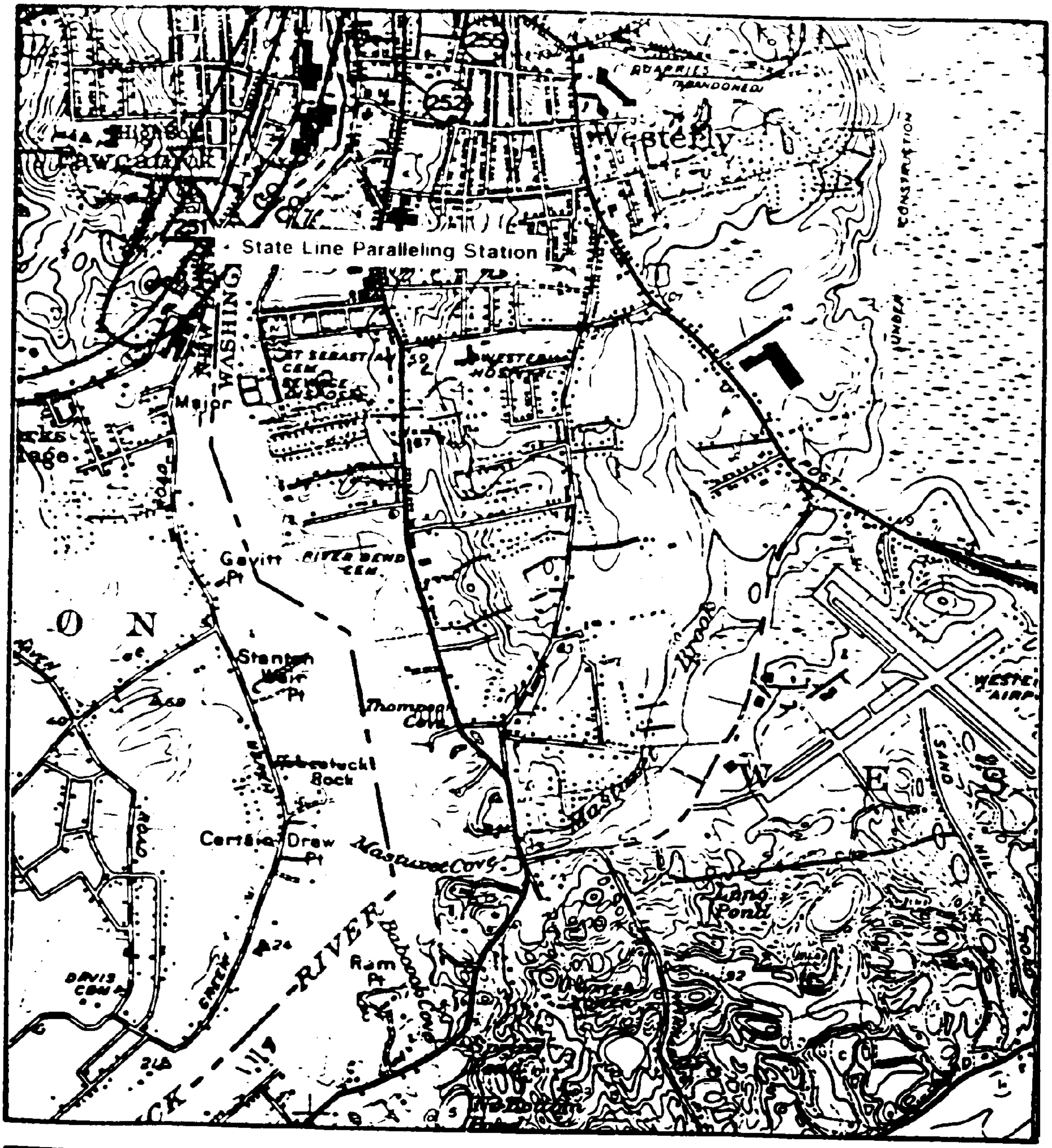


FIGURE 11

USGS Topographic Map
Mystic Quadrangle
Showing Project Area

N



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: WATCH HILL, RI-CT

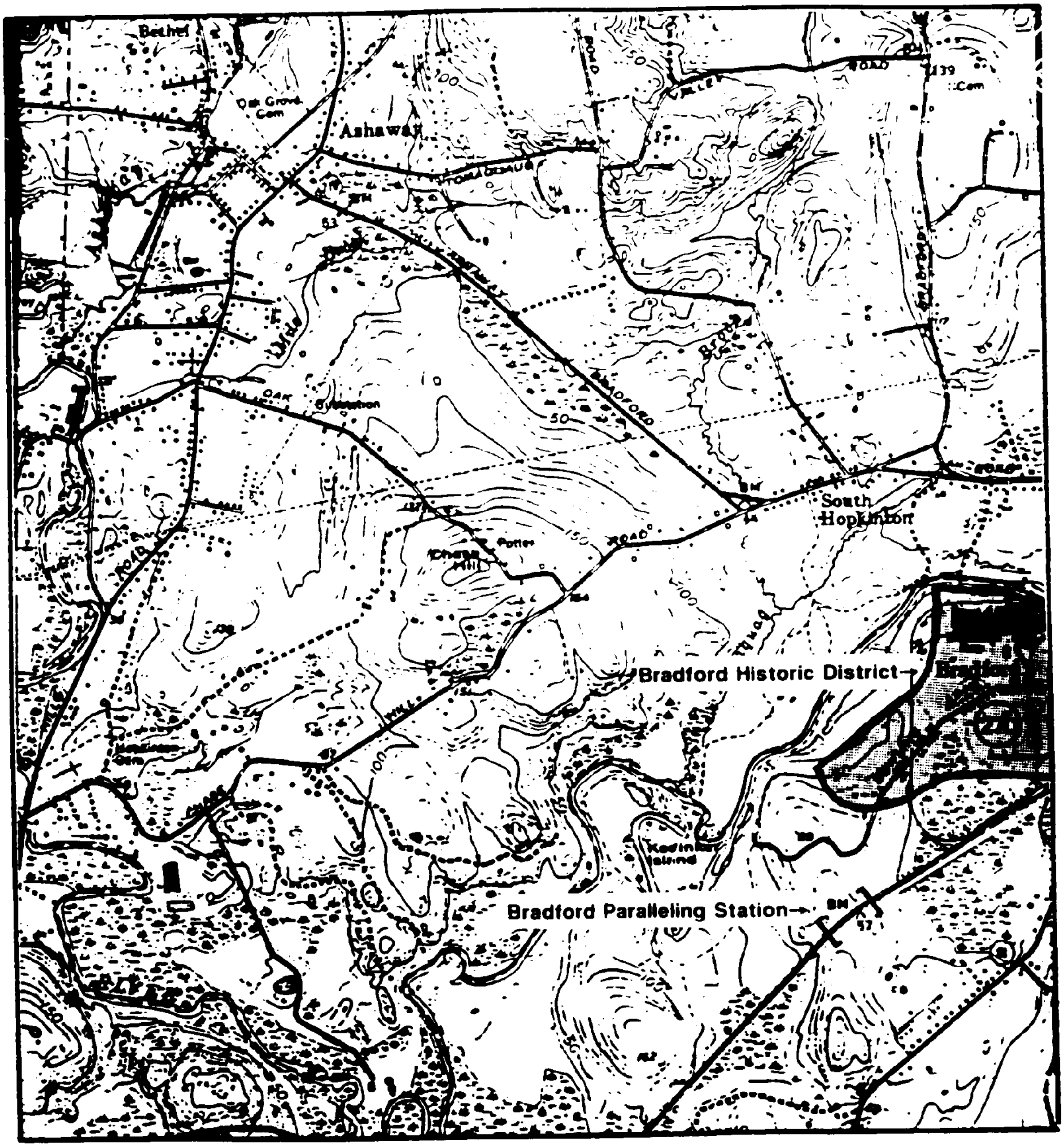
SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 12

From DeLeuw, Cather/Parsons 1979 B

Cultural Resources



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: ASHAWAY, CT–RI

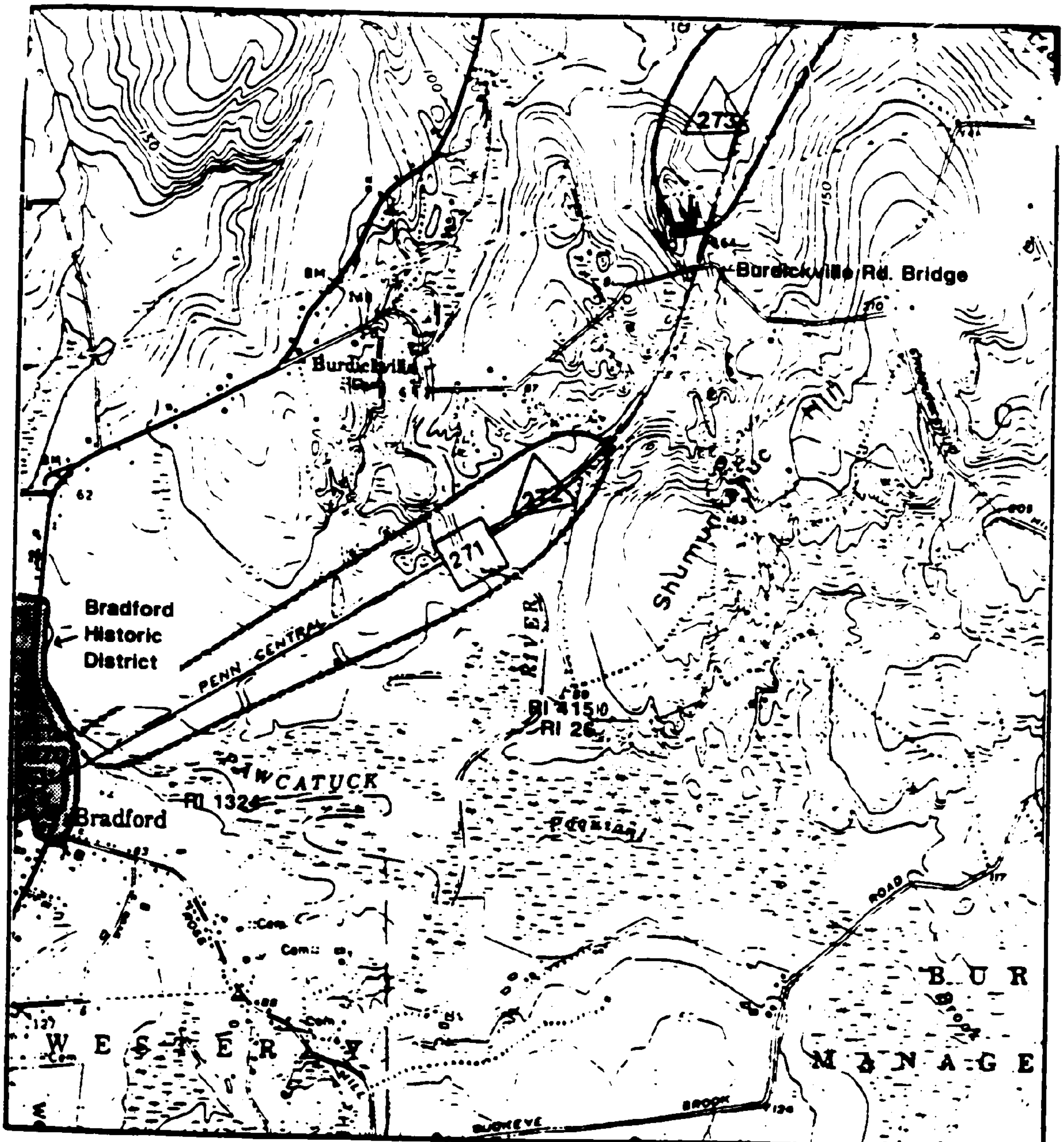
SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 13

From DeLeuw, Cather/Parsons 1979 B

Cultural Resources



LEGEND

- △ Archeological Zone
- ○ Historic Structure or District
- □ Historic Railroad Structure

USGS Quad: CAROLINA, RI

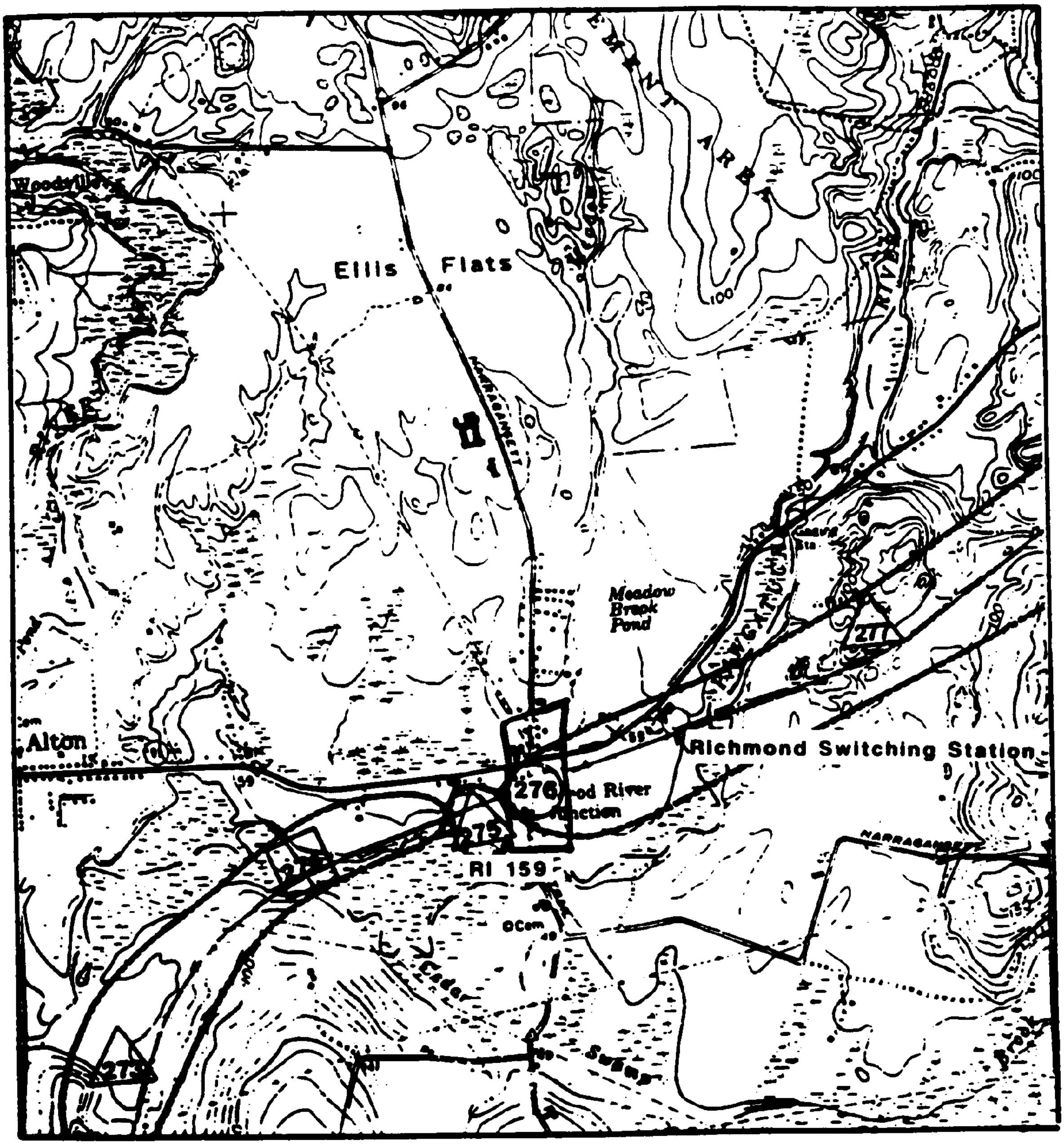
SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 14

From DeLeuw, Cather/Parsons 1979 B

Cultural Resources



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: CAROLINA, RI

SCALE 1:24,000

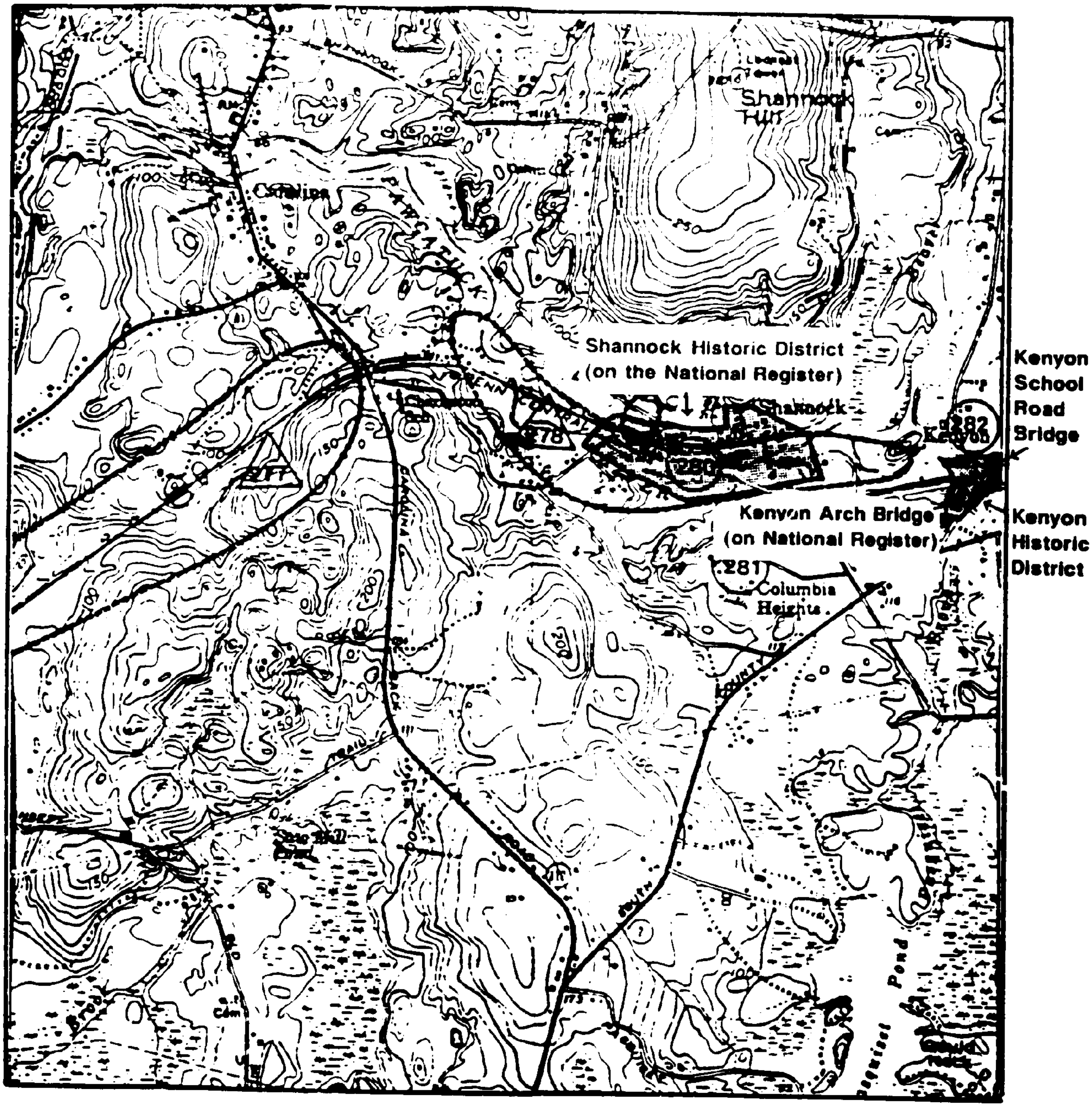
Northeast Corridor Improvement Project

Federal Railroad Administration, Department of Transportation

FIGURE 15

From DeLeuw, Cather/Parsons 1979 B

Cultural Resources



LEGEND

- △ Archeological Zone
- ○ Historic Structure or District
- □ Historic Railroad Structure

USGS Quad: CAROLINA, RI

SCALE 1:24,000

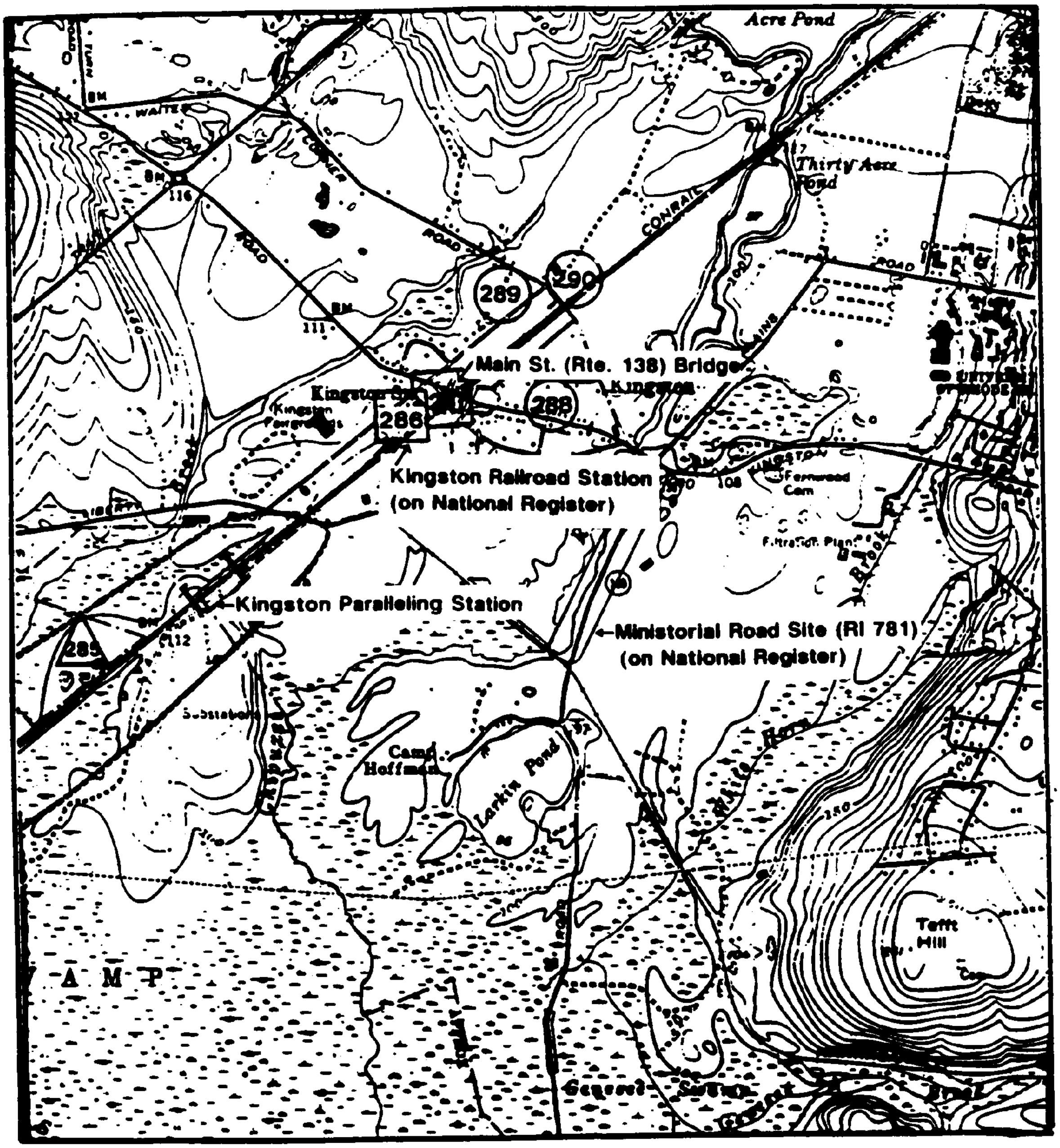
Northeast Corridor Improvement Project

Federal Railroad Administration, Department of Transportation

FIGURE 16

From DeLeuw, Cather/Parsons 1979 B

Cultural Resources



LEGEND

- △ Archeological Zone
- ○ Historic Structure or District
- □ Historic Railroad Structure

USGS Quad: KINGSTON, RI

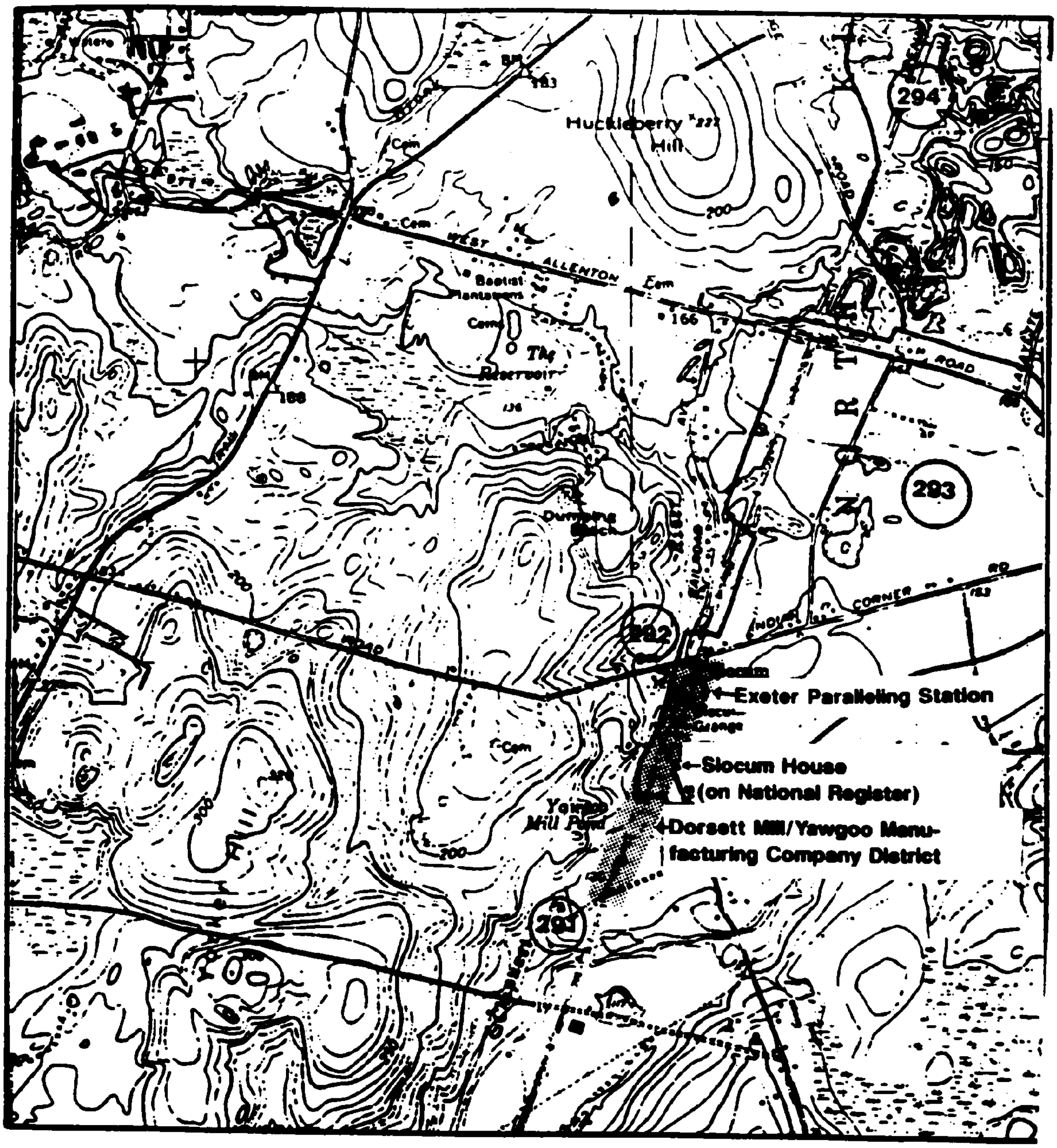
SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 17

From DeLeuw, Cather/Parsons 1979 B

Cultural Resources



LEGEND

- △ Archeological Zone
- ○ Historic Structure or District
- □ Historic Railroad Structure

USGS Quad: SLOCUM, RI

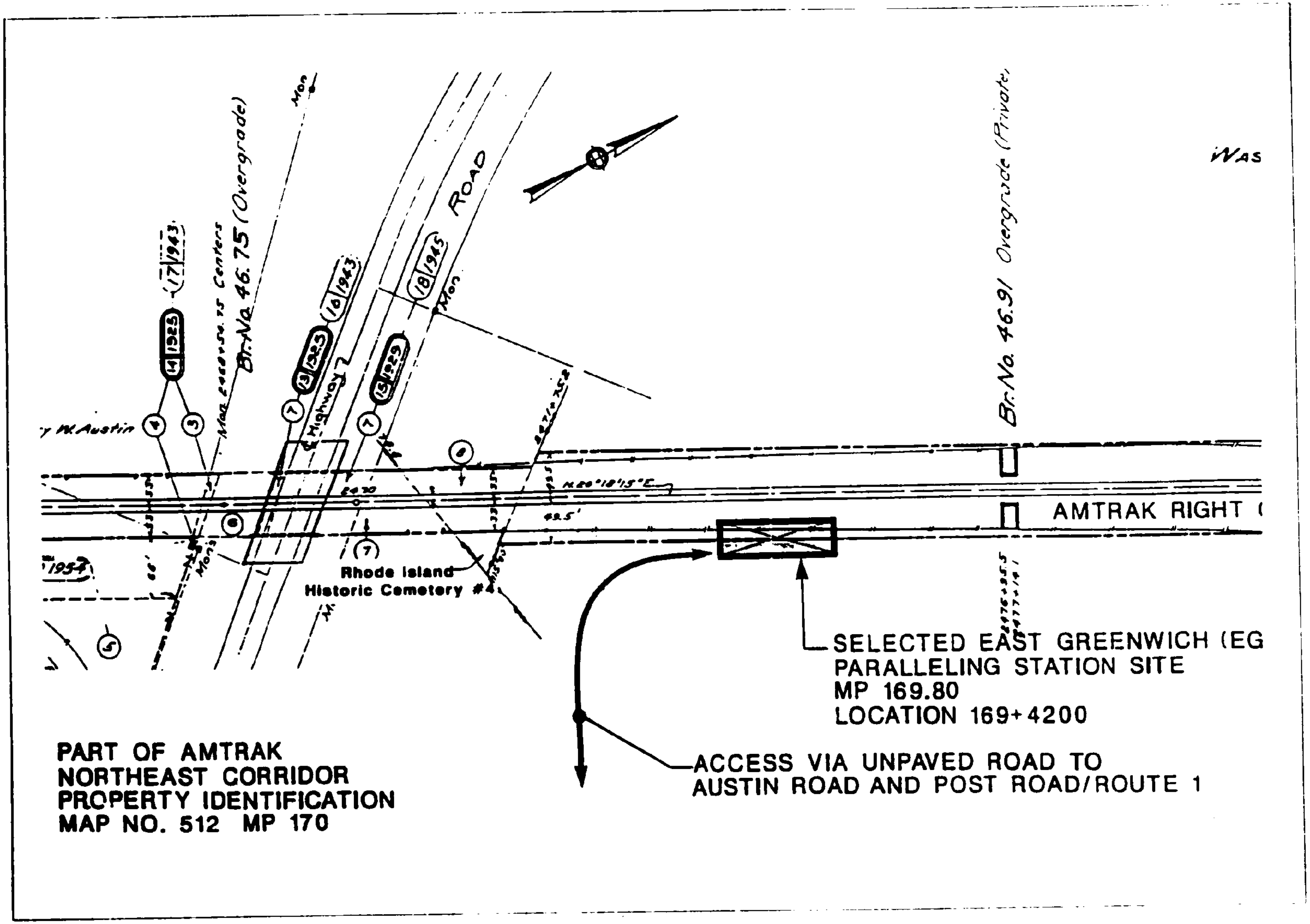
SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 18

From, DeLeuw, Cather/Parsons 1979 B

Cultural Resources



Br. No. 46.75 (Overgrade)
Br. No. 46.91 Overgrade (Private
ROAD
Highway 7
Rhode Island Historic Cemetery #4
AMTRAK RIGHT
SELECTED EAST GREENWICH (EG
PARALLELING STATION SITE
MP 169.80
LOCATION 169+4200
ACCESS VIA UNPAVED ROAD TO
AUSTIN ROAD AND POST ROAD/ROUTE 1
PART OF AMTRAK
NORTHEAST CORRIDOR
PROPERTY IDENTIFICATION
MAP NO. 512 MP 170

FIGURE 19

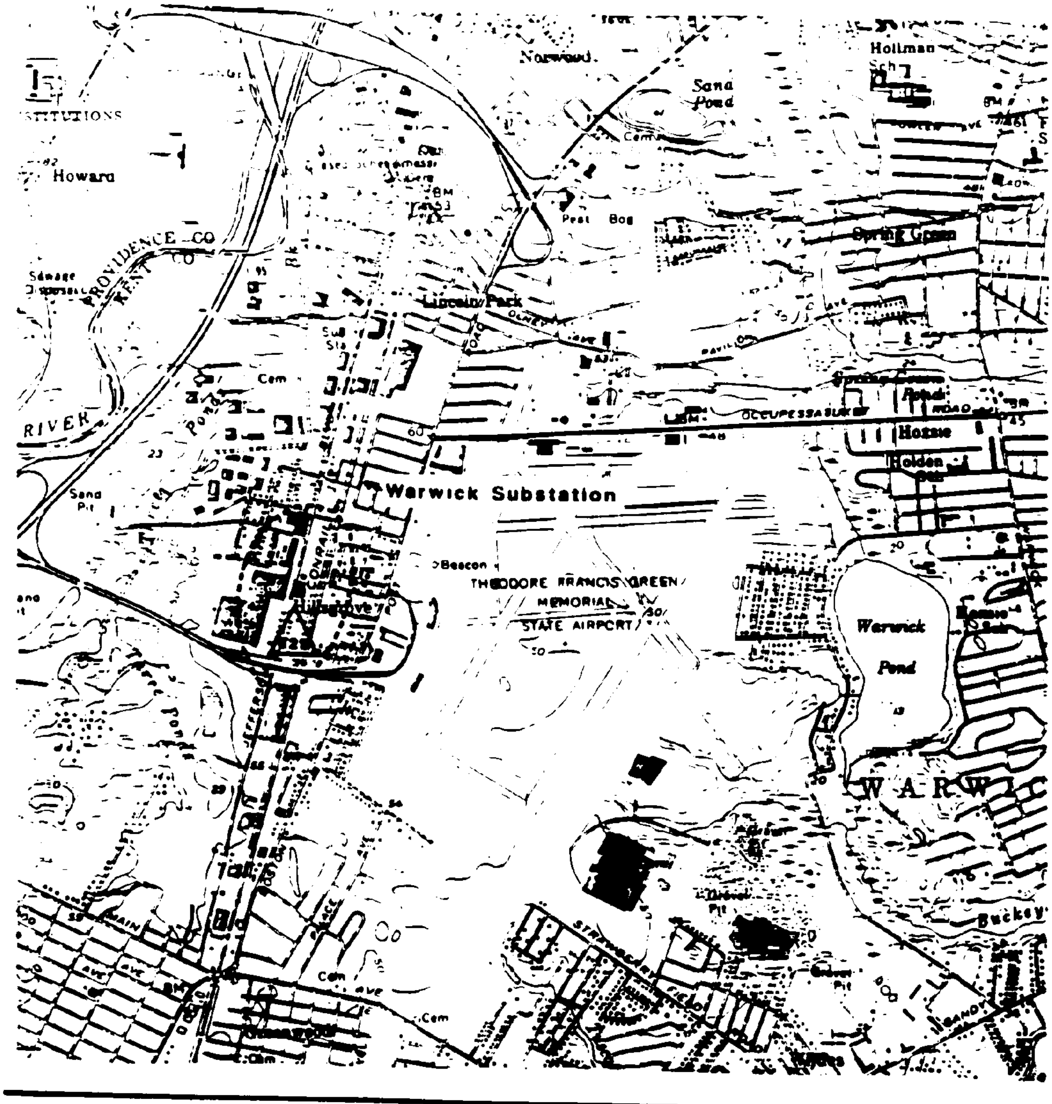
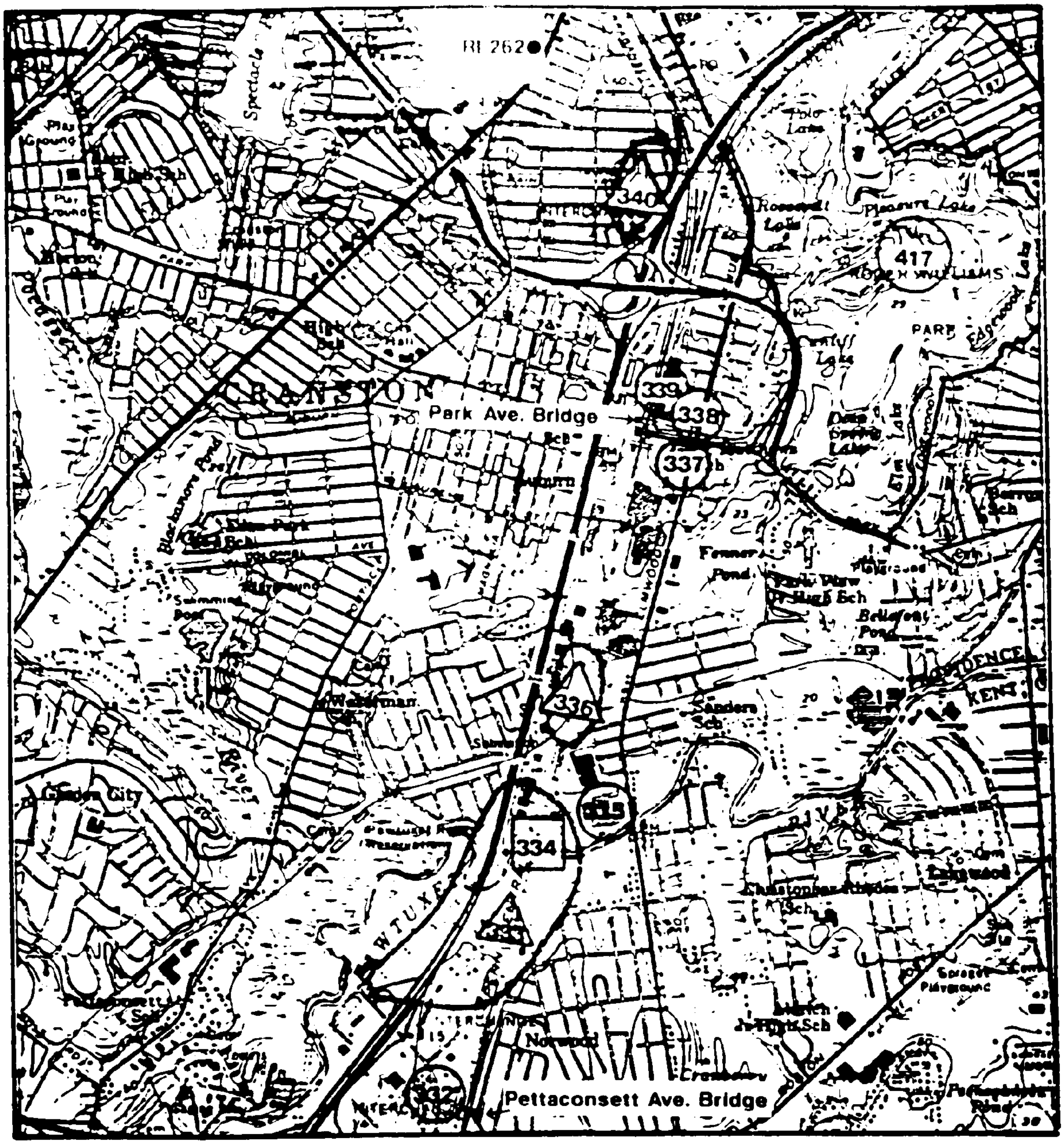


FIGURE 20

USGS Topographic Map
East Greenwich Quadrangle
Showing Project Area

N



LEGEND

- △ Archeological Zone
- ○ Historic Structure or District
- □ Historic Railroad Structure

USGS Quad: PROVIDENCE, RI

SCALE 1:24,000

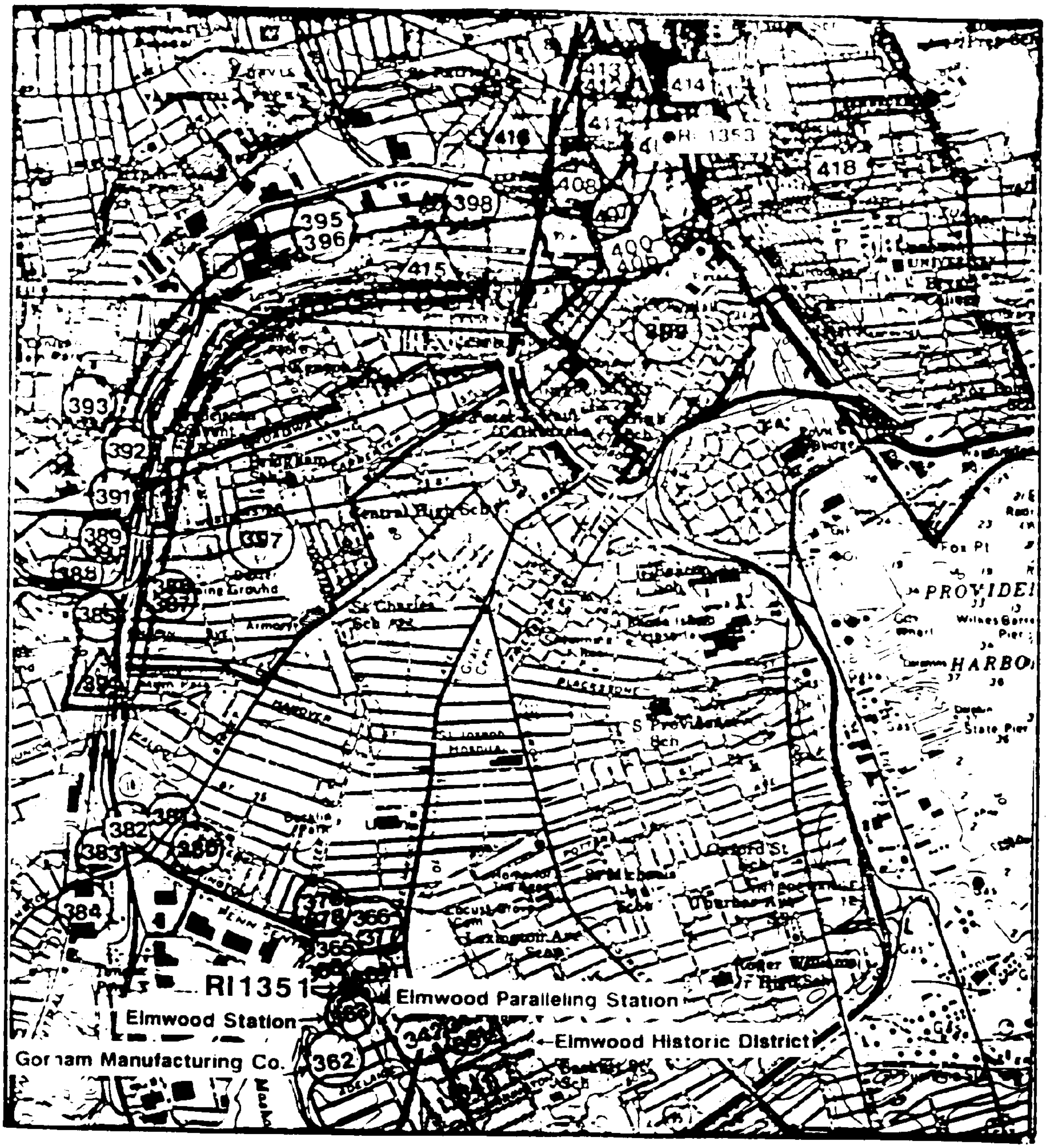
Northeast Corridor Improvement Project

Federal Railroad Administration, Department of Transportation

FIGURE 21

From DeLeuw, Cather/Parsons 1979 B

Cultural Resources



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: PROVIDENCE, RI

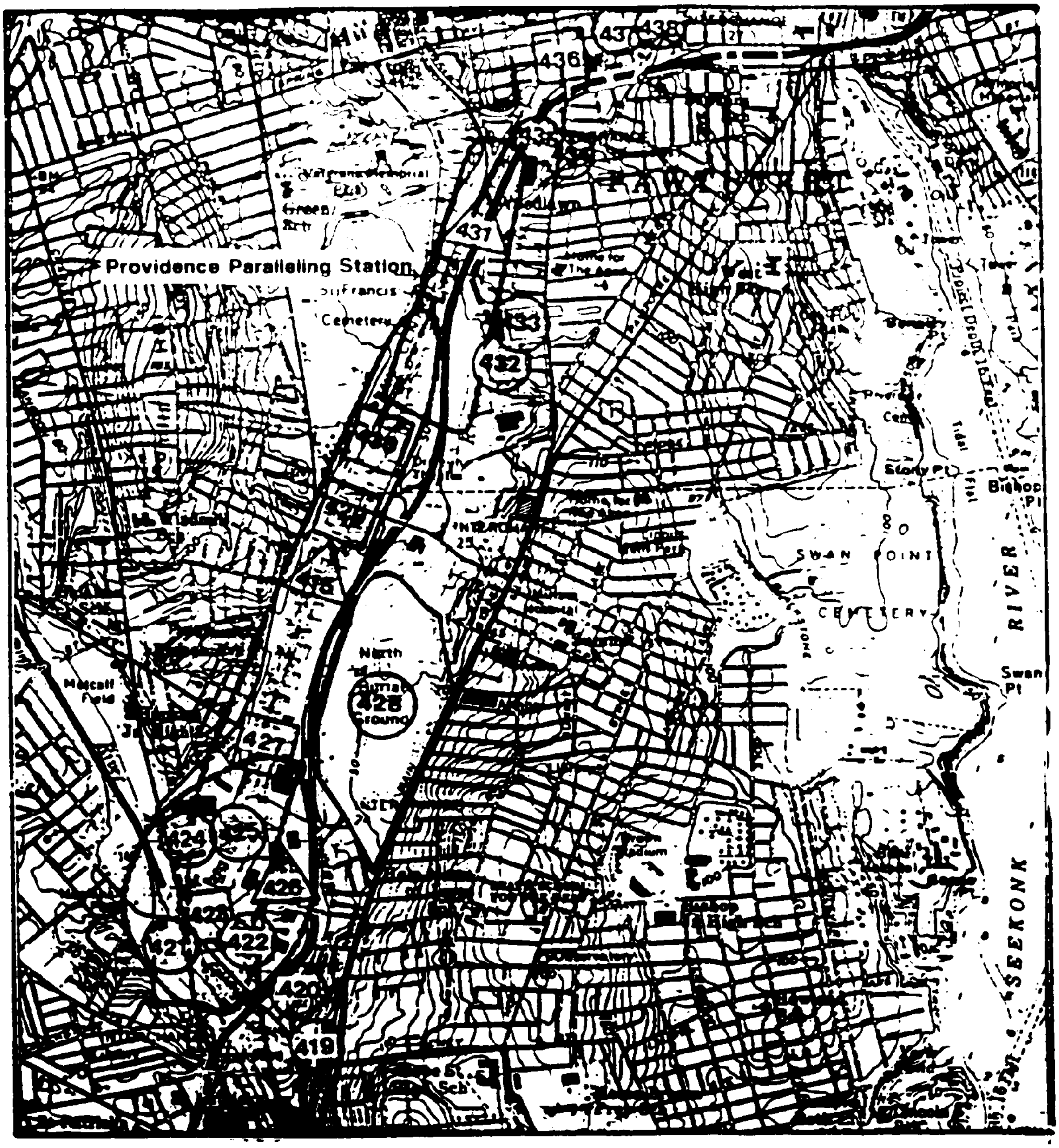
SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 22

From DeLeuw, Cather/Parsons 1979 B

Cultural Resources



LEGEND

△ Archeological Zone
○ Historic Structure or District
□ Historic Railroad Structure

USGS Quad: PROVIDENCE, RI

SCALE 1:24,000

Northeast Corridor Improvement Project
Federal Railroad Administration, Department of Transportation

FIGURE 23

From DeLeuw, Cather/Parsons 1979 B

Cultural Resources

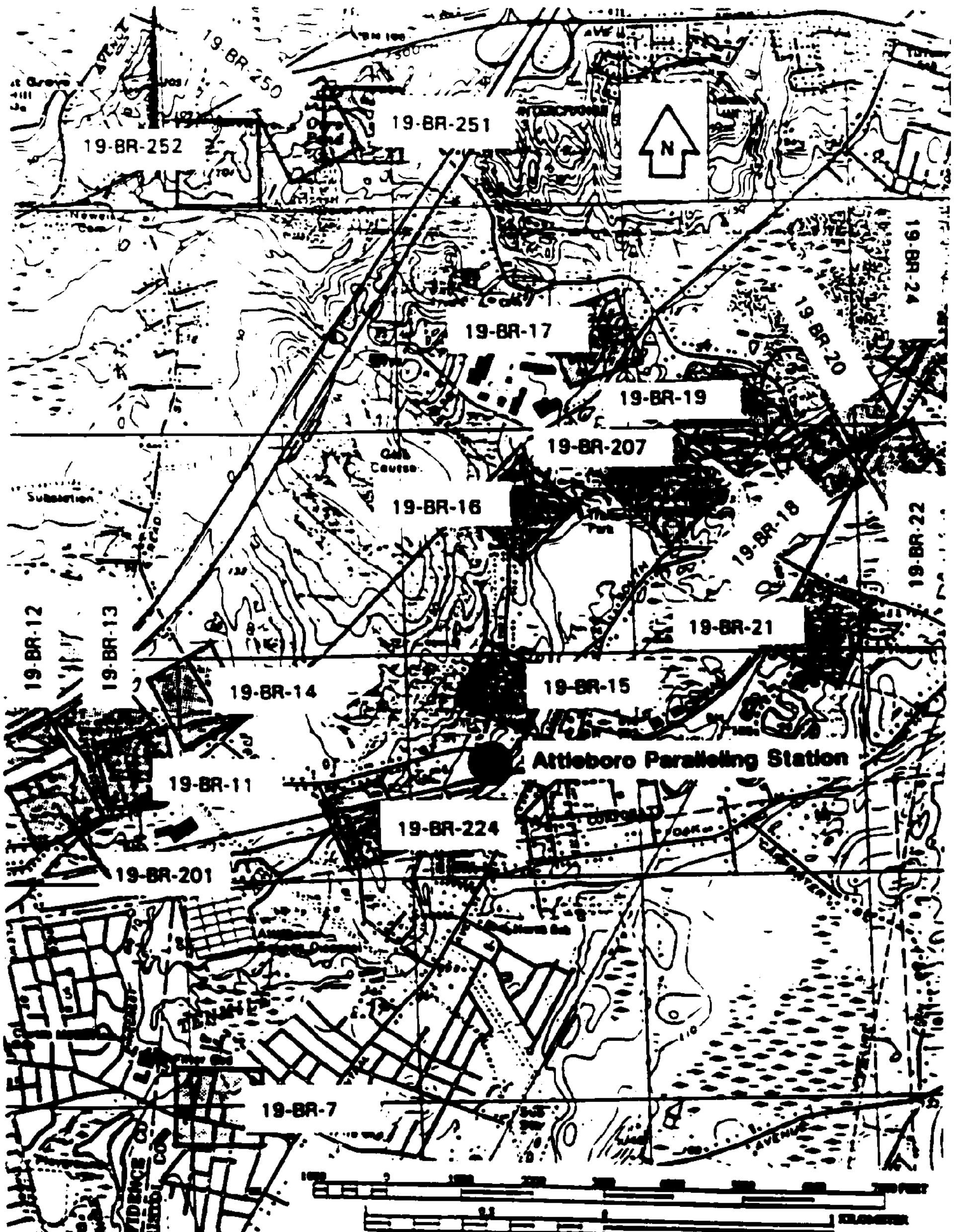


Figure 24. Location of the proposed Attleboro Paralleling Station along AMTRAK's Northeast Corridor Electrification Improvement Project Area, in Attleborough, Massachusetts, on the MA-RI USGS quadrangle, with the location of known prehistoric sites.

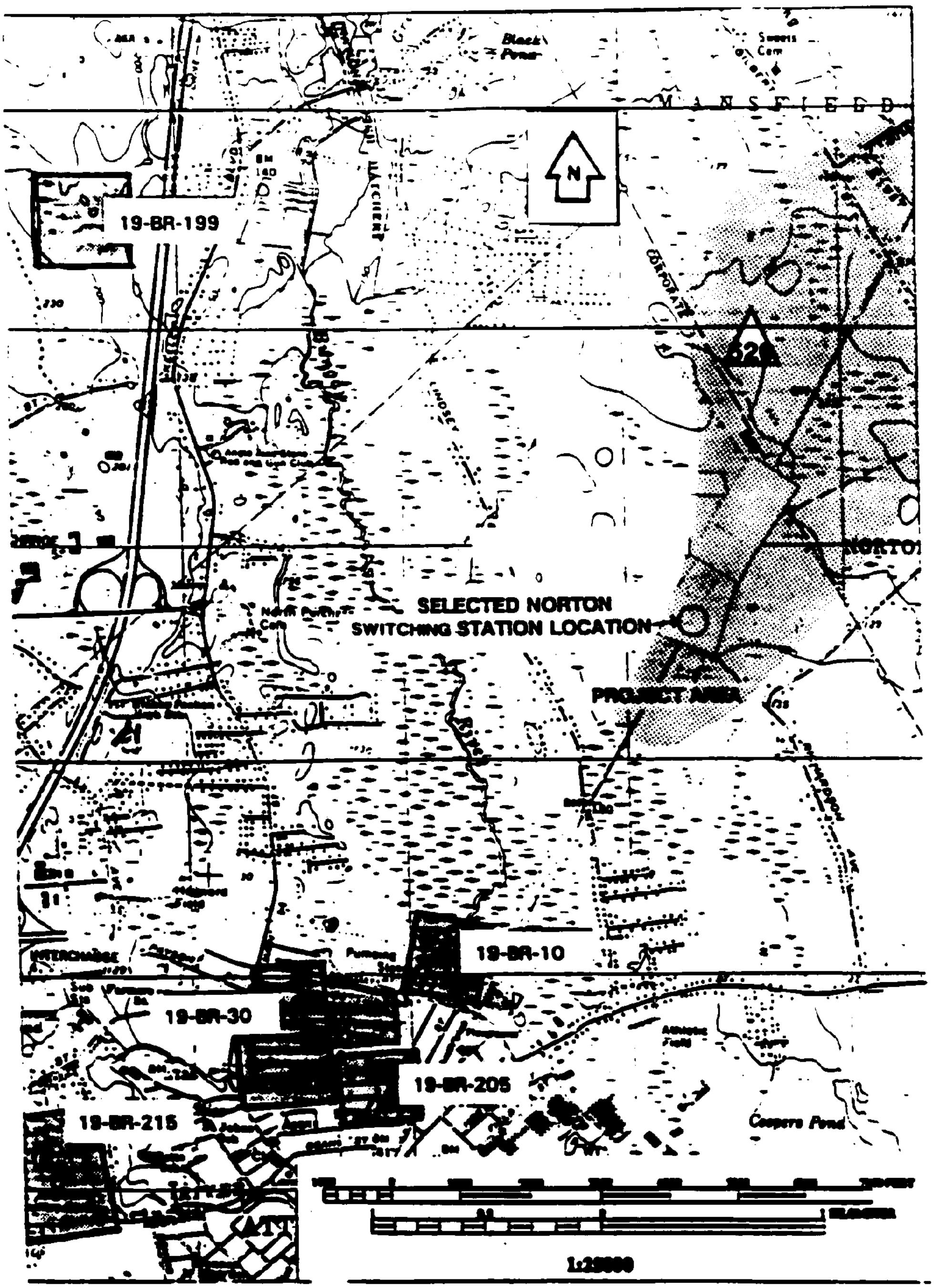


Figure 25. Location of the proposed Norton Switching Station, along AMTRAK's Northeast Corridor Electrification Improvement Project Area, in Attleboro, Massachusetts, on the MA-RI USGS quadrangle, with the location of known prehistoric sites.

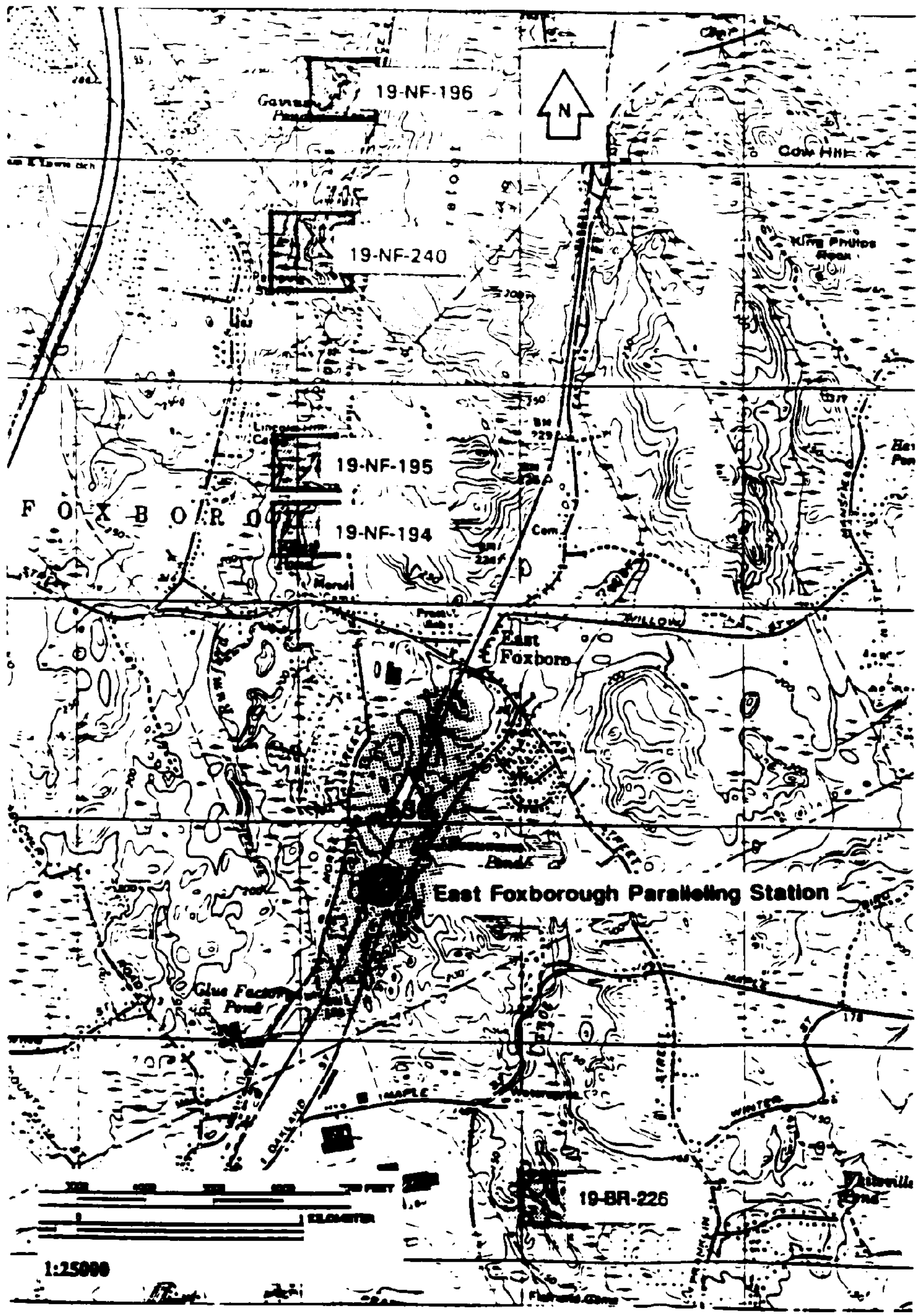


Figure 26. Location of the proposed East Foxboro Paralleling Station along AMTRAK's Northeast Corridor Electrification Improvement Project Area, in Foxborough, Massachusetts, on the Mansfield, MA USGS quadrangle, with the location of known prehistoric sites.

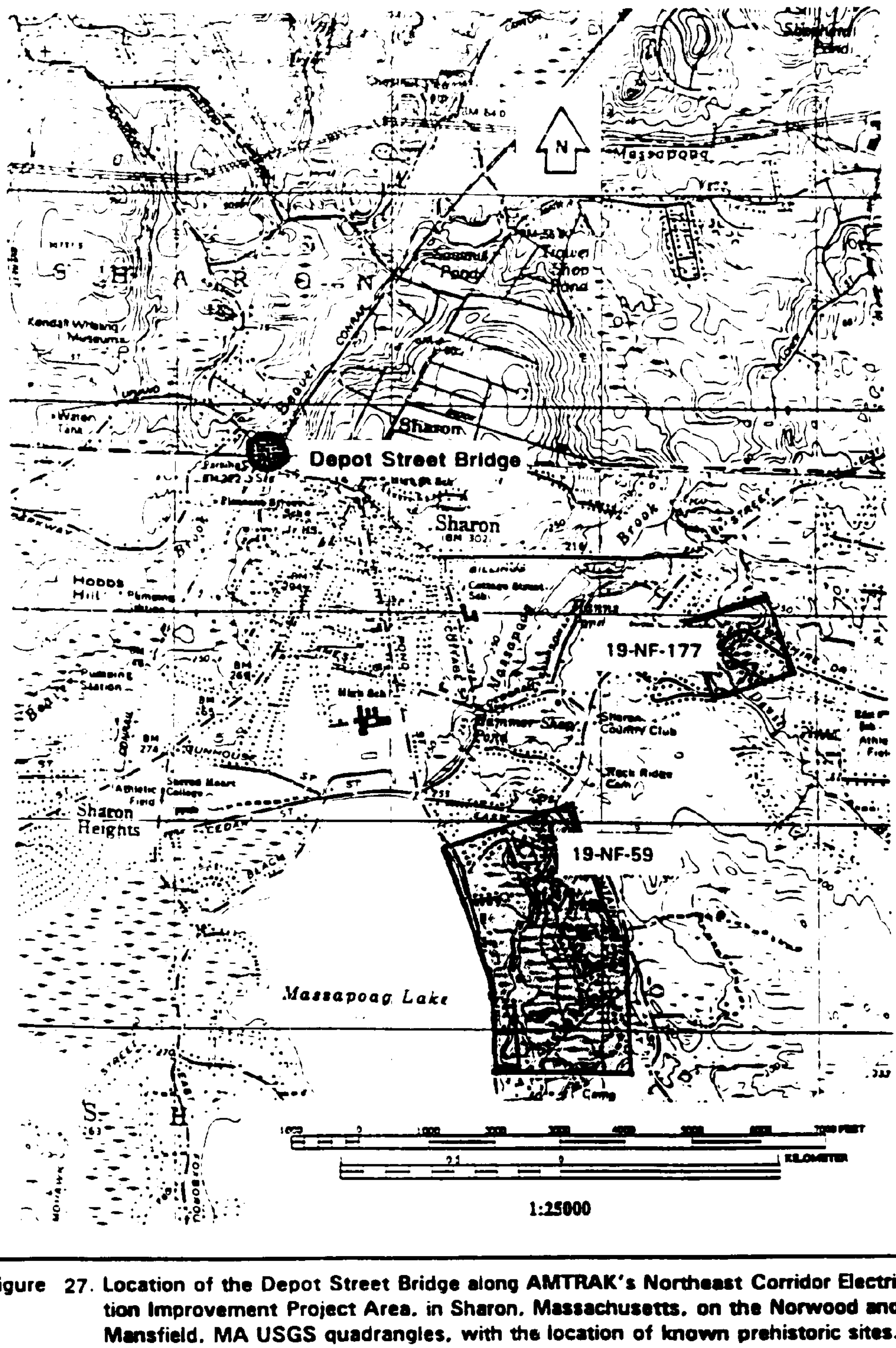


Figure 27. Location of the Depot Street Bridge along AMTRAK's Northeast Corridor Electrification Improvement Project Area, in Sharon, Massachusetts, on the Norwood and Mansfield, MA USGS quadrangles, with the location of known prehistoric sites.

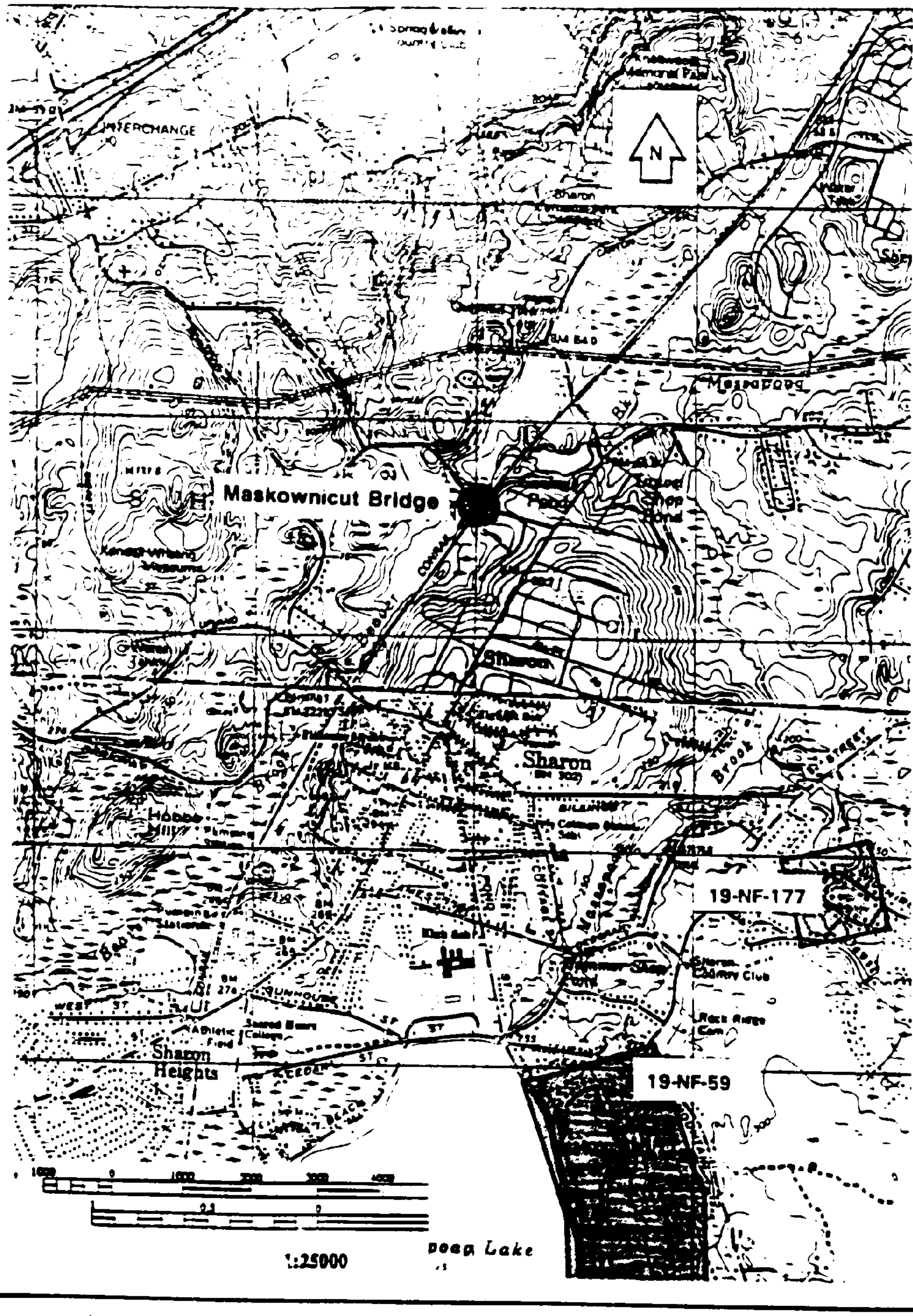


Figure 28. Location of the Maskownicut Street Bridge along AMTRAK's Northeast Corridor Electrification Improvement Project Area, in Sharon, Massachusetts, on the Norwood and Mansfield, MA USGS quadrangles, with the location of known prehistoric sites.

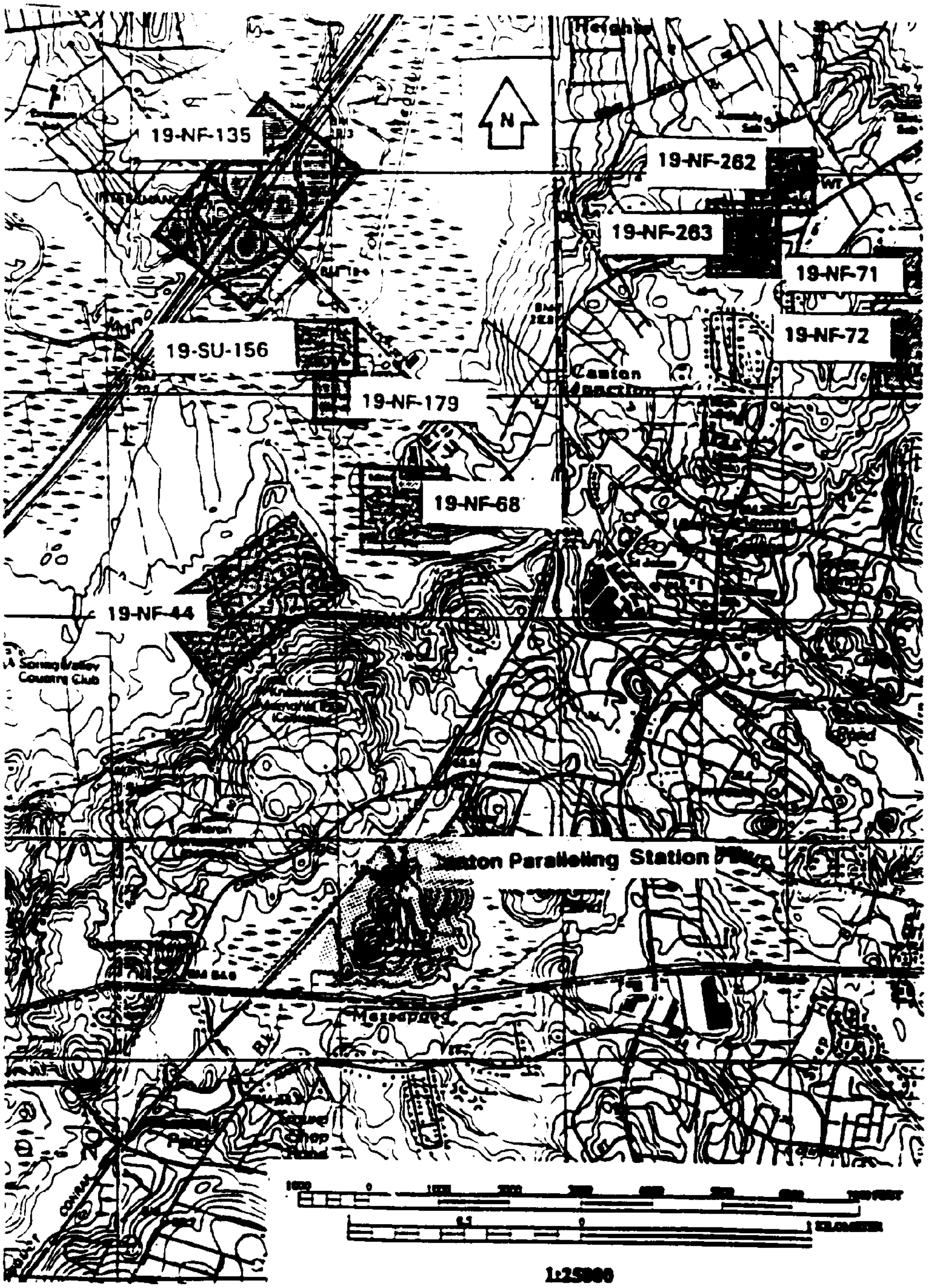


Figure 29. Location of the proposed Canton Paralleling Station along AMTRAK's Northeast Corridor Electrification Improvement Project Area, in Sharon, Massachusetts, on the Norwood, MA USGS quadrangle, with the location of known prehistoric sites.

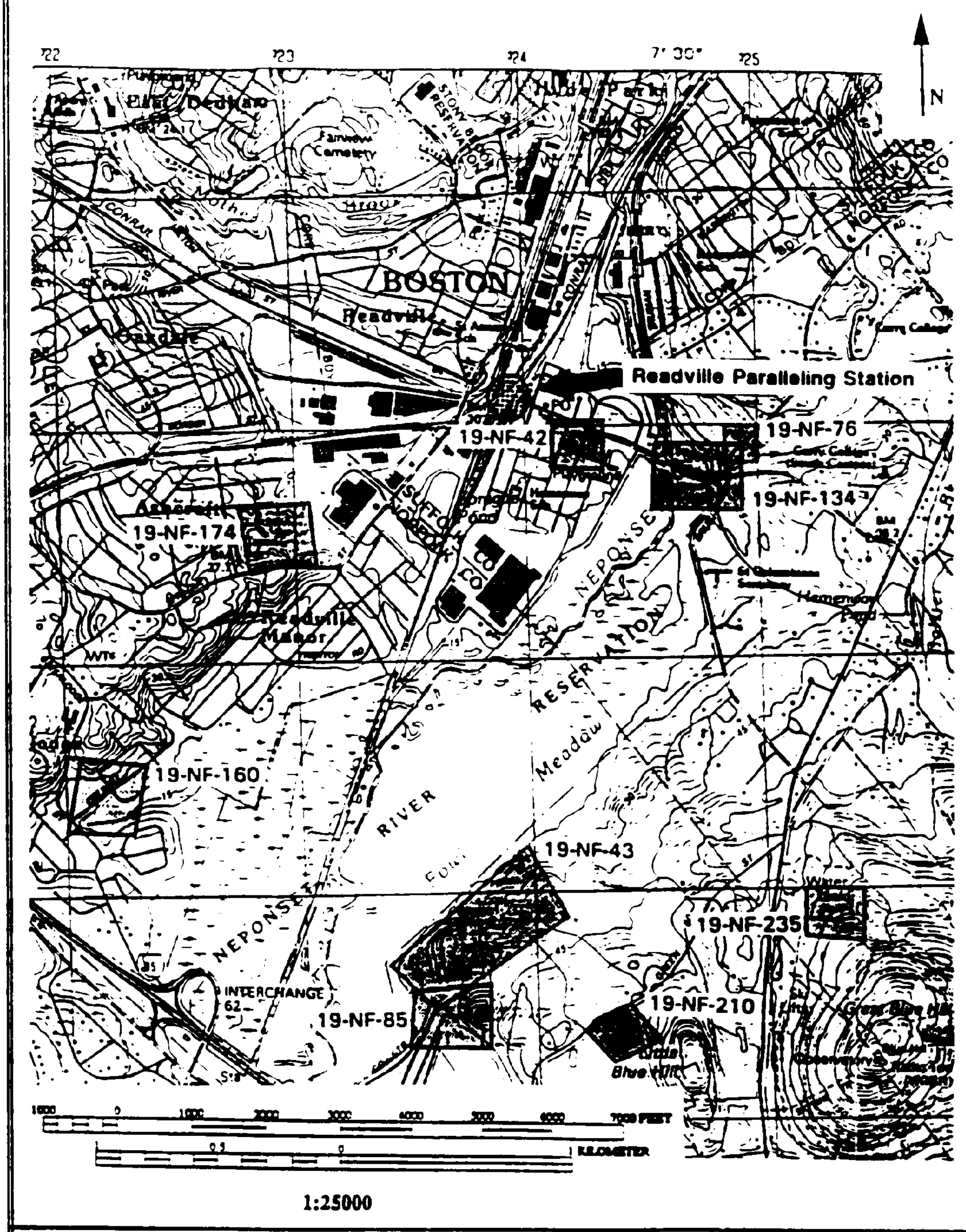


Figure 30. Location of the proposed Readville Paralleling Station along the AMTRAK's Northeast Corridor Electrification Improvement Project Area, in the Hyde Park section of Boston, Massachusetts, on the Boston South USGS quadrangle, with the location of known prehistoric sites.

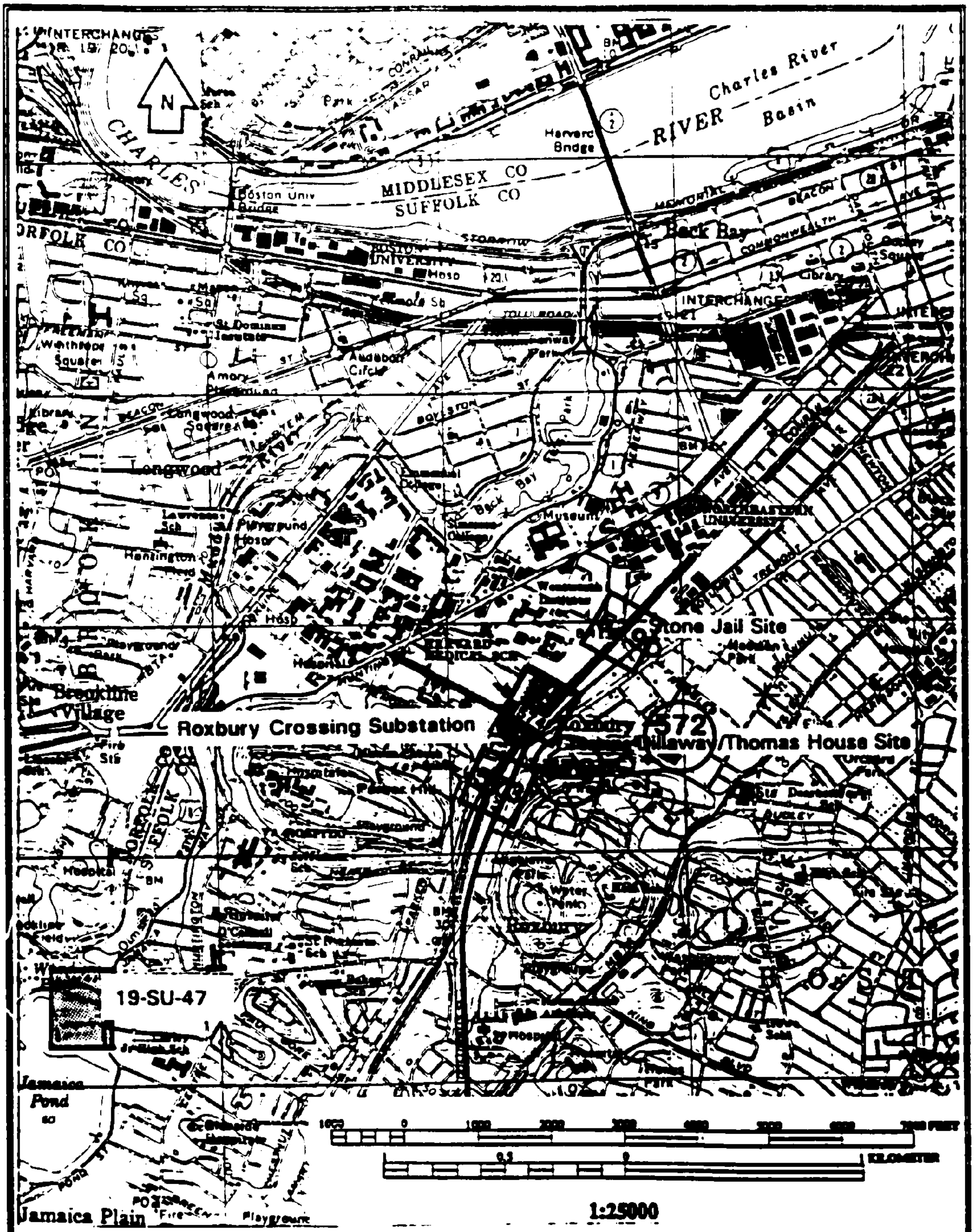


Figure 31. Location of the proposed Roxbury Crossing Substation and Feeder Alignment, along AMTRAK's Northeast Corridor Electrification Improvement Project Area, in Roxbury, Massachusetts, on the Boston South USGS quadrangle, with the location of known prehistoric sites.

TECHNICAL STUDY 8
PUBLIC SAFETY

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TECHNICAL STUDY 8
PUBLIC SAFETY

8.1 INTRODUCTION

Rail operations within the NEC present the potential for train accidents involving both vehicles and pedestrians crossing the tracks. The danger of accidents involving motor vehicles is largely limited to at-grade rail-highway grade crossings. Collisions involving pedestrians could occur at established at-grade crossings, at illegal paths across or along the railroad right-of-way (ROW), and at railroad stations with pedestrian crossings of tracks.

Within the 156-mile corridor are 14 at-grade intersections of streets with the rail main line. The existing risk of a collision at these locations could be increased by the proposed action as: the number of trains traveling the corridor increases, the average operating speed of the trains increases, and the volume of vehicular traffic increases. Conversely, improvements in traffic control and warning devices at each of these crossings, or the closing of crossings, could reduce or eliminate the risk of collisions between train and vehicular traffic.

Pedestrian crossings of the rail corridor were identified at 36 locations; the 14 at-grade rail-highway crossings and 22 illegal locations. In addition, 10 commuter rail stations also involve pedestrian crossing of tracks. Increases in the number of trains traveling the corridor, and the average operating speed of the trains, could increase the potential for rail-pedestrian accidents. Improved warning devices and barriers to pedestrian crossings could reduce the potential for rail-pedestrian accidents.

8.2 REGULATORY SETTING

There are no Federal or state regulations that specifically address assessment of public safety impacts. However, *Federal Highway Administration (FHWA) Technical Report TS-86-215 (U.S. Department of Transportation/FHWA)* and *Railroad-Highway Grade Crossings Resource Allocation Procedure-Users Guide (FRA/DOT, 1987)* provide guidelines for preparation of an accident prediction model at grade crossings. The guidelines include procedures for developing and calibrating an accident prediction model for vehicle-rail accidents. In addition, *FHWA Technical Advisory T6640.8a* provides general guidance on the preparation and processing of environmental documents and identifies public safety hazards and accident rates as among the impacts to be evaluated.

8.3 AFFECTED ENVIRONMENT

Vehicular traffic crossing the ROW within established grade crossings and pedestrian traffic crossing both at grade crossings and elsewhere along the corridor may be affected by the proposed action. This section reviews the existing conditions at each of the grade crossings with respect to train operations, highway traffic volumes, the number of existing at-grade crossings, the types of traffic warning and control devices at those crossings, and accommodations for

TABLE 8-1
PHYSICAL CHARACTERISTICS OF EXISTING GRADE CROSSINGS

Crossing Name	Location	Legal Status	ID #	Mile Post	Speed Limit (mph)	Gates	Flashing Lights	Number of Lanes	Average Daily Traffic
Chapman's Crossing	Old Lyme, CT	Private	500319L	112.19	70	No	No	1	*
Miner's Lane	Waterford,CT	Public	500307S	120.20	60	Yes	Yes	2	900
Bank St. Connector	New London,CT	Public	500297N	122.60	25	Yes	Yes	2	200
State Street	New London,CT	Public	500295A	122.76	25	Yes	Yes	2	500
Gov. Winthrop Blvd	New London,CT	Public	500294T	123.90	25	Yes	Yes	2	2,470
School Street	Groton, CT	Public	500278J	131.50	70	Yes	Yes	2	900
Broadway Extension	Groton, CT	Public	500297C	132.30	50	Yes	Yes	2	1,220
Latimer Point	Stonington,CT	Public	500275N	133.40	70	Yes	Yes	2	370
Wampassuc	Stonington,CT	Public	500272T	134.90	70	Yes	Yes	2	310
Walker's Dock	Stonington,CT	Private	500268D	136.65	70	Yes	Yes	1	*
Freeman's	Stonington,CT	Private	500267W	136.70	70	Yes	Yes	1	*
Palmer Street	Stonington,CT	Public	500263V	140.55	80	Yes	Yes	2	1,650
Wolf Rocks Road	Exeter, RI	Public	**	160.30	100	Yes	Yes	2	**
Lazy Lady Farm	Attleboro, MA	Private	537225R	198.96	100	No	No	1	*

* Private crossing - Average Daily Traffic unavailable   ** Programmed to be grade separated in 1993

Two accidents occurred at Privateer Street and at Spar Yard Street, respectively, in New London, both of which have since been closed to highway traffic. Table 8-2 lists the eight reported accidents. All of these accidents occurred in Connecticut and include property damage but no injuries or fatalities. No grade crossing accidents have been reported since 1985.

8.3.2 Pedestrian Crossings

Pedestrians illegally cross the tracks at a number of locations other than the rail-highway grade crossings. As described in further detail below, pedestrians crossing the tracks along the corridor or at stations incur greater risk of accidents than those crossing within the designated crossing points. Frequency of train service, operating speed, and the level of noise associated with the train operation may affect the probability of pedestrian-train accidents.

8.3.2.1 Existing Pedestrian Crossings Along Corridor Pedestrian crossings along the study corridor were identified through interviews with local police officials, Amtrak security patrol personnel, state and local officials, and on-site surveys. During the field observations some locations could be readily identified but others were less obvious. Additional crossings were identified at public meetings held in November and December of 1992.

Observations suggest that these pedestrian crossings are generally located at previously closed grade crossings or at locations which provide a "short-cut" pedestrian route. These crossings are also located adjacent to residential areas, playgrounds, and parks.

TABLE 8-2
GRADE CROSSING ACCIDENTS REPORTED TO THE FRA

YEAR	LOCATION	INJURY	FATALITY	COMMENTS
1975	Gov. Winthrop Boulevard	no	no	Train struck auto stopped on tracks.
1978	Walker Dock	no	no	Train struck auto stopped on tracks.
1978	Privateer Street Crossing (closed)	no	no	Train struck truck moving across tracks.
1981	Spar Yard Street (closed)	no	no	Train struck auto stopped on tracks.
1982	School Street	no	no	Train struck auto stalled on tracks.
1983	Freeman's	no	no	Train struck auto stopped on tracks.
1984	Gov. Winthrop Boulevard	no	no	Train struck auto stalled on tracks.
1985	Gov. Winthrop Boulevard	no	no	Train struck tractor-trailer moving across tracks.

The majority of the pedestrians who cross the tracks illegally are school age children who often climb over the barriers and guard rails, walk around existing fencing, or cut holes in fences to take a short-cut, perhaps to a playground or to their residence. Many pedestrian crossings are located where fencing has been previously installed along the ROW.

As shown in Table 8-3, thirteen locations in Connecticut were identified where pedestrians are likely to cross tracks. Table 8-3 also includes five locations that were identified in Rhode Island and four identified in Massachusetts. These crossings should not be considered a complete listing of all crossings; rather, the list defines only the major and most obvious crossings along the corridor between New Haven and Boston.

8.3.2.2 Pedestrian Crossings Within Stations Passengers cross the main line tracks to access the platforms at several of the rail stations in the NEC. A field survey was conducted to identify the existing status of pedestrian crossings at all stations within the study corridor. This survey included the stations served by Amtrak as well as those served by commuter rail.

There are 22 passenger rail stations within the study corridor. Four of these stations are served by Amtrak only, 12 are served by commuter rail only, and 6 stations are served by both Amtrak and commuter rail. Ten of the stations surveyed have at-grade pedestrian crossings (Canton Junction, MA; Kingston, RI; Mystic, New London, Old Saybrook, Westbrook, Clinton, Madison, Guilford, and Branford, CT). Five stations have overpasses (South Attleboro, Sharon, Route 128, Hyde Park Ruggles Street, MA) and four have underpasses (New Haven, CT; Westerly, RI; and Attleboro and Mansfield, MA). At the remaining three stations the tracks are accessed directly from the station platforms.

Amtrak's express service does not stop at any of the stations with at-grade pedestrian crossings and conventional service stops only at four of these stations (Kingston, Mystic, New London and Old Saybrook). With Amtrak trains passing some stations at speeds of 50 to 100 mph, pedestrians crossing the tracks could be exposed to a safety hazard. Table 8-4 summarizes the survey results and lists all stations in the corridor including existing train speed limits and status of existing pedestrian crossings.

8.3.2.3 Pedestrian Accidents. Federal and state agencies do not routinely publish reports summarizing pedestrian accidents along railroad ROWs. However, records maintained by FRA for the past five years indicate an average of two people per year are struck by trains, both at station areas and along the NEC.

8.4 ENVIRONMENTAL CONSEQUENCES AND MITIGATION MEASURES

Changes in rail operations, vehicular and pedestrian activity, and implementation of transportation and safety programs could alter the potential of accidents between trains, vehicles, and pedestrians. The proposed action would increase both the number and size of trains operating along the rail corridor and the operating speed of those trains.

TABLE 8-3
ILLEGAL PEDESTRIAN CROSSINGS

Location	Milepost	Town	Fenced	Number Tracks	Speed Limit (mph)
CONNECTICUT					
Railroad Avenue	92.80	Madison	no	2	90
Privateer LTD	96.00	Clinton	partial	2	85
No. Broadway	99.20	Westbrook	partial	2	85
Westbrook Hgts Rd.	101.30	Westbrook	no	2	90
Boston Post Rd	105.20	Old Saybrook	no	2	90
Near Shore Road	107.60	Old Lyme	no	2	75
Rocky Neck St Park	112.65	East Lyme	yes (break)	2	75
Ridgewood Drive	113.80	East Lyme	no	2	75
Gada Road	114.80	East Lyme	no	2	75
Grand Street	116.20	East Lyme	yes (break)	2	75
Near MP	128.30	Groton	no	2	55
Spicer Avenue	130.40	Groton	no	2	55
Near MP	136.20	Stonington	no	2	50
RHODE ISLAND					
Old Baptist Rd	168.50	Warwick	no	2	100
Rocky Hollow Rd	170.00	Warwick	no	2	90
Queen Street	171.50	Warwick	no	2	85
Alger Avenue	172.90	Warwick	no	2	85
Folly Landing	173.90	Warwick	no	2	80
MASSACHUSETTS					
Knight Street	193.70	Attleboro	no	2	100
Oak Street	197.78	Attleboro	yes	3	100
Morse/Summer Pl	206.00	East Foxboro	yes	2	95
Garden Street	209.52	Sharon	partial	2	95

TABLE 8-4
STATION CHARACTERISTICS AND PEDESTRIAN ACCESS AT RAILROAD STATIONS

STATION	NO. of TRACKS	PLATFORM	PASSENGER ACCESS	FENCING[1]	TYPE SERVICE[2]	CURRENT AMTRAK SPEED (MPH)
New Haven	8	High level	Pedestrian underpass	N/A	B	15
Branford, Guilford, Madison, Clinton, Westbrook, Old Saybrook	2	Short, low level, adjacent to one track only	Across tracks at grade	FS	C	50-90
New London	2	Full length, low level, outside both tracks	State St. public grade crossing	I	A	25
Mystic	2	Full length, low level, outside both tracks	Broadway public grade crossing	I	A	55
Westerly	2	Full length, low level, outside both tracks	Pedestrian tunnel to westbound track	I	A	75
Kingston	2	Low level, outside eastbound track; narrow low level between tracks on westbound side	Across track at grade	None	A	100
Providence	4	Full length, high level.	Direct from terminal	N/A	B	N/A[3]
South Attleboro	2	Full length, low level, outside both tracks[4]	Pedestrian overpass to eastbound track	I	C	100

continued on next page

TABLE 8-4 (continued)
STATION CHARACTERISTICS AND PEDESTRIAN ACCESS AT RAILROAD STATIONS

STATION	NO. of TRACKS	PLATFORM	PASSENGER ACCESS	FENCING[1]	TYPE SERVICE[2]	CURRENT AMTRAK SPEED (MPH)
Attleboro	3	Full length, low level, outside both tracks[4]	Underpass on adjacent streets	I	C	95 wb 100 eb
Mansfield	2	Full length, low level, outside both tracks[4]	Underpass on adjacent Route 106	I	C	100
Sharon	2	Full length, low level, outside both tracks	Depot Street overpass	I	C	95
Canton Junction	2	Full length, low level, outside both tracks	Across tracks at grade	I	C	80
Route 128	2	Full length, low level, outside both tracks	Pedestrian overpass to eastbound track	I	B	60
Hyde Park	3	Full length, low level, outside outer tracks	Overpass on River Street	I	C	100
Ruggles	3	Full length, high level between western tracks	Overhead rapid transit station	N/A	C	100
Back Bay	3	Full length, high level	Direct from terminal	N/A	B	N/A[3]
South Station	11	Full length, high level	Direct from terminal	N/A	B	N/A[3]

[1] I = Intertrack fencing; FS = Fencing on far side of tracks from the parking/access; BS = Fencing on both sides of tracks.
[2] A = Amtrak service only; B= Both Amtrak and Commuter Service; C = Commuter service only.
[3] Not applicable because all trains stop at this station.
[4] Also, short, high level platforms outside both tracks for handicapped access.

The no-build alternative would also increase the number of trains operating in the corridor while maintaining current operating speeds, which would consequently increase the potential for accidents. This section describes these changes and their impacts upon public safety within the corridor. Improvements that could be made in conjunction with implementation of the proposed action which may mitigate safety concerns are also described and, where possible, quantified.

8.4.1 Evaluation Criteria

Evaluation criteria for assessing public safety impacts are shown in Table 8-5.

8.4.2 Vehicular Safety Impacts

Estimates of train-highway vehicle collisions were made using procedures outlined in the *FHWA Technical Report TS-86-215 (U.S. DOT/FHWA)* and *Railroad-Highway Grade Crossings Resource Allocation Procedure-Users Guide (FRA/USDOT, 1987)*. Based upon the physical and operating characteristics of each grade crossing (train and traffic volumes and operating speeds, the number of lanes and tracks, roadway condition, and types of traffic control devices present at the crossing) the number and severity of such accidents, on an annual basis were forecast. A comparison of the results produced by the application of these algorithms was made against historical accident/collision data for each grade crossing. The number of predicted accidents is summarized in Table 8-6.

Using the accident/collision prediction methodology, 0.208 collisions annually between Amtrak trains and highway vehicles were predicted for the nine public crossings analyzed; one collision approximately every 4.75 years. This represents a conservative estimate as there have been no reported collisions at any of these crossings since 1985. A total of 0.284 Amtrak-vehicle collisions were predicted for the 2010 no-build conditions and 0.307 collisions with the proposed action (or one every four and three years respectively). Appendix A includes results of the accident prediction modeling for crossings.

TABLE 8-5. EVALUATION CRITERIA FOR PUBLIC SAFETY IMPACTS

IMPACT CRITERIA	MEASURE
Effect of increase of train speed and frequency on vehicular safety.	Comparison of probability of vehicular accidents with current accident rates.
Effect of increase of train speed and frequency on pedestrian safety.	Comparison of probability of pedestrian accidents with current accident rate.

TABLE 8-6
PREDICTED RAIL-VEHICULAR COLLISIONS AT GRADE CROSSINGS
(collisions per year)

CROSSING	ANNUAL NUMBER OF COLLISIONS PREDICTED			TRAIN SPEED LIMIT (MPH)	
	EXISTING	NO-BUILD	BUILD	EXISTING AND NO-BUILD	BUILD
Chapman's Crossing[1]	N/A	N/A	N/A	70	75
Miner Lane	0.024	0.034	0.036	60	80
Bank Street	0.017	0.026	0.028	25	35
State Street	0.021	0.029	0.031	25	35
Governor Wintrop Blvd.	0.031	0.040	0.043	25	35
School Street	0.024	0.032	0.035	70	85
Broadway Extension	0.026	0.034	0.037	50	80
Latimer Point	0.019	0.027	0.030	70	85
Wampassuc	0.018	0.026	0.028	70	80
Walker's Dock[1]	N/A	N/A	N/A	70	100
Freeman's[1]	N/A	N/A	N/A	70	100
Palmer Street	0.028	0.036	0.039	80	100
Wolf Rocks Road[2]	N/A	N/A	N/A	100	140
Lazy Lady Farm[1]	N/A	N/A	N/A	95	150
TOTAL	0.208	0.284	0.307		

[1] This crossing is private. Consequently, no traffic data is available. However, there have been no reported collisions at this location in the past five years. This trend is not anticipated to change under either future alternative.

[2] Crossing is programmed for closure.

For the future conditions, the model was run incorporating the proposed changes in train frequency and speeds as well as the projected traffic volumes at each grade crossing. The physical characteristics at grade crossings, however, were assumed to remain unchanged.
The projected increase in train/vehicle collisions at the grade crossings can be attributed primarily to the increased vehicular traffic and is evidenced by the small difference between the existing and no-build conditions. Speed and operating frequency of trains seems to have minimal

impact on the predicted value of accidents and the change due to electrification would not be significant.

8.4.3 Pedestrian Safety Impacts

The total number of pedestrians crossing the tracks in the project area is not known. However, according to the information obtained from FRA, an average of two persons per year are struck by trains within the study corridor. While many pedestrians use the designated grade crossings, there are other pedestrian crossings and potential accident locations. Twenty two locations were identified, through field surveys and public comments, as being likely railroad ROW crossing points.

Some of these crossings are easily identifiable and are known to the local police. Well worn paths crossing the tracks, breaks in ROW fencing, and other signs are evidence of pedestrian crossing activity. Less frequently used locations cannot be identified. Without the electrification project the number of trains using the corridor on a daily basis would increase by two in each direction by the year 2010. The average train operating speeds would remain unchanged and would, therefore, result in no measurable increase in risk to the pedestrians crossing the tracks.

With the proposed action, however, Amtrak speed limits would increase by between 15 and 55 mph and the frequency of service is proposed to increase from 20 daily trains to 52 trains per day. The increase in train speeds could reduce the amount of time for pedestrians to respond to an approaching train. It could also increase the potential for misjudging the speed of the train and thus the potential for failing to clear the tracks in sufficient time to avoid an accident.

There are no grade separated pedestrian ways at ten of the 22 railroad stations in the study corridor (Canton Junction, MA; Kingston, RI; Mystic, New London, Old Saybrook, Westbrook, Clinton, Madison, Guilford, and Branford, CT). Commuter and Amtrak passengers boarding and alighting the trains at these stations must cross the tracks at grade. These ten and an additional seven stations (Westerly, RI; South Attleboro, Attleboro, Mansfield, Sharon, Canton Junction, Route 128 and Hyde Park, MA) have low level platforms. Low level platforms could encourage crossing the tracks at grade and create a potential safety hazard. At the Connecticut stations, commuters arriving on the track farther from the platform actually alight directly onto the track between the commuter train and the platform. This combination of proposed higher speeds and more frequent express service and the existing low level platforms and at-grade pedestrian crossings, could increase the potential hazards to boarding, alighting and waiting passengers.

8.4.4 Mitigation Measures

8.4.4.1 Vehicular Safety. The 1992 Amtrak Authorization and Development Act (Public Law 102-533) has directed the Secretary of the Department of Transportation to develop a plan by September 30, 1993 for the elimination of all grade crossings on the Northeast Corridor east of New Haven by December 31, 1997. Under this plan, closure of these crossings would closely coincide with implementation of the proposed action. Therefore, no additional mitigation measures are required.

8.4.4.2 Pedestrian Safety. The potential for train-pedestrian accidents could be minimized through increased enforcement of prohibitions against pedestrian entry into the ROW, enhancement of the public safety education programs, and installation of ROW fencing.

Pedestrians walking along or crossing the railroad ROW, except at public crossings, are trespassing on railroad property. While increased enforcement in the form of more frequent patrols by Amtrak security personnel and local police departments would discourage this activity, it is unlikely a sufficient presence could be maintained along the entire 156-mile corridor to be fully effective. It is therefore recommended that resources be concentrated on a more extensive educational program and additional ROW fencing.

Amtrak should enhance the funding of both community and school educational programs in all areas where pedestrians could potentially cross the tracks at grade. These programs should be aimed at both school children and the general public, and should stress the potential hazards associated with high speed trains, and safety issues associated with crossing railroad tracks. It is recommended that Amtrak cooperate with local school officials, in particular, to develop and implement such programs.

The installation of additional fencing along the ROW would reduce pedestrian crossings of the track. Currently, approximately fifteen percent of the corridor has right-of-way fencing; most of the fencing has been installed by the adjacent property owners and is located primarily in urbanized areas. Fencing should be installed at locations where there are established, well-worn paths crossing the tracks, such as those listed in Table 8-7. Additional areas that should be fenced would include areas adjacent to school yards, playgrounds and other recreational areas (e.g., ball fields, beaches, picnic areas, and bike/hiking trails). Residential areas, particularly those with a high density of housing, should also be fenced. Fencing, however, must be placed selectively, so as not to prevent pedestrians who attempt to cross the tracks from safely completing their trip.

Consideration should also be given to the needs of emergency response personnel. In less developed areas, fencing can also adversely affect wildlife by restricting their ability to roam.

The risk of pedestrian accidents in the station areas could increase as a result of the proposed higher speeds and more frequent express service. The stations at which these hazards could exist are shown in Table 8-8. New London and Mystic Station are not included because there are public grade crossings at these stations. Mitigation measures to reduce these hazards would include the installation of flashing signals and bells to warn of the arrival of high-speed trains and platform markings to keep them further away from moving trains.

TABLE 8-7
PROPOSED FENCE LOCATIONS

LOCATION	APPROXIMATE MILEPOST	APPROXIMATE LENGTH (ft.)
Railroad Avenue, Madison, CT	92.8	1,200
Privateer LTD, Clinton, CT	96.0	900
Broadway Street, Westbrook, CT	99.2	800
Westbrook Heights Road, Westbrook, CT	101.3	1,000
Boston Post Road east, Old Saybrook, CT	105.2	1,600
Near Shore Road, Old Lyme, CT	107.6	1,200
Rocky Neck State park, East Lyme, CT	112.7	repair break
Ridgewood Drive, East Lyme, CT	113.8	500
Gada Road, East Lyme, CT	114.8	900
Grand Street, East Lyme, CT	116.2	repair break
Near Milepost 128.3, Groton, CT	128.3	900
Spicer Avenue, Groton, CT	130.3	900
Near Milepost 136.2	136.2	1,200
Old Baptist Road, Warwick, RI	168.5	1,100
Rocky Hollow Road, Warwick, RI	170.0	5,400
Queen Street, Warwick, RI	171.5	480
Alger Avenue, Warwick, RI	172.9	150
Folly Landing, Warwick, RI	173.9	275
Knight Street, Hebronville, MA	193.7	900
Oak Street, Attleboro, MA	197.8	repair break
Morse/Summer Place, East Foxboro, MA	206.0	1,450
Garden Street, Sharon, MA	209.5	1,265
TOTAL	----	22,120

TABLE 8-8
CHANGE IN EXPRESS SERVICE SPEEDS AND RECOMMENDED MITIGATION MEASURES AT RAILROAD STATIONS

STATION	TRAIN SPEED LIMITS		PROPOSED SAFETY MITIGATION MEASURES
	EXISTING & NO-BUILD	BUILD	
Branford*, Guilford*, Madison*, Clinton*, Westbrook*, Old Saybrook*	50 to 90	65 to 120	Flashing signals & bells. Hold commuter trains outside the station when Amtrak through trains are passing.
Westerly	75	100	Flashing signals & bells.
Kingston*	100 wb[1]/ 80 eb	150	Flashing signals & bells.
So. Attleboro	100 wb/95 eb	150	Flashing signals & bells.
Attleboro	95 wb/100 eb	150	Flashing signals & bells.
Mansfield	100	150	Flashing signals & bells.
Sharon	95	140	Flashing signals & bells.
Canton Junction*	off peak: 80[(2)]	150	Flashing signals & bells.
Route 128	60	150	Flashing signals & bells.
Hyde Park	80 wb/100 eb	150	Flashing signals & bells.
Ruggles	100	150	Flashing signals & bells.

* Passengers required to cross tracks at grade.
[1] wb = westbound; eb = eastbound.
[2] In peak periods, 60 mph westbound and 50 mph eastbound.

APPENDIX A
Accident Prediction Modeling Results

ACCIDENT PREDICTION MODEL - 1992 Existing Conditions

CROSSING NAME: Miner Lane (MP120.20 - ID 500319L) Waterford, CT

Input Values		CALCULATED VALUES Number of Accidents Per Yr		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	900	EI	29.492879	MS	0.0168	MS	0.2455
Trains/Day	22	MT	1.353102	TT	0.7608	TK	1.2594
No. Main Tracks	2	DT	2.108923	TS	1.1005	UR	1.3445
Trains/Daylight	13	HP	1.000000	UR	1.4290	PI	0.3493
Pavement Type	1	MS	1.000000	PF	0.1014		
Max Speed	60	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2						
TO	9	a	0.055727				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.024476				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 1992 Existing Conditions

CROSSING NAME: State Street (MP122.76–ID 500295A) New London, CT

Input Values		CALCULATED VALUES: Number of Accidents Per Yr		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	500	EI	24.809444	MS	0.0402	MS	0.3315
Trains/Day	22	MT	1.353102	TT	0.7608	TK	1.2594
No. Main Tracks	2	DT	2.108923	TS	1.1005	UR	1.3445
Trains/Daylight	13	HP	1.000000	UR	1.4290	PI	0.2845
Pavement Type	1	MS	1.000000	PF	0.0450		
Max Speed	25	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2						
TO	10	a	0.046878				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.021203				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 1992 Existing Conditions

CROSSING NAME: Gov. Winthrop Blvd.(MP123.07–ID 500294T) New London, CT

Input Values		CALCULATED VALUES Number of Accidents Per Yr		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	2471	EI	39.697336	MS	0.0402	MS	0.3315
Trains/Day	22	MT	1.353102	TT	0.7608	TK	1.2594
No. Main Tracks	2	DT	2.108923	TS	1.1005	UR	1.3445
Trains/Daylight	13	HP	1.000000	UR	1.4290	PI	0.2845
Pavement Type	1	MS	1.000000	PF	0.0450		
Max Speed	25	HT	1.000000				
Highway Type	3	HL	1.152577				
No. of Lanes	2						
TO	8	a	0.075009				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.030991				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Frincp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 1992 Existing Conditions

CROSSING NAME: School Street (MP131.50–ID 500278J) Groton, CT

Input Values		CALCULATED VALUES Number of Accidents Per Yr		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	900	EI	28.677386	MS	0.0144	MS	0.2329
Trains/Day	20	MT	1.353102	TT	0.7668	TK	1.2594
No. Main Tracks	2	DT	2.108923	TS	1.1005	UR	1.3445
Trains/Daylight	13	HP	1.000000	UR	1.4290	PI	0.3614
Pavement Type	1	MS	1.000000	PF	0.1155		
Max Speed	70	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2						
TO	10	a	0.054186				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.023920				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL - 1992 Existing Conditions

CROSSING NAME: Broadway Extention (MP132.3–ID 500277C) Stonington, CT

Input Values		CALCULATED VALUES					
		Number of Accidents Per Yr		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	1220	EI	31.362315	MS	0.0201	MS	0.2614
Trains/Day	20	MT	1.353102	TT	0.7668	TK	1.2594
No. Main Tracks	2	DT	2.108923	TS	1.1005	UR	1.3445
Trains/Daylight	13	HP	1.000000	UR	1.4290	PI	0.3352
Pavement Type	1	MS	1.000000	PF	0.0854		
Max Speed	50	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2						
TO	9	a	0.059260				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.025730				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 1992 Existing Conditions

CROSSING NAME: Latimer Point Road (MP133.40 – ID 500275N) Stonington, CT

Input Values		CALCULATED VALUES Number of Accidents Per Yr		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	370	EI	22.078441	MS	0.0144	MS	0.2329
Trains/Day	20	MT	1.353102	TT	0.7668	TK	1.2594
No. Main Tracks	2	DT	2.108923	TS	1.1005	UR	1.8076
Trains/Daylight	13	HP	1.000000	UR	2.0421	PI	0.2963
Pavement Type	1	MS	1.000000	PF	0.0837		
Max Speed	70	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2						
TO	11	a	0.041718				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.019203				
Urban/Rural	2						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 1992 Existing Conditions

CROSSING NAME: Wampassuc (MP134.9–ID500272T) Stonington, CT

Input Values		CALCULATED VALUES					
		Number of Accidents Per Yr		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	306	EI	20.878698	MS	0.0144	MS	0.2329
Trains/Day	20	MT	1.353102	TT	0.7668	TK	1.2594
No. Main Tracks	2	DT	2.108923	TS	1.1005	UR	1.3445
Trains/Daylight	13	HP	1.000000	UR	1.4290	PI	0.3614
Pavement Type	1	MS	1.000000	PF	0.1155		
Max Speed	70	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2						
TO	11	a	0.039451				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.018302				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 1992 Existing Conditions

CROSSING NAME: Palmer Street (MP140.55 – ID 500263S) Stonington, CT

Input Values		CALCULATED VALUES Number of Accidents Per Yr		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	1653	EI	34.293882	MS	0.0126	MS	0.2225
Trains/Day	20	MT	1.353102	TT	0.7668	TK	1.2594
No. Main Tracks	2	DT	2.108923	TS	1.1005	UR	1.8076
Trains/Daylight	13	HP	1.000000	UR	2.0421	PI	0.3059
Pavement Type	1	MS	1.000000	PF	0.0945		
Max Speed	80	HT	1.000000				
Highway Type	5	HL	1.152577				
No. of Lanes	2						
TO	9	a	0.064799				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.027641				
Urban/Rural	2						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL - 1992 Existing Conditions

Summary of Results

Grade Crossing	Accidents Per Year	Fatality Probabilit	Injury Probability
Miner Lane (MP120.20--ID 500319L) Waterford, CT	0.024	0.101	0.349
Bank Street (MP122.50-ID 500297N) New London, CT	0.017	0.045	0.284
State Street (MP122.76-ID 500295A) New London, CT	0.021	0.045	0.284
Gov. Winthrop Blvd.(MP123.07-ID 500294T) New London, CT	0.031	0.045	0.284
School Street (MP131.50-ID 500278J) Groton, CT	0.024	0.116	0.361
Broadway Extention (MP132.3-ID 500277C) Stonington, CT	0.026	0.085	0.335
Latimer Point Road (MP133.40-ID 500275N) Stonington, CT	0.019	0.084	0.296
Wampassuc (MP134.9-ID500272T) Stonington, CT	0.018	0.116	0.361
Palmer Street (MP140.55-ID 500263S) Stonington, CT	0.028	0.095	0.306
Total	0.208		

ACCIDENT PREDICTION MODEL – 2010 No–Build Conditions

CROSSING NAME: Miner Lane (MP120.20–ID 500319L) Waterford, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	1200	EI	34.457737	MS	0.0168	MS	0.2455
Trains/Day	28	MT	1.353102	TT	0.7456	TK	1.2594
No. Main Tracks	2	DT	2.694038	TS	1.1005	UR	1.3445
Trains/Daylight	?2	HP	1.000000	UR	1.4290	PI	0.3493
Pavement Type	1	MS	1.000000	PF	0.1033		
Max Speed	60	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	8	a	0.083173				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.033521				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 No-Build Conditions

CROSSING NAME: Bank Street (MP122.50–ID 500297N) New London, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	400	EI	24.941306	MS	0.0402	MS	0.3315
Trains/Day	28	MT	1.353102	TT	0.7456	TK	1.2594
No. Main Tracks	2	DT	2.694038	TS	1.1005	UR	1.3445
Trains/Daylight	52	HP	1.000000	UR	1.4290	PI	0.2845
Pavement Type	1	MS	1.000000	PF	0.0459		
Max Speed	25	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	9	a	0.060202				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.026060				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 No-Build Conditions

CROSSING NAME: State Street (MP122.76-ID 500295A) New London, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	600	EI	28.101175	MS	0.0402	MS	0.3315
Trains/Day	28	MT	1.353102	TT	0.7456	TK	1.2594
No. Main Tracks	2	DT	2.694038	TS	1.1005	UR	1.3445
Trains/Daylight	52	HP	1.000000	UR	1.4290	PI	0.2845
Pavement Type	1	MS	1.000000	PF	0.0459		
Max Speed	25	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	8	a	0.067830				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.028657				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 No-Build Conditions

CROSSING NAME: Gov. Winthrop Blvd.(MP123.07-ID 500294T) New London, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	2600	EI	43.258990	MS	0.0402	MS	0.3315
Trains/Day	28	MT	1.353102	TT	0.7456	TK	1.2594
No. Main Tracks	2	DT	2.694038	TS	1.1005	UR	1.3445
Trains/Daylight	52	HP	1.000000	UR	1.4290	PI	0.2845
Pavement Type	1	MS	1.000000	PF	0.0459		
Max Speed	25	HT	1.000000				
Highway Type	3	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	6	a	0.104417				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.039561				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 No–Build Conditions

CROSSING NAME: School Street (MP131.50–ID 500278J) Groton, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	1000	EI	32.658165	MS	0.0144	MS	0.2329
Trains/Day	28	MT	1.353102	TT	0.7456	TK	1.2594
No. Main Tracks	2	DT	2.694038	TS	1.1005	UR	1.3445
Trains/Daylight	52	HP	1.000000	UR	1.4290	PI	0.3614
Pavement Type	1	MS	1.000000	PF	0.1184		
Max Speed	70	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	8	a	0.078829				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.032190				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 No–Build Conditions

CROSSING NAME: Broadway Extention (MP132.3–ID 500277C) Stonington, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	1300	EI	35.278792	MS	0.0201	MS	0.2614
Trains/Day	28	MT	1.353102	TT	0.7456	TK	1.2594
No. Main Tracks	2	DT	2.694038	TS	1.1005	UR	1.3445
Trains/Daylight	52	HP	1.000000	UR	1.4290	PI	0.3352
Pavement Type	1	MS	1.000000	PF	0.0876		
Max Speed	50	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	7	a	0.085155				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.034117				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 No-Build Conditions

CROSSING NAME: Latimer Point Road (MP133.40 – ID 500275N) Stonington, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	500	EI	26.633587	MS	0.0144	MS	0.2329
Trains/Day	28	MT	1.353102	TT	0.7456	TK	1.2594
No. Main Tracks	2	DT	2.694038	TS	1.1005	UR	1.8076
Trains/Daylight	52	HP	1.000000	UR	2.0421	PI	0.2963
Pavement Type	1	MS	1.000000	PF	0.0859		
Max Speed	70	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	9	a	0.064287				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.027467				
Urban/Rural	2						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 No-Build Conditions

CROSSING NAME: Wampassuc (MP134.9-ID500272T) Stonington, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	400	EI	24.941306	MS	0.0144	MS	0.2329
Trains/Day	28	MT	1.353102	TT	0.7456	TK	1.2594
No. Main Tracks	2	DT	2.694038	TS	1.1005	UR	1.3445
Trains/Daylight	52	HP	1.000000	UR	1.4290	PI	0.3614
Pavement Type	1	MS	1.000000	PF	0.1184		
Max Speed	70	HT	1.000000				
Highway Type	6	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	9	a	0.060202				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.026060				
Urban/Rural	1						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 No-Build Conditions

CROSSING NAME: Palmer Street (MP140.55–ID 500263S) Stonington, CT

Input Values		C A L C U L A T E D		V A L U E S Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	1700	EI	38.175917	MS	0.0126	MS	0.2225
Trains/Day	28	MT	1.353102	TT	0.7456	TK	1.2594
No. Main Tracks	2	DT	2.694038	TS	1.1005	UR	1.8076
Trains/Daylight	52	HP	1.000000	UR	2.0421	PI	0.3059
Pavement Type	1	MS	1.000000	PF	0.0970		
Max Speed	80	HT	1.000000				
Highway Type	5	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	7	a	0.092148				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.036164				
Urban/Rural	2						
Switch Trains	2						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL - 2010 No-Build Conditions

Summary of Results

Grade Crossing		Accidents Per Year	Fatality Probability	Injury Probability
Miner Lane (MP120.20-ID 500319L) Waterford, CT		0.034	0.103	0.349
Bank Street (MP122.50-ID 500297N) New London, CT		0.026	0.046	0.284
State Street (MP122.76-ID 500295A) New London, CT		0.029	0.046	0.284
Gov. Winthrop Blvd.(MP123.07-ID 500294T) New London, CT		0.040	0.046	0.284
School Street (MP131.50-ID 500278J) Groton, CT		0.032	0.118	0.361
Broadway Extention (MP132.3-ID 500277C) Stonington, CT		0.034	0.088	0.335
Latimer Point Road (MP133.40-ID 500275N) Stonington, CT		0.027	0.086	0.296
Wampassuc (MP134.9-ID500272T) Stonington, CT		0.026	0.118	0.361
Palmer Street (MP140.55-ID 500263S) Stonington, CT		0.036	0.097	0.306
	Total	0.284		

ACCIDENT PREDICTION MODEL – 2010 Build Conditions

CROSSING NAME: Miner Lane (MP120.20–ID 500319L) Waterford, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	1200	EI	41.340973	MS	0.0126	MS	0.2225
Trains/Day	52	MT	1.353102	TT	0.7074	TK	1.2594
No. Main Trac	2	DT	2.498599	TS	1.0000	UR	1.3445
Trains/Daylight	34	HP	1.000000	UR	1.4292	PI	0.3721
Pavement Typ	1	MS	1.000000	PF	0.1511		
Max Speed	80	HT	1.000000				
Highway Type	4	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	7	a	0.092548				
Acc. Data (yrs)	5						
No. Accidents	0	A	0.036279				
Urban/Rural	1						
Switch Trains	0						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 Build Conditions

CROSSING NAME: Bank Street (MP122.50–ID 500297N) New London, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	400	EI	29.923503	MS	0.0288	MS	0.2954
Trains/Day	52	MT	1.353102	TT	0.7074	TK	1.2594
No. Main Trac	2	DT	2.498599	TS	1.0000	UR	1.3445
Trains/Dayligh	34	HP	1.000000	UR	1.4290	PI	0.3085
Pavement Typ	1	MS	1.000000	PF	0.0724		
Max Speed	35	HT	1.000000				
Highway Type	4	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	9	a	0.066988				
Acc. Data (yrs	5						
No. Accidents	0	A	0.028377				
Urban/Rural	1						
Switch Trains	0						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL - 2010 Build Conditions

CROSSING NAME: State Street (MP122.76 - ID 500295A) New London, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	600	EI	33.714605	MS	0.0288	MS	0.2954
Trains/Day	52	MT	1.353102	TT	0.7074	TK	1.2594
No. Main Trac	2	DT	2.498599	TS	1.0000	UR	1.3445
Trains/Daylight	34	HP	1.000000	UR	1.4290	PI	0.3085
Pavement Typ	1	MS	1.000000	PF	0.0724		
Max Speed	35	HT	1.000000				
Highway Type	4	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	8	a	0.075475				
Acc. Data (yrs	5						
No. Accidents	0	A	0.031139				
Urban/Rural	1						
Switch Trains	0						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 Build Conditions

CROSSING NAME: Gov. Winthrop Blvd.(MP123.07–ID 500294T) New London, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	2600	EI	51.900376	MS	0.0288	MS	0.29[illegible]4
Trains/Day	52	MT	1.353102	TT	0.7074	TK	1.2594
No. Main Trac	2	DT	2.498599	TS	1.0000	UR	1.3445
Trains/Daylight	34	HP	1.000000	UR	1.4290	PI	0.3085
Pavement Typ	1	MS	1.000000	PF	0.0724		
Max Speed	35	HT	1.000000				
Highway Type	4	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	6	a	0.116187				
Acc. Data (yrs	5						
No. Accidents	0	A	0.042606				
Urban/Rural	1						
Switch Trains	0						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL - 2010 Build Conditions

CROSSING NAME: School Street (MP131.50-ID 500278J) Groton, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	1000	EI	39.181914	MS	0.0119	MS	0.2179
Trains/Day	52	MT	1.353102	TT	0.7074	TK	1.2594
No. Main Trac	2	DT	2.498599	TS	1.0000	UR	1.3445
Trains/Dayligh	34	HP	1.000000	UR	1.4290	PI	0.3769
Pavement Typ	1	MS	1.000000	PF	0.1590		
Max Speed	85	HT	1.000000				
Highway Type	4	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	7	a	0.087715				
Acc. Data (yrs	5						
No. Accidents	0	A	0.034877				
Urban/Rural	1						
Switch Trains	0						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 Build Conditions

CROSSING NAME: Broadway Extention (MP132.3 – ID 500277C) Stonington, CT

Input Values		CALCULATED	VALUES	Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	1300	EI	42.326043	MS	0.0126	MS	0.2225
Trains/Day	52	MT	1.353102	TT	0.7074	TK	1.2594
No. Main Trac	2	DT	2.498599	TS	1.0000	UR	1.3445
Trains/Dayligh	34	HP	1.000000	UR	1.4290	PI	0.3721
Pavement Typ	1	MS	1.000000	PF	0.1511		
Max Speed	80	HT	1.000000				
Highway Type	4	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	7	a	0.094753				
Acc. Data (yrs	5						
No. Accidents	0	A	0.036906				
Urban/Rural	1						
Switch Trains	0						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 Build Conditions

CROSSING NAME: Latimer Point Road (MP133.40 – ID 500275N) Stonington, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	500	EI	31.953844	MS	0.0119	MS	0.2179
Trains/Day	52	MT	1.353102	TT	0.7074	TK	1.2594
No. Main Trac	2	DT	2.498599	TS	1.0000	UR	1.3445
Trains/Daylight	34	HP	1.000000	UR	1.4290	PI	0.3769
Pavement Typ	1	MS	1.000000	PF	0.1590		
Max Speed	85	HT	1.000000				
Highway Type	4	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	8	a	0.071534				
Acc. Data (yrs	5						
No. Accidents	0	A	0.029874				
Urban/Rural	1						
Switch Trains	0						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 Build Conditions

CROSSING NAME: Wampassuc (MP134.9–ID500272T) Stonington, CT

Input Values		CALCULATED VALUES					
				Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	400	EI	29.923503	MS	0.0126	MS	0.2225
Trains/Day	52	MT	1.353102	TT	0.7074	TK	1.2594
No. Main Trac	2	DT	2.498599	TS	1.0000	UR	1.3445
Trains/Daylight	34	HP	1.000000	UR	1.4290	PI	0.3721
Pavement Typ	1	MS	1.000000	PF	0.1511		
Max Speed	80	HT	1.000000				
Highway Type	4	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	9	a	0.066988				
Acc. Data (yrs	5						
No. Accidents	0	A	0.028377				
Urban/Rural	1						
Switch Trains	0						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL – 2010 Build Conditions

CROSSING NAME: Palmer Street (MP140.55 – ID 500263S) Stonington, CT

Input Values		CALCULATED VALUES		Fatality Probability		Injury Probability	
CROSS TYPE	3	K	0.000575	CF	440.90	CI	4.48
ADT	1700	EI	45.801903	MS	0.0101	MS	0.2061
Trains/Day	52	MT	1.353102	TT	0.7074	TK	1.2594
No. Main Trac	2	DT	2.498599	TS	1.0000	UR	1.3445
Trains/Dayligh	34	HP	1.000000	UR	1.4290	PI	0.3901
Pavement Typ	1	MS	1.000000	PF	0.1820		
Max Speed	100	HT	1.000000				
Highway Type	4	HL	1.152577				
No. of Lanes	2	Number of Accidents Per Yr					
TO	7	a	0.102535				
Acc. Data (yrs	5						
No. Accidents	0	A	0.039055				
Urban/Rural	1						
Switch Trains	0						

a = Initial Accident Prediction Factor
A = Final Accident Prediction Factor
PF = Probability of a Fatal Accident
PI = Probability of an Injury Accident

Highway Type	Inventory Code	ht Value	Highway	
Rural				
Interstate	01	1	Paved	1
Princp Art	02	2	Unpaved	2
Minor Art	06	3		
Major Col	07	4	Urban	1
Minor Col	08	5	Rural	2
Local	09	6		
Urban				
Interstate	11	1		
Other Frway	12	2		
Princp Art	14	3		
Minor Art	16	4		
Col	17	5		
Local	19	6		

ACCIDENT PREDICTION MODEL - 2010 Build Conditions

Summary of Results

Grade Crossing	Accidents Per Year	Fatality Probability	Injury Probability
Miner Lane (MP120.20-ID 500319L) Waterford, CT	0.03627918	0.15109893	0.37205495
Bank Street (MP122.50-ID 500297N) New London, CT	0.03	0.07	0.31
State Street (MP122.76-ID 500295A) New London, CT	0.0311	0.07235828	0.3085
Gov. Winthrop Blvd.(MP123.07-ID 500294T) New London, CT	0.0426	0.07235828	0.3085
School Street (MP131.50-ID 500278J) Groton, CT	0.0349	0.15903865	0.3769
Broadway Extention (MP132.3-ID 500277C) Stonington, CT	0.0369	0.15111176	0.3721
Latimer Point Road (MP133.40-ID 500275N) Stonington, CT	0.0299	0.15903865	0.3769259
Wampassuc (MP134.9-ID500272T) Stonington, CT	0.02837707	0.15111176	0.37205495
Palmer Street (MP140.55-ID 500263S) Stonington, CT	0.03905532	0.18195049	0.39010453
Total	0.30748948		

TECHNICAL STUDY 9
TRANSPORTATION, TRAFFIC AND CIRCULATION

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9.1 INTRODUCTION

This study addresses the potential effects of Amtrak's proposed electrification project on transportation patterns and resources, including rail, automobile and aircraft. The proposed action would increase the number of trains operating on the Northeast Corridor (NEC) rail line and result in increased Amtrak intercity ridership; an increase that is anticipated to be achieved by attracting additional ridership from other modes of intercity travel in the corridor. Both positive and negative transportation effects may result from these changes in modal choice as described below:

- **Increased Traffic on the Rail Corridor.** The proposed action would increase both the number of Amtrak trains operating along the NEC and the average operating speeds of these trains. Increased Amtrak service may also affect freight and commuter rail services operating within the corridor.

- **Increased Traffic at Railroad Stations.** The primary effect of increased Amtrak ridership would be evidenced on the street network in the immediate vicinity of rail stations served by the proposed new service. These stations include the five at which Amtrak's proposed express service would stop: New Haven, CT; Providence, RI; and Route 128, Back Bay and South Station in Massachusetts. Increased patronage would increase the amount of traffic approaching each express station, resulting in some potential for deterioration of traffic operations in the vicinity of the stations. Additional rail patronage would also increase demand for parking at the rail stations.

- **Reduced Automobile and Aircraft Use.** Changes in modal choice for intercity travel in the NEC, from aircraft or automobiles to Amtrak's passenger service, may affect airport surface and highway congestion. Improved intercity rail service would have the potential to reduce the number of airline flights between cities served by train service, thereby reducing congestion in the vicinity of the corridor's airports. Intercity highways would also exhibit some decrease in traffic volumes and associated congestion where travelers choose to travel by train rather than by automobile.

- **Construction Impacts.** Short-term, construction-related impacts may affect automobile traffic in the areas of the highway bridges to be modified to accommodate the catenary system.

- **Changes in Delay at Highway-Railroad Grade Crossings.** The proposed electrification would include increased frequency and length of trains, which may change the existing delays experienced by motorists at grade crossings.

TABLE 9-1
EXISTING (1988) DISTRIBUTION OF ANNUAL TRIPS BY TRAVEL MODE

TRAVEL MODE	NUMBER TRIPS	% OF TRIPS
Intercity Train	1,053,000	5.85
Intercity Aircraft	3,529,000	19.61
Automobile	13,418,000	74.54
TOTAL	**18,000,000**	**100**

SOURCE: Volpe Center, 1992

9.3.1.1 Existing Amtrak Service and Ridership. Based on the Amtrak Northeast Timetable (October 1992 through April 1993), ten trains depart from Boston's South Station on a daily basis operating to New Haven via Providence and points south. Two are express trains, of which one makes intermediate stops only at Back Bay, Route 128 and Providence Stations while the second express train also stops at New London. The remaining trains make all of the express service stops as well as providing service to stations at Kingston and Westerly, Rhode Island and Mystic and Old Saybrook, Connecticut; however, not all such trains make all intermediate stops between Boston and New Haven.

An equal number of trains travel in the opposite direction from points south through New Haven to Boston. In addition to this service, Amtrak operates one daily round trip train between Washington, DC, and Montreal, PQ, along the railroad route between New Haven and New London. This train, known as the Montrealer, makes station stops at New Haven and New London. Table 9-2 shows the departure, arrival and travel times for typical weekday service. Table 9-3 shows the number of daily departures for each station. Over 16 million passengers board and alight at these stations annually, including nearly 1.8 million Amtrak passengers and 14.2 million commuter service passengers (Table 9-4).

Ridership on the New York to Boston segment of the NEC has not increased significantly since Amtrak introduced new equipment and instituted new marketing and pricing programs in the late 1970s. In fact, ridership dropped dramatically in the early 1980s due to competition from Peoples Express Airline, which went out of business in the mid 1980s.

9.3.1.2 Other Existing Intercity Travel Modes. There are three other available modes of travel in the NEC: intercity bus, airlines and automobiles. Intercity bus travel is not addressed herein because it is not anticipated to be affected by the proposed project. As the least expensive but most time consuming mode of travel, it appears that intercity bus riders are not time sensitive. Conversely, aircraft and automobile use are more likely to be affected by the proposed electrification project and the existing use of these modes is discussed below.

TABLE 9-2
EXISTING BOSTON-NEW HAVEN AMTRAK SERVICE ON THE NORTHEAST CORRIDOR[1]

10 WEEKDAY WESTBOUND TRAINS

TRAIN NUMBER	TRAIN TYPE	NO. OF STOPS	DEPART BOSTON	ARRIVE N.H.	TRAVEL TIME
151	Express	4	6:05A	8:34A	2 hrs.- 29'
169	Conven.	8	7:10A	10:08A	2 hrs.- 58'
171	Conven.	6	9:15A	12:09P	2 hrs.- 54'
155	Express	3	10:15A	12:39P	2 hrs.- 24'
173	Conven.	5	11:15A	2:05P	2 hrs.- 50'
175	Conven.	4	1:30P	4:15P	2 hrs.- 45'
177	Conven.	7	3:10P	6:13P	3 hrs.- 03'
179	Conven.	4	4:30P	7:12P	2 hrs.- 42'
193	Conven.	8	6:10P	9:05P	2 hrs.- 55'
67	Conven.	7	10:10P	1:16A	3 hrs.- 06'

10 WEEKDAY EASTBOUND TRAINS

TRAIN NUMBER	TRAIN TYPE	NO. OF STOPS	DEPART BOSTON	ARRIVE N.H.	TRAVEL TIME
190	Conven.	8	11:19A	2:15P	2 hrs.- 56'
170	Conven.	6	1:12P	4:03P	2 hrs.- 51'
172	Conven.	7	3:04P	6:00P	2 hrs.- 56'
154	Express	4	3:45P	6:14P	2 hrs.- 29'
174	Conven.	8	5:04P	8:08P	3 hrs.- 04'
156	Express	3	5:53P	8:22P	2 hrs.- 29'
176	Conven.	6	7:13P	10:00P	2 hrs.- 47'
178	Conven.	8	9:07P	12:14A	3 hrs.- 07'
66	Conven.	8	5:17A	8:35A	3 hrs.- 18'
12	Conven.	4	8:57A	11:54A	2 hrs.- 57'

NOTES: [1] Service continues south.
Express = Express train with reservations required.
Conven. = Conventional train without reservations required.

SOURCE: Amtrak, Northeast Timetable, October 25, 1992 through April 3, 1993.

TABLE 9-3
TOTAL EXISTING AMTRAK DAILY DEPARTURES

STATION	WESTBOUND	EASTBOUND
Boston/South St.	10	--
Boston/Back Bay	10	10
Boston/Rt. 128	10	10
Providence	10	10
Kingston	9	9
Westerly	5	5
Mystic	6	6
New London	11	10
Old Saybrook	10	10
New Haven	--	11

SOURCE: Amtrak, Northeast Timetable, October 25, 1992 through April 3, 1993.

TABLE 9-4
EXISTING AMTRAK AND COMMUTER RIDERSHIP AT EXPRESS STATIONS
(on & off in thousands)

STATION	AMTRAK PASSENGERS	COMMUTER RAIL PASSENGERS	TOTAL
South Station	897	7,100	7,997
Back Bay	121	4,356	4,477
Route 128	161	815	976
Providence	305	320	625
New Haven	314	1,647	1,961
TOTAL	**1,798**	**14,238**	**16,036**

SOURCE: Amtrak, MBTA, ConnDOT

Existing Air Passenger Service and Ridership. Of the approximately 18 million total intercity trips made in the Northeast corridor in 1988, approximately 3.5 million (19.6 percent) were made by air (Table 9-1). Air passenger service in the NEC is provided between Boston and New York, Boston and Providence, Providence and New Haven, and Providence and New York (there is no commercial airline service available between Boston and New Haven). Service between these cities is discussed below.

Boston-New York. There are 81 scheduled daily departures from Boston to the three New York airports (LaGuardia, John F. Kennedy, and Newark). Six commercial airlines provide service between Boston and New York: American Airlines, Continental Airlines, U.S. Air, Delta Airlines, TWA, and Northwest Airlines. According to the *January 1993 Official Airline Guide*, (Rand McNally, 1993) the first flight leaves Boston at 6:00 a.m. and the last departure is at 10:50 p.m. Scheduled service from the New York airports to Boston is almost identical. The first flight leaves New York at 6:20 a.m. and the last departure is scheduled for 10:00 p.m.

Providence-New York. There are 48 scheduled flights in each direction between Providence and New York. The first flight leaves New York at 6:45 a.m. and the last flight departs at 10:40 p.m. The first flight leaves Providence at 6:30 a.m. and the last departure is scheduled for 9:30 p.m. (Rand McNally, 1993). American Airlines, Continental Airlines, U.S. Air, TWA, and Delta Airlines provide service between Providence and New York.

Boston-Providence: There are eight departures from Boston for Providence and six departures from Providence to Boston. Only Delta Airlines provides service between these two cites.

Providence-New Haven: There are three daily flights in each direction between Providence and New Haven. Delta Airlines provides this service.

Existing Automobile Travel. Automobiles provide the largest share of all modes for passenger transportation in this corridor. Of approximately 18 million intercity trips in the Northeast corridor in 1988, 13.4 million (74.5 percent) trips were made by automobile (Table 9-1). The approximate distance and vehicular travel time between the proposed express service cities in the NEC are shown below:

	Approximate Distance (miles)	Automobile Travel Time
Boston - Providence	48	50 minutes
Boston - New Haven	148	2 hours and 40 minutes
Boston - New York	225	4 hours
Providence - New Haven	104	2 hours
Providence - New York	181	3 hours and 20 minutes
New Haven - New York	77	1 hour and 25 minutes

The existing annual vehicle miles of travel (VMT) between the potentially affected express service city pairs are as follows:

City Pair	Existing Total VMT (in millions)
Boston - New Haven	278
Boston - New York	1,760
Providence - New Haven	29
Providence - New York	593

9.3.2 Other Existing Rail Operations

Two freight and two commuter rail systems operate on portions of the NEC between New Haven and Boston. A description of their operations is provided below.

9.3.2.1 Existing Freight Rail Operations and Requirements

Existing Freight Rail Operations. For many years, the NEC segment from Boston to New Haven was a major freight service corridor. However, all long haul freight trains have been routed away from the Boston to New Haven route and local service freight train operations have been substantially reduced. Today, two freight railroads operate within the Northeast Corridor: Consolidated Rail Corporation (Conrail) and the Providence and Worcester Railroad (P&W). Conrail operates freight service along NEC route segments in Massachusetts and P&W operates along NEC route segments in Connecticut and Rhode Island. Conrail service is not anticipated to be adversely affected by the proposed action and, therefore, is not discussed further. Table 9-5 shows a typical daily pattern of freight service operations between New Haven and Boston.

Freight Service Clearance Requirements. The freight railroad industry has developed larger capacity and new technology cars to meet the needs of its customers. Some cars require higher vertical clearance dimensions and have been limited to route segments which can accommodate these specialized car movements. In terms of specific vertical measurements, the appropriate dimension is a car clearance standard which defines the distance from the top of rail to the top of car. The freight cars and equipment now in general use throughout the United States include these types:

Plate B Low Height Boxcar. This is a minimal height general purpose boxcar which possesses a car clearance vertical dimension of 15'-1".

Plate C Standard Boxcar. This is also a general purpose boxcar which has a slightly higher vertical car clearance dimension of 15'-6".

Plate F "High Cube" Boxcar. This is a larger capacity boxcar which involves a vertical car clearance height of 17'-0".

Trailer on Flat Car (TOFC). This equipment consists of a specialized railroad flat car that supports a truck trailer (or trailers), and requires a car clearance of 17'-0".

Enclosed Tri Level Auto Carrier Car. This car was developed over the past several years in order to transport finished automobiles in damage-proof equipment and requires a car clearance of 19'-1".

Double Stack Car. This car evolved from technology known as Container on Flat Car (COFC). This arrangement is similar to TOFC except that the truck trailer is separated from its wheel assembly and then placed on the railroad flat car. For a single container on the flat car, the equipment vertical clearance is substantially less than the TOFC arrangement. The railroad industry has now devised a specialized low floor articulated flatcar upon which two containers are "stacked". This arrangement requires high clearance routes for such trains. Since there are two standard container heights (8'-6" and 9'-6"), the car clearance vertical standard differs according to the mix of the two container types, as follows:

Mix	Car Clearance[1]
Two 8'-6" units	18'-0"
One unit of each	19'-0"
Two 9'-6" units	20'-0"

[1] Includes container car platform which is 1'-0" above top of rail

The preceding discussion has focused on the physical car clearance vertical dimensions. To define the total required vertical clearance, railroads generally add a 3 to 6 inch tolerance to the car clearance dimension. Therefore, a double stack configuration of two 9'-6" cars would require a 20'-6" vertical clearance from top of rail to the underside of any structure above the track. At present, because of the vertical clearance limitations of a large number of overhead structures, the NEC route between New Haven and Boston does not permit operations of Enclosed Tri Level Auto carrier cars or of any of the double stack configurations.

9.3.2.2 Existing Commuter Rail Operations. Commuter rail operations occur within two distinct segments on the Northeast Corridor: between Boston and Providence and between New Haven and Old Saybrook. The Massachusetts Bay Transportation Authority (MBTA) provides commuter rail service between Boston and Providence. At the present time, the daily two-way frequency of commuter trains ranges from 10 along the Providence-South Attleboro segment (MP185.0 to MP 192.0) to 130 trains along the Forest Hills-South Station segment (MP 223.7 to MP 229.3).

TABLE 9-5
EXISTING FREIGHT SERVICE ON THE NEC
(weekday two-way operations)

LINE SEGMENT	MILEPOST LIMITS	NO. of TRAINS (1993)
New Haven-Groton	73.8-124.6	2
Groton-Davisville	124.6-168.0	0
Davisville-Atwells	168.0-184.2	2
Atwells-Lawn	184.2-188.8	4
Lawn-South Attleboro	188.8-192.2	0
South Attleboro-Attleboro	197.2-192.2	2
Attleboro-Mansfield	197.2-204.2	4
Mansfield-Canton Junction	204.2-213.8	2
Canton Junction-Route 128	213.8-217.2	4
Route 128-Readville	217.2-220.0	6
Readville-Back Bay	220.0-228.0	0
Back Bay-Boston Herald	228.0-228.3	4
Boston Herald-South Bay Wye	228.3-228.5	2
South Bay Wye-South Station	228.5-229.4	0
TOTAL		32

SOURCE: Providence & Worcester Railroad and Conrail.

In 1990, the Connecticut Department of Transportation (ConnDOT) contracted with Amtrak to operate a new commuter passenger service between Old Saybrook and New Haven with five intermediate stops. This service is known as Shore Line East and consists of the operation of 18 trains per day; 8 in the westbound direction and 10 in the eastbound direction. Table 9-4 shows the existing intercity and commuter rail boarding and alighting at each Amtrak express station and Table 9-6 shows the number of daily commuter rail departures on all commuter rail stations in the New Haven-Boston segment of the NEC.

TABLE 9-6
EXISTING COMMUTER RAIL SERVICE ON THE NORTHEAST CORRIDOR
(number of daily departures)

STATION	WESTBOUND	EASTBOUND
MBTA		
Boston/South Station	67	..
Boston/Back Bay	64	63
Ruggles Street	43	28
Hyde Park	17	21
Route 128	26	27
Canton Junction	20	24
Sharon	14	14
Mansfield	16	16
Attleboro	14	16
South Attleboro	5	14
RIDOT		
Providence	-	5
ConnDOT		
Old Saybrook	8	-
Westbrook	8	10
Clinton	8	10
Madison	8	10
Guilford	8	10
Branford	8	10
New Haven	-	10

SOURCE: MBTA and ConnDOT

Currently, no commuter passenger trains operate on the NEC segment between Old Saybrook and Providence. However, the Rhode Island Department of Transportation is considering plans to reinstate passenger service south of Providence to Kingston. No specific program has been funded at this time.

9.3.3 Existing Traffic Operations in the Northeast Corridor

9.3.3.1 Existing Traffic and Parking at Express Railroad Passenger Stations. There are 22 railroad passenger stations on the NEC between and including New Haven and South Station in Boston (Table 9-7). Of these, twelve stations are served by commuter rail only, four stations are served by Amtrak's intercity service only, and six are served by both commuter rail and intercity service. All ten of the stations currently served by Amtrak would continue to be served

TABLE 9-7
EXISTING AMTRAK AND COMMUTER RAIL STATIONS
NEW HAVEN, CT TO BOSTON, MA

STATION	AMTRAK EXPRESS	AMTRAK CONVENTIONAL	COMMUTER
Boston/South Station	✓	✓	✓
Boston/Back Bay	✓	✓	✓
Ruggles St.			✓
Hyde Park			✓
Boston/Route 128	✓	✓	✓
Canton Junction			✓
Sharon			✓
Mansfield			✓
Attleboro			✓
S. Attleboro			✓
Providence	✓	✓	✓
Kingston		✓	
Westerly		✓	
Mystic		✓	
New London	*	✓	
Old Saybrook		✓	✓
Westbrook			✓
Clinton			✓
Madison			✓
Guilford			✓
Branford			✓
New Haven	✓	✓	✓

* May be served by express service in the future

SOURCE: Amtrak, MBTA, Connecticut DOT

by the proposed express service. These include New Haven, Providence, Route 128, Back Bay and South Stations, and are discussed in detail below. The proposed electrification would have minor effects on the conventional stations; therefore, these stations are not discussed further.

Traffic operations were evaluated in the vicinity of the express passenger stations through an analysis of level-of-service (LOS) at the key intersections. LOS is a measure used to quantitatively express the quality or efficiency of the traffic flow at a particular location or intersection. Included in the expression of operating conditions are travel time, speed, and freedom to maneuver, which are collectively known as driver comfort. Factors included in the determination of operating conditions include the physical attributes of the road, such as width, grade, horizontal curvature, signage and signalization; and traffic variety and mix (e.g. the proportion of cars and trucks. LOS is a measure that rates operating conditions from A (the best, free-flowing conditions) to F (the worse, forced-flow conditions), as described in Table 9-8. The LOS analysis was conducted in accordance with the procedures outlined in the Highway Capacity Manual, Transportation Research Board, Special Report 209, 1985 and using the CINCH computer program developed by the Central Transportation Planning Staff, Boston, Massachusetts.

At each of the express stations, those signalized and unsignalized intersections which would be directly affected by traffic to and from the passenger stations were identified, existing traffic volumes and intersection configuration determined, and morning and evening peak hour operations evaluated. The peak hours generally fall between 7 to 9 a.m. and 4 to 6 p.m., although it may vary at different locations. Table 9-9 summarizes the existing peak hour traffic operations for these key locations which are discussed below.

In addition to traffic analysis, existing Amtrak parking demand at each express station was determined and the available parking supply was reviewed. Existing Amtrak ridership, mode of arrival and auto occupancy factor at each station was used to determine the existing needs. Table 9-10 shows auto occupancy rates and the existing mode of arrival at each station, including park and ride, passenger drop off and other (e.g. mass transit or taxi).

South Station. South Station is located in downtown Boston, less than one-half mile from the Massachusetts Turnpike (I-90) and the Fitzgerald Expressway (I-93). Local access is provided by Summer Street and Atlantic Avenue, which are heavily traveled arterial streets. The key intersection of Atlantic Avenue and Summer Street is signalized and currently operates at LOS F in both the AM and PM peak hours.

There are no public, off-street parking spaces at South Station. However, the station is served by extensive public transit service including 212 MBTA commuter trains, one subway line which operates at approximately 5 minute headway during peak hours, and several bus routes. Within a couple of blocks of the station, a limited amount of off-street parking is available at public garages with parking costs varying between $9 and $18 per day. There is currently a freeze on public parking in downtown Boston. In order to achieve compliance with National Ambient Air Quality Standards (NAAQS), the Environmental Protection Agency (EPA) has mandated that the maximum number of public parking spaces in downtown Boston be limited to 35,503. Therefore, the provision of additional parking is precluded by the EPA mandate.

Back Bay Station. Back Bay Station is located within the city limits of Boston in a commercial and residential area west of the "downtown core." The station is less than 1/4 mile from the Massachusetts Turnpike (I-90). Local access is provided by Dartmouth Street, Stuart Street, Clarendon Street and Columbus Avenue. The Dartmouth Street and Columbus Avenue intersection is signalized and currently operates at LOS F in both the AM and PM peak hours. The Dartmouth Street and Stuart Street intersection, also signalized, operates at LOS B in both the AM and PM peak hours. The signalized intersection of Clarendon Avenue and Columbus Avenue also operates at LOS B in both the AM and PM peak hours.

TABLE 9-8
LEVEL OF SERVICE DESIGNATIONS AT KEY INTERSECTIONS NEAR EXPRESS SERVICE RAILROAD STATIONS

Category/Description	Delay(a) Range (Seconds/ Vehicle)	Reserve(b) Capacity Passenger (Cars/Hour)
LOS A: Describes a condition of free flow, with low volumes and relatively high speeds. There is little or no reduction in maneuverability due to the presence of other vehicles, and drivers can maintain their desired speeds. Little or no delays result for side street motorists.	0.00-5.0	400
LOS B: Describes a conditions of stable flow, with desired operating speeds relatively unaffected, but with a slight deterioration of maneuverability within the traffic stream. Side street motorists experience short delays.	5.1-15.0	300-399
LOS C: Describes a condition still representing stable flow, but speeds and maneuverability begin to be restricted. The general level of comfort begins to deteriorate noticeably at this level. Motorists entering from side streets experience average delays.	15.1-25.0	200-299
LOS D: Describes a high-density traffic condition approaching unstable flow. Speeds and maneuverability become more seriously restricted, and the driver experiences a poor level of comfort. Side street motorists may experience long delays.	25.1-40.0	100-199
LOS E: Represents conditions at or near the capacity of the intersection. Flow is usually unstable, and freedom to maneuver within the traffic stream becomes extremely difficult. Very long delays may result for side street motorists.	40.1-60.0	0-99
LOS F: Describes forced flow or breakdown conditions with queuing along critical approaches. Operating conditions are highly unstable as characterized by erratic vehicle movements along each approach.	60.1 or greater	N/A

SOURCE: Highway Capacity Manual, 1985

NOTES: (a) Delay ranges relate to the mean stopped delay incurred by all vehicles entering the intersection and do not consider the effects of traffic signal coordination. This criteria is intended for use in the evaluation of signalized intersections.

(b) Reserve capacity refers to the unused capacity of the minor approach, on a per lane basis. This criterion is limited to existing mode of arrival at each station, including park and ride, passenger drop off and other (e.g. mass transit or taxi).

TABLE 9-9
EXISTING LEVEL OF SERVICE[1] AT CRITICAL INTERSECTIONS

STATION	INTERSECTION	APPROACH	EXISTING AM	EXISTING PM
South	Summer Street/Atlantic Avenue	Overall	F	F
Route 128	Blue Hill Drive/Route. 128	LT 128 ramp	D	B
		LT Blue Hill	A	A
	Blue Hill Drive/University Avenue	LT Univ.	A	D
		Blue Hill (all)	F	F
Providence	Smith/Gaspee/State Streets	All movements from Gaspee	F	F
	Francis/Gaspee Streets	Overall	A	B

NOTES: [1] See Table 9-8 for Level of Service definitions.
New Haven and Back Bay not analyzed

SOURCE: Traffic counts taken March and April, 1993.

TABLE 9-10
MODE OF ARRIVAL AT EACH STATION
(in percent)

STATION	PARK & RIDE	PASSENGER	OTHER
South Station	8	22	70
Back Bay	8	22	70
Route 128	70	28	2
Providence	40	35	25
New Haven	50	38	12
Auto Occupancy	1.1	1.3	1.3

There are no public off-street parking spaces available at Back Bay station. Some parking is available in public garages adjacent to and within a couple of blocks of the station at prices ranging between $9 and $18 per day. The EPA parking freeze imposed on downtown Boston also applies to the area around Back Bay Station, limiting existing and future parking supply. Back Bay Station is served by a large number of commuter and subway trains and buses operated by the MBTA.

Route 128 Station. The MBTA owns and operates the Route 128 station located adjacent to the Route I-95/Route 128 interchange in Dedham. Local access is provided via University Avenue and Blue Hill Drive. The Blue Hill Drive and University Avenue intersection is an unsignalized, three-way intersection which currently operates at LOS D/C in the AM/PM peak hours. The Blue Hill Drive intersection at Route 128 southbound off-ramp is also unsignalized. All movements at this intersection operate at LOS F in both the AM and PM peak hours.

Currently there are 820 parking spaces in the surface parking lot at the Route 128 station. An additional 300 spaces are available at the nearby Green Lodge parking lot, although these spaces are not an integral part of the Route 128 Station. The current parking rate is $3.00 per day. Amtrak's intercity and MBTA's commuter rail services operate at this station. All of the available parking is fully used by the intercity and commuter rail patrons.

Previous studies have proposed improving the Route 128 station with high-level platforms, expanded parking and other improvements. Amtrak and MBTA have agreed to jointly fund the construction of the high-level platforms to service both intercity and commuter trains, and although design and construction of the high-level platforms is expected to be completed within three years, no additional parking is planned at this time.

Providence Station. The Providence station was moved from the Old Union Station building to its current location on Smith Street in 1986. The station is located in downtown Providence less than one half mile from I-95 with local access provided by Francis, Smith and Gaspee Streets.

The Capital Center Project plan provides for roadway and intersection improvements around the Providence station. Many of the improvements have already been completed but some are still under construction, which has temporarily altered the traffic flow pattern. The Gaspee and Francis street intersection, which was recently signalized, operates at LOS B/C in the AM and PM peak traffic hours. The Smith/Gaspee/State Street intersection currently operates at LOS E during the AM and PM peak hours. Gaspee Street south of the station is closed due to construction.

A 360 space underground parking structure, owned and operated by the Rhode Island Department of Transportation, provides public parking for the Providence station. The available parking exceeds the current demand, with only about 50 percent of the spaces occupied on a typical weekday. The current parking fee is $7.50 per day or $3.00 per day for commuter rail passengers. The station is served by commuter rail and local bus service.

New Haven. The New Haven railroad station is located on the fringe of downtown New Haven, about one mile from the I-91/I-95 interchange. Local access is provided via Route 1, State Route 34 and Church Street. No current traffic volumes or studies were available. However, no traffic congestion was observed on the local access streets during the morning and evening peak hours.

The station was renovated in 1982 and an attached 887 space parking garage was constructed, with another 320 spaces provided in an adjacent surface parking lot. Of these, 125 spaces are leased to the New Haven Police Department. Owned and operated by ConnDOT, the garage is 90 percent occupied on a typical weekday. The surface lot fills only on Wednesdays due to matinee theater days in New York. The parking fee is $4.50 per day from 6:00 AM to 6:00 PM or $0.75 per hour to a maximum of $7.00. The monthly parking fee is $63.60. The New Haven station is also served by commuter train and local bus service.

9.3.3.2 Existing Traffic Patterns at Overhead Bridges to be Modified. In many cases, the existing vertical distance between the existing rail line and overhead structures is not sufficient to accommodate the proposed catenary system. Included among such structures are highway bridges, in which case alterations to the bridge may have a short-term effect on local traffic patterns.

The vertical distance can be increased in one of two ways: either the railroad track can be lowered by removing some of the stone ballast (a technique known as undercutting) or the structure can be raised. As part of their proposal, Amtrak plans to undercut the tracks rather than raise the bridges where ever feasible. At seventeen bridges, however, undercutting alone would not achieve the Amtrak required clearance. Eight of these bridges are being programmed for replacement or reconstruction by the states and are being evaluated in other environmental documents. Amtrak has proposed to raise or replace the remaining nine bridges (Table 9-11). At these bridges and the surrounding streets, traffic patterns and flows could be affected during construction. One bridge (Johhnycake Hill Road) is a pedestrian bridge, therefore vehicular traffic would not be affected during construction. Three bridges could be modified using a staged construction schedule, in which case it would not be necessary to close these bridges during construction. It would, however, be necessary that the remaining five bridges be closed to traffic for the construction duration. Table 9-12 shows the existing daily traffic on each of the nine bridges, identifies those that would require detours during construction, and indicates the duration of construction.

9.3.4 Existing Delay at Grade Crossings

Changes in intercity rail operations by Amtrak could affect the frequency and duration of gate closures, and consequently, affect delays experienced by motorists at the grade crossings. Over the years state and local agencies have cooperated with Amtrak in closing many grade crossings

TABLE 9-11
EXISTING CLEARANCE AT BRIDGES PROPOSED FOR MODIFICATION BY AMTRAK

BRIDGE NAME /LOCATION	MILEPOST	EXISTING CLEARANCE (in feet)	
		TRACK 1	TRACK 2
Johnnycake Hill Rd. Old Lyme, CT	108.51	17.6	17.6
Millstone Point Rd. Waterford, CT	117.31	16.7	17.1
Burdickville Rd. Charlestown, RI	148.41	17.3	17.7
Kenyon School/Beaver River Rd. Richmond, RI	154.04	18.0	17.7
RI Rte. 138/Main St. So. Kingston, RI	158.32	17.9	18.0
Pettaconsett Ave. Warwick, RI	178.48	16.7	16.7
Park Ave. Cranston, RI	180.29	16.7	16.7
Depot St. Sharon, MA	211.04	17.9	17.6
Maskwonicut St. Sharon, MA	211.62	17.7	17.9

SOURCE: Amtrak, May 1993

or separating them with overpasses or underpasses. There are currently 14 highway-railroad grade crossings between New Haven and Boston. Of these, twelve are located in Connecticut, one is in Rhode Island and one in Massachusetts. Twelve crossings (Table 9-13) are equipped with gates, bells and flashing lights. Two private crossings: Chapman's crossing in Old Lyme, CT, and Lazy Lady crossing in Attleboro, MA, are not equipped with these devices and therefore were not evaluated for delay.

The amount of delay experienced by motorists at each crossing is a function of train speed and and frequency. For example, with increased train frequency and length, motorists could be more likely to experience an incident of delay. Conversely, as train speed increases, the time that the gates are down at a grade crossing would be reduced and therefore the average delay would decrease.

TABLE 9-12. LOCATION AND CHARACTERISTICS OF PROPOSED BRIDGE MODIFICATIONS

BRIDGE	MILE POST	LOCATION	1993 AV. DAILY TRAFFIC	ACTION	DETOUR	DURATION (in months)
Johnnycake Hill Rd.	108.51	Old Lyme, CT	N/A	Replace	No[1]	1
Millstone Point Rd.	117.31	Waterford, CT	4,290	Raise	No	2.5
Burdickville Rd.	148.41	Charlestown, RI	150	Replace	No	4
Kenyon School/ Beaver River Rd.	154.04	Richmond, RI	3,215	Replace	Yes	3
Main Street	158.32	South Kingston, RI	14,315	Raise	No	3
Pettaconsett Ave.	178.46	Warwick, RI	1,360	Replace	Yes	4.5
Park Avenue	180.29	Cranston, RI	17,470	Raise	Yes	4
Depot Street	211.04	Sharon, MA	12,050	Replace	Yes	9
Maskwonicut St.	211.62	Sharon, MA	1,770	Raise	Yes	3

[1] Footbridge

SOURCE: Amtrak

In this evaluation, delay per train event and average delay per vehicle were estimated at each grade crossing. Average delay per train event was estimated as the sum of: 1) gate down time prior to train arrival (10 seconds), 2) train passage (based on speed and length of train), 3) deceleration time for arriving vehicles (7 seconds), and 4) acceleration time for vehicles starting after the gate opens (3 seconds). An average delay for vehicles delayed per train event was calculated as one-half the time per train event. This assumes that vehicles may encounter the closed gates at any point during the time the gates are in the closed position, from the moment they close to just before they open.

Table 9-13 shows existing delay per train event and average delay per vehicle as well as train speed, number of trains per day and the number of cars per train. The average delay of vehicles delayed per train event ranges from approximately twelve seconds at Wolf Rocks Road where Amtrak trains travel at 100 mph, to approximately seventeen seconds at Bank Street, State Street and Governor Winthrop Boulevard, where Amtrak trains travel at 25 mph. It should be pointed out that the State Street and Bank Street crossings are in close proximity to the railroad station and are closed for the duration of the train stop and not only for the duration of the train passage time, as reflected in Table 9-13. Characteristics of each crossing, including the type of surrounding land use and the functional classification of the intersecting road are described in Table 9-14.

TABLE 9-13. EXISTING VEHICLE DELAY AT GRADE CROSSINGS
(in seconds)

GRADE CROSSING	SPEED (mph)	NO. of TRAINS /DAY	DELAY PER TRAIN EVENT	DELAY PER VEHICLE[1]
Miners Lane[2]	60	24	25	13
Bank Street[2]	25	24	33	17
State Street[2]	25	24	33	17
Gov. Winthrop Blvd.[2]	25	24	33	17
School Street[2]	70	24	25	12
Broadway Ext.	50	0	27	13
Latimer Point Rd.	70	0	25	12
Wampassuc	70	0	25	12
Walkers Dock Rd.	70	0	25	12
Freemans Crossing	70	0	25	12
Palmer Street	80	0	24	12
Wolf Rocks Rd.	100	0	23	12

SOURCE: Amtrak.
NOTES: [1] Computed based on 0.5 x time grade crossing gates in down position.
[2] Does not includes Montrealer Service.

TABLE 9-14. ROADWAY AND DEVELOPMENT CHARACTERISTICS OF GRADE CROSSINGS

GRADE CROSSING	STREET TYPE	SURROUNDING LAND USE	SURROUNDING CHARACTER
Miners Ln.	Local	Industrial	Rural
Bank St.	Local	Commercial	Urban
State St.	Local	Commercial	Urban
Gov. Winthrop Blvd.	Minor Arterial	Commercial	Urban
School St.	Local	Residential	Suburban
Broadway Ext.	Local	Commercial	Suburban
Latimer Point Rd.	Local	Residential	Rural
Wampassuc	Local	Residential	Rural
Walkers Dock Rd.	Private	Residential	Suburban
Freemans Crossing	Private	Residential	Suburban
Palmer St.	Minor Collector	Residential	Urban
Wolf Rocks Rd.	N/A-to be closed	Residential	Rural

9.4 ENVIRONMENTAL CONSEQUENCES AND MITIGATION MEASURES

This section addresses the transportation and traffic impacts of the proposed electrification project. Potential impacts include:

- Increased rail traffic, which may affect the intercity, commuter and freight rail operations on the NEC;
- Construction impacts upon these operations;
- Reduced aircraft ridership and interstate highway traffic due to shifts in modal choice to the intercity train;
- Increased traffic and parking demand at railroad stations serviced by Amtrak and reduced traffic at major airports due to increased intercity ridership; and
- Changes in traffic flow patterns in the vicinity of the highway bridges to be modified during construction.

The following sections present the relevant transportation and traffic conditions for the design year 2010 without the proposed project (the future baseline or "no-build" conditions) in order to provide a basis for comparison with the conditions that would result from the electrification project. Then, conditions that would result from the electrification project are presented (the "build" conditions) and a comparison is made between the two alternatives. Intercity bus travel is not addressed herein because it is not anticipated to be affected by the proposed electrification. As the most time consuming mode of travel, intercity bus riders are not time sensitive, which is the primary attractiveness of the proposed action.

Section 9.4.2 addresses the changes in intercity passenger service and ridership for all modes, including the electrified trains. Section 9.4.3 addresses the effects of the electrification on other users of the NEC rail line, specifically, freight and commuter operations. Traffic flow and parking impacts are discussed in section 9.4.4, including those at the express railroad stations and, during construction, at the nine bridges to be modified. The electrification may affect vehicular delay at grade crossings, which is addressed in section 9.4.5. For those potential effects that may require mitigation, the proposed mitigation measures are presented in section 9.5.

9.4.1 Evaluation Criteria

The evaluation criteria employed to assess the impacts of the alternatives upon the transportation system within the NEC are shown in Table 9-15.

9.4.2 Projected 2010 Intercity Service and Ridership

This section describes anticipated changes in overall intercity travel patterns in the NEC, as well as changes in modal choice. These changes are projected to occur between the existing situation

TABLE 9-15. EVALUATION CRITERIA FOR TRANSPORTATION, TRAFFIC AND CIRCULATION IMPACTS

IMPACT CRITERIA	MEASURE	IMPACT THRESHOLD
Effect of increase in train speed and frequency on vehicle delay at grade crossings.	Comparison of project- generated delay at crossings with existing delay.	None
Effect of project-generated traffic at train stations on existing traffic patterns.	Comparison of project- generated traffic with existing flows.	Decline in peak hour LOS, below LOS D, at key intersections.
Effect of project-generated intercity train ridership on aircraft and automobile traffic.	Project-generated reduction in aircraft use.	None.
	Project-generated reduction in vehicle miles of travel.	None.
Effect of bridge modifications on traffic flow pattern.	Temporary change in traffic flow pattern and/or vehicle delay.	Decline in peak hour LOS, below LOS C in rural areas and LOS D in urban areas, at key intersections along alternate routes.
Effect on other NEC railroad operations (commuter, freight)	Adverse operating or economic effects	None
Effect of change in project-generated traffic on parking capacity at train stations.	Change in parking demand at each train station.	None

and the design year 2010 without electrification (no-build alternative) and between the 2010 no-build and electrification alternatives.

9.4.2.1 Projected Service and Ridership Without Electrification: Without electrification, no improvement in intercity travel time is expected and only a minor increase in train frequency (two additional departures each way) is planned by Amtrak for the year 2010. However, total intercity travel in the NEC (between four major city pairs: Boston-New York, Providence-New York, Boston-New Haven and Providence-New Haven) is expected to increase by approximately 3.7 million (21 percent) in the period between 1988 and 2010, as shown in Table 9-16 (CRA, 1993). This increase represents a change of less than one percent annually over the 22 year period and is the result of normal growth in corridor travel. Boston-Providence travel is not included in these estimates as the metropolitan areas of these cities nearly overlap and the majority of the travel between these cities is commuter-oriented, rather than intercity-oriented.

TABLE 9-16. 2010 PROJECTED ANNUAL INTERCITY TRAVEL ON THE NEC WITHOUT ELECTRIFICATION (in thousands)

MODE	SCENARIO	NYC-BOS	NYC-PRO	BOS-NH	PRO-NH	TOTAL	TOTAL CHANGE
AUTO	1988	7,825	3,278	1,876	283	13,262	2,657 20.0%
	No Build	9,432	3,908	2,244	335	15,919	
AIR	1988	3,164	325	NA	NA	3,489	292 8.4%
	No-Build	3,474	307	NA	A	3,781	
RAIL	1988	714	189	115	23	1,041	830 79.7%
	No-Build	1,143	429	248	51	1,871	
TOTAL	1988	11,703	3,792	1,991	306	17,792	3779 21.2%
	No-Build	14,049	4,644	2,492	386	21,571	

SOURCE: Charles River Associates, 1993.

NOTES: Boston-Providence travel is not included as most such travel is commuter-oriented rather than intercity oriented.

Under the no-build alternative, total 2010 Amtrak intercity ridership in the NEC is predicted to increase by nearly 80 percent over the 22 year period (three percent annually), from approximately 1 million to 1.9 million passengers. This represent a slight change in the proportion of travelers that would choose intercity rail over auto or air travel, as shown below (in thousands):

Annual Trips by Travel Mode

	Existing (1988)		No-Build (2010)	
	Number	Percent	Number	Percent
Auto	13,262	74.5	15,919	73.8
Air	3,489	19.6	3,781	17.5
Rail	1,041	5.9	1,871	8.7
TOTAL	17,792	100.0	21,571	100.0

As stated earlier, no improvements in intercity rail travel time are planned by Amtrak to account for this modal shift. It is likely this is primarily due to the increase in the relative attractiveness of intercity rail travel as highways and airports in the corridor, which are currently at or near capacity, become more congested over the next 22 years.

9.4.2.2 Projected Intercity Service and Travel With Electrification: With electrification, the express service travel time between Penn Central station, New York and South station, Boston would decrease to under three hours (2 hours and 52 minutes), from approximately 4 hours under the no-build alternative. At the same time, Amtrak plans to increase the frequency of express service from 2 trains in each direction under the no-build conditions to 16 in each direction.

As shown in Table 9-17, implementation of the electrification project is not anticipated to have any effect on total intercity travel in the NEC. Rather, implementation of the electrification project is expected to create significant shifts in choices made by travelers regarding their mode of travel, as shown below (in thousands):

	Existing (1988)		2010 No-Build		2010 Electrification	
	Number	Percent	Number	Percent	Number	Percent
Auto	13,418	74.5	15,919	73.8	15,595	72.3
Air	3,529	19.6	3,781	17.5	2,351	10.9
Rail	1,053	5.9	1,871	8.7	3,627	16.8

As shown above, the electrification project would have a marginal effect on automobile traffic because the factors that make automobile travel more attractive than rail will remain in place. These factors include the conveniences of individualized schedule and direct origin and destination travel, as well as the lower cost per passenger for more than one passenger, relative to air and Amtrak service.

Substantial shifts could be made, however, from air to rail mode. Total Amtrak ridership in this market is anticipated to nearly double, from nearly 1.9 million to over 3.6 million. Most of this increase is expected to be a result of modal shift from air to rail. As shown in Table 9-18, air ridership in this market is expected to decrease by more than one third from nearly 3.8 million to approximately 2.4 million. In the two major air markets, Boston-New York City and Providence-New York City, Amtrak ridership is anticipated to grow by over 100 and 80 percent, respectively.

Several factors are responsible for this shift. Some of it is due to the attractiveness of intercity rail relative to other modes as those modes become more congested. This is evidenced by the increased rail ridership under the no-build conditions. However, the primary factors are the proposed significant improvements in Amtrak's travel time and service. First, by reducing the express travel time from Boston to New York City from four hours to just under three hours, intercity rail becomes substantially competitive with the air market. The flying time between the major airports of these two cities is approximately one hour. However, unlike the train

TABLE 9-17
2010 PROJECTED ANNUAL INTERCITY TRAVEL
ON THE NEC WITH ELECTRIFICATION (in thousands)

MODE	SCENARIO	NYC-BOS	NYC-PRO	BOS-NH	PRO-NH	TOTAL	CHANGE
Auto	No-Build	9,432	3,908	2,244	335	15,919	324 -0.3%
	Build	9,256	3,800	2,210	329	15,595	
Air	No-Build	3,474	307	NA	NA	3,781	-1430 -38.0%
	Build	2,292	59	NA	NA	2,351	
Rail	No-Build	1,143	429	248	51	1,871	1,756 93.9%
	Build	2,502	7,86	282	57	3,627	
TOTAL	No-Build	14,049	4,644	2,492	386	21.571	2 0.01%[1]
	Build	14,050	4,645	2,492	386	21,573	

SOURCE: Source: Charles river Associates, 1993.

NOTES: [1] Rounding off error.

Boston-Providence travel is not included as most such travel is commuter-oriented rather than intercity oriented.
NYC = New York City, NY PROV = Providence, RI
BOS = Boston, MA NH = New Haven, CT

TABLE 9-18
CHANGE IN AIR AND RAIL RIDERSHIP
FOR 2010 NO-BUILD SCENARIO TO BUILD SCENARIO (in thousands)

MODE	SCENARIO	NYC-BOS	NYC-PRO	BOS-NH	PRO-NH	TOTAL
Air	No-Build	3,474	307	NA	NA	3,781
	Build	2,292	59	NA	NA	2,351
	% Change	-34.0	-80.0	NA	NA	-37.8
Rail (Amtrak)	No-Build	1,143	429	248	51	1 871
	Build	2,502	786	282	57	3,627
	% Change	100.2	83.2	13.7	11.8	93.9

SOURCE: Charles river Associates, 1993.

NOTES: See notes for Table 9-17

terminals, the airports are located outside the city centers and access to and from the airports is inconvenient and unpredictable. Second, by increasing the number of express trains from two to 16 in each direction daily, the availability of service is somewhat more competitive with the airlines, which provides service every 30 minutes. The same factors apply to the Providence-New York City market.Although the aircraft ridership would decrease substantially as a result of the proposed electrification (34 percent for the Boston-New York market at Boston's Logan International airport, for example), the effect on vehicular traffic around the airport is less substantial. Of all Logan passengers, 64.8 percent make their trips to and from the airport by some type of automobile (private, taxi, limousine). Assuming the same percentage for Boston-New York passengers (a reduction of 1.2 million passengers annually), 765,936 vehicle trips annually would be saved due to the electrification, or 2,553 on a typical weekday (dividing by 300 days gives a typical weekday, as weekday traffic is heavier than weekends). This equals two percent of Logan's average weekday traffic of 132,408 vehicles (LOGIC, 1993), a barely perceptible change. As the decrease in air ridership at Providence airport is not as great (248,000 passengers), and the change would be spread over three airports in New York, it is anticipated that the effect on vehicular traffic at these locations would be even less significant.

While the air markets would experience a significant decrease in ridership as a result of the proposed electrification, it is not anticipated that the availability of service (daily flights) would change significantly. Rather than reducing service, the airlines are more likely to attempt to maintain frequent departures by shifting to smaller, more economical aircraft in an attempt to remain competitive and to retain passengers and revenues. This would enable the airlines to retain their attractiveness to passengers for whom the availability of departures every half-hour is crucial.

9.4.2.3 Summary of Impacts of Intercity Ridership and Service. It is anticipated that the no-build alternative would result in normal increases in NEC travel between 1988 and 2010 for the three modes examined (automobile, air and rail), for a total growth of 21 percent. A slight modal shift may occur from air and auto use to intercity rail, as a result of the increasing congestion experienced on highways and at airports, but this shift would not be significant. No significant additional growth in total intercity travel would be generated by the proposed electrification. The proposed project would, however, substantially affect the mode of travel in the corridor, particularly by generating a significant shift from intercity air to intercity rail service.

It is anticipated that the proposed electrification project could nearly double Amtrak's ridership in this segment of the NEC (from 1.9 million under the no-build conditions to 3.6 million under the build conditions). Electrification is not expected to induce new traffic in the NEC and would have little effect on intercity automobile travel. Most of the increase in Amtrak ridership would come from modal shifts from air passenger services, which would experience a reduction in projected ridership of approximately 40 percent or 1.4 million. Both the improved travel time and increased frequency of Amtrak service are responsible for this shift. It is anticipated that the airlines would shift to smaller aircraft and maintain essentially the same frequency of service. Thus, the effect of this shift on airport traffic is not anticipated to be adverse.

9.4.3 Impacts to Other Rail Operations on the Northeast Corridor

Section 403 of the Federal Rail Passenger Service Act provides that "except in an emergency, intercity passenger trains operated by or on behalf of the Corporation (Amtrak) shall be accorded preference over freight trains in the use of any given track, junction or crossing.....". As a result, freight and commuter trains operating on the NEC receive lower dispatch and control priority than Amtrak intercity trains, with commuter trains taking precedence over freight. The effects on freight and commuter operations of Amtrak's proposed electrification and the increase in Amtrak service from 22 to 52 trains daily are described in the sections below. In addition, section 9.4.3.1 contains a discussion of the effect of the catenary installation on the vertical clearance available for freight operations. Since there would be little change in the frequency of service and operating speed between the existing and no-build conditions, no effects on freight or commuter service are anticipated for the year 2010 without electrification.

9.4.3.1 Operational Impacts on Freight Rail. Providence & Worcester (P&W) and Conrail are the two freight rail operators in the NEC. These companies project that freight rail operations on the NEC in the study area will increase from the existing 32 daily movements to 49 daily movements in 2010. The line segments of the NEC used for freight service and the current and projected (2010) level of train movements are presented in Table 9-19.

Freight trains on the NEC receive a lower priority for scheduling than passenger trains and increased frequency of passenger trains could affect the freight train operations. Rail operation simulations by Amtrak indicate that the proposed Amtrak 2010 passenger train schedule would reduce the time available for freight train movements, especially in the daytime. It is estimated that two of the three existing P&W local freight trains in Connecticut and Rhode Island would require an additional 1.5 to 2 hours to perform the same amount of work, and that the third local would require an additional 3 to 3.5 hours. In view of the enhanced Amtrak speeds and frequency, any new freight operations may be restricted to nighttime.

The scheduling of the planned Amtrak service would impact freight service in two ways. First, by requiring additional time to complete the same amount of work, the cost of providing freight service would increase. Second, requiring shippers to receive or deliver freight shipments outside normal business hours would be inconvenient and increase shippers costs.

Amtrak plans to maintain the current published clearances under the numerous overhead bridges on the NEC. The presence of the catenary, however, could increase the cost of any future program to increase clearance to accommodate double stack and tri-level cars. Because of the amount of space required for the catenary and associated connections and insulators, a freight clearance program could requires certain bridges to be raised with the propose project that would not be required under the no-build alternative. In addition, the bridges that would be raised by Amtrak as part of the electrification project might have to be raised again for a freight clearance program. Furthermore, with increased passenger train frequencies and speeds, any future work on the rail line would become more complex. There are presently no funds to undertake a program to increase bridge clearances for freight operations. However, the P&W is concerned

TABLE 9-19
EXISTING AND PROJECTED FREIGHT SERVICE ON THE NEC
(weekday two-way operations)

LINE SEGMENT	MILEPOST LIMITS	1993 TRAIN OPERATIONS	2010 TRAIN OPERATIONS
New Haven-Groton	73.8-124.6	2	6
Groton-Davisville	124.6-168.0	0	2
Davisville-Atwells	168.0-184.2	2	6
Atwells-Lawn	184.2-188.8	4	8
Lawn-South Attleboro	188.8-192.2	0	0
South Attleboro-Attleboro	197.2-192.2	2	2
Attleboro-Mansfield	197.2-204.2	4	7
Mansfield-Canton Junction	204.2-213.8	2	2
Canton Junction-Route 128	213.8-217.2	4	4
Route 128-Readville	217.2-220.0	6	6
Readville-Back Bay	220.0-228.0	0	0
Back Bay-Boston Herald	228.0-228.3	4	4
Boston Herald-South Bay Wye	228.3-228.5	2	2
South Bay Wye-South Station	228.5-229.4	0	0
TOTAL		32	49

SOURCE: Providence & Worcester Railroad and Conrail.

that the increase cost and complexity of any freight clearance program undertaken after the electrification project is completed could actually preclude the undertaking of such a program and permanently limit freight service to its present heights limitations.

Freight cars requiring higher clearances, such as double stacks and tri-level auto carriers, are rapidly becoming the industry standard for selected major corridor routes. By not being able to offer its customers the most efficient type of equipment, the freight railroads on this part of the NEC would be placed at a competitive disadvantage in a highly competitive transportation market.

The combination of added costs, inconvenience, and limitations of the type of freight rail cars that can be used could have a serious impact on existing and future freight rail movements. Some existing shippers may divert shipments to transportation alternatives and some potential shippers may locate in other areas with more favorable transportation services. This latter impact has implications for the state of Rhode Island's plans to develop a commercial port to be served by the P&W at Quonset Point. This port would be in competition with port facilities in Boston, the New York City area, and other east coast ports which have service via rail lines that can accommodate the larger dimension rail cars.

According to the estimates developed by the P&W, the additional operating costs and potential loss of new business related to schedule and height restrictions could result in an annual revenue loss of $900,000 to cause P&W to cease operations (P&W General Counsel letter to FRA dated January 12, 1993).

9.4.3.2 Construction Impacts on Freight Rail. Construction of the overhead catenary system would require the removal of between five and fifteen miles of mainline tracks from service at various times throughout the construction period. Most of this work would occur in the evening. Currently, most (28 out of 32 movements) of the regular freight operations occur during daylight hours and therefore would not be affected by the construction. However, some regular nighttime movements could be affected by the construction, and projected extra movements or excess dimension (high and wide) movements, made almost exclusively at night, may be affected to a greater degree. In addition, regular local freight, if unduly delayed during its daylight operation, could be affected by the scheduled removal of one main track during late afternoon hours.

9.4.3.3 Impacts on Commuter Operations. Currently there are two commuter rail systems operating over two separate segments of the Boston-New Haven NEC: ConnDOT's Shore Line East service between New Haven and Old Saybrook and the MBTA commuter service between Providence and Boston (and points in between). Both are planning for improved and more frequent service along the Northeast Corridor. In addition, the RIDOT has initiated plans for commuter service between Providence and Kingston, Rhode Island. As shown in Table 9-20, the number of commuter operations on the corridor is anticipated to grow from a current total of 148 to 218 daily in 2010.

The existing and proposed commuter rail service can be accommodated on the NEC, however, the combination of the proposed increase in Amtrak frequency and speed and the proposed increase in freight and commuter services, approaches the capacity of the existing two and three track system. To achieve this high level of capacity all parties will be required to implement operational procedures designed to maximize capacity in a highly disciplined manner while also maintaining high safety and reliability standards.

Commuter operations should not be adversely affected by the proposed construction, because these operations occur primarily during the day.

TABLE 9-20
EXISTING AND PROJECTED COMMUTER SERVICE ON THE NEC
(Weekday two-way operations)

AGENCY	OPERATES ON NEC		1993 OPERATIONS	2010 OPERATIONS
	FROM:	TO:		
MBTA	Boston	Forest Hills	130	162
	Forest Hills	Readville	96	131
	Readville	Canton Jct.	67	81
	Canton Jct.	Attleboro	32	31
	Attleboro	S. Attleboro	28	27
	S. Attleboro	Providence	10	11
RIDOT	Providence	Kingston	0	24
ConnDOT	New Haven	Old Saybrook	18	32
	New Haven	New London	0	10

Source: MBTA, ConnDOT and RIDOT.

9.4.3.4 Summary of Impacts to Other NEC Operations. Although all of the proposed 2010 design year intercity, freight and commuter operations raise the demand on the NEC to near capacity levels, all of these operations could be accommodated on the corridor. No impacts to commuter service are expected.

Existing P&W movements in Rhode Island may require an additional 1.5 to 3.5 hours to complete and new freight movements may also require additional time. In addition, all projected new freight movements would have to occur at night. Each of these may be adverse. The additional time for existing P&W movements may cost that company significantly more in operating costs. In addition, restrictions of all new freight service to nighttime operations may be undesirable to new customers (due to their inability to receive the shipments at that time) and therefore reduce the likelihood of their using rail freight service. This could have significant economic implications for the freight operators and the northeast region as a whole.

9.4.4 Traffic and Parking Impacts

This section addresses the local long-term impacts of increased traffic and parking requirements at the stations served by the Amtrak express trains, which would occur as a result of the anticipated increase in Amtrak ridership. It also addresses the construction impacts on local traffic patterns related to raising overhead highway bridges to accommodate the catenary.

9.4.4.1 Traffic Operations Impacts. The anticipated increase in Amtrak ridership, discussed in section 9.4.2 and shown in Table 9.17, could affect traffic operations in the vicinity of the Amtrak stations, especially the five stations served by high speed or "express" trains: South Station, Back Bay, Route 128, Providence and New Haven. Table 9-21 presents the projected daily 2010 no-build and with electrification average weekday Amtrak-generated traffic at the five express stations.

The project-generated peak hour volumes (peak hour access traffic volumes) for the existing condition, and the no-build and electrification alternatives are:

Peak Hour Traffic Volumes at Express Stations

Station	Existing	2010 No-Build	2010 Build
South Station	178	216	329
Back Bay	24	48	103
Route 128	83	239	550
Providence	132	268	430
New Haven	157	253	280

As it can be seen from the peak hour volumes, the increase in traffic volumes due to the proposed action are minimal at the New Haven and Back Bay stations (27 and 55 peak hour vehicles respectively). These increases are not expected to develop a change in the level-of-service (LOS) and therefore these stations are not included in the analysis below. As explained in Section 9.3, LOS is a measure used to quantitatively express the quality or efficiency of the traffic flow at a particular location or intersection.

Level of Service Analysis. To determine the traffic impact of the added vehicular traffic, a LOS analysis was conducted at the intersections that could be affected by increased traffic at these express service stations: Providence, Route 128 and South stations. Table 9-22 presents the 2010 LOS at these intersections with and without electrification. Both the AM and PM peak hour analysis was conducted and the worst of these conditions are presented below.

Providence. Two intersections could be potentially impacted in the vicinity of these stations. These are: Smith/Gaspee/State Streets and Francis/Gaspee Streets.

Smith/Gaspee/State Streets. Traffic operations at this unsignalized intersection would improve over current levels (LOS F) due to planned signalization of the intersection by the RIDOT. The LOS due to the proposed action changes from C to D and average delay per vehicle increases from 24 to 27 seconds.

Francis/Gaspee Streets. Traffic operations at this signalized intersection would decline over the existing conditions. The existing LOS B would change to LOS C under the no-build conditions. Due to the proposed action this LOS changes to D and the average delay per vehicle increases from 22 seconds to 33 seconds.

TABLE 9-21
PROJECTED AVERAGE WEEKDAY VEHICULAR TRAFFIC
AT EXPRESS STATIONS
GENERATED BY AMTRAK RIDERSHIP

STATION	AVERAGE WEEKDAY TRAFFIC		
	2010 WITHOUT ELECTRIFICATION	2010 WITH ELECTRIFICATION	CHANGE (NO-BUILD TO BUILD)
South Station	1670	2530	860
Back Bay	370	790	420
Route 128	1840	4203	2390
Providence	2060	3310	1250
New Haven	1940	2150	210

Since the proposed action would have only minor impacts at the above intersections and the electrification LOS are within the acceptable range for urban areas, no mitigation measures are considered necessary.

Route 128 Station. Two intersections could be potentially impacted at this station. These are: Route 128 Southbound Ramp intersection at Blue Hill Drive and University Avenue intersection at Blue Hill Drive.

Route 128 SB Ramp/Blue Hill Drive. Due to normal increase in the background traffic, the LOS at this unsignalized intersection would deteriorate from existing LOS D to F in the no-build condition. The proposed electrification would further increase traffic at this intersection. Although the LOS will remain F, available reserve capacity for the left turn movement from SB 128 Ramp decreases from -175 to -264.

The Massachusetts Highway Department (MHD) is planning to add lanes to Route 128 including the section adjacent to the Route 128 Station. It is not known at this time whether the MHD is planning any improvements at this ramp. Amtrak should contact the MHD so improvements at the ramp could be incorporated in the planning and design of the additional lane project.

TABLE 9-22
EXPRESS STATION INTERSECTION ANALYSIS

Table 9-22A
Unsignalized Intersections (AM Peak)

Intersection/Approach	Location	1993 Existing RC	1993 Existing Demand	1993 Existing LOS	2010 No-Build RC	2010 No-Build Demand	2010 No-Build LOS	With Electrification RC	With Electrification Demand	With Electrification LOS
Blue Hill Dr/Rt 128	Boston, MA									
LT Form 128 Ramp		198	457	D	-175	669	F	-264	730	F
LT From Blue Hill Dr		1016	35	A	876	51	A	846	51	A
Blue Hill Dr/Univ Av	Boston, MA									
LT From Univ Av		491	184	A	See Table 9-22 C			See Table 9-22 C		
All Moves From Blue Hill		-199	550	F						
Smith/Gaspee/State	Providence, RI									
LT From WB Smith		472	319	A	See Table 9-22 C			See Table 9-22 C		
All From Gaspee		-278	500	F						
All From State		34	52	E						

Table 9-22B
Unsignalized Intersections (PM Peak)

Intersection/Approach	Location	1993 Existing RC	1993 Existing Demand	1993 Existing LOS	2010 No-Build RC	2010 No-Build Demand	2010 No-Build LOS	With Electrification RC	With Electrification Demand	With Electrification LOS
Blue Hill Dr/Rt 128	Boston, MA									
LT Form 128 Ramp		327	89	B	-45	165	F	-124	179	F
LT From Blue Hill Dr		447	52	A	89	96	E	39	97	E
Blue Hill Dr/Univ Av	Boston, MA									
LT From Univ Av		167	717	D	See Table 9-22 D			See Table 9-22 D		
All From Blue Hill		-133	201	F						
Smith/Gaspee/State	Providence, RI									
LT From WB Smith		181	386	D	See Table 9-22 D			See Table 9-22 D		
All From Gaspee		-390	410	F						
All From State		-179	197	F						

RC = Available Reserve Capacity LOS = Level-of-Service

TABLE 9-22 (continued)
EXPRESS STATION INTERSECTION ANALYSIS

Table 9-22C
Signalized Intersections (AM Peak)

Intersection/Approach	Location	1993 Existing			2010 No-Build			With Electrification		
		V/C	Delay	LOS	V/C	Delay	LOS	V/C	Delay	LOS
Summer/Atlantic Overall	Boston, MA	1.03	105	F	0.76	19	C	0.76	19	C
Blue Hill/Univ Av Overall	Boston, MA	See Table 9-22 A			0.55	11	B	0.59	12	B
Smith/Gaspee/State Overall	Providence, RI	See Table 9-22 A			0.9	24	C	0.93	27	D
Francis/Gaspee Overall	Providence, RI	0.42	5	A	0.88	17	C	0.95	21	C

Table 9-9D
Signalized Intersections (PM Peak)

Intersection/Approach	Location	1993 Existing			2010 No-Build			With Electrification		
		V/C	Delay	LOS	V/C	Delay	LOS	V/C	Delay	LOS
Summer St/Atlantic Av Overall	Boston, MA	1.28	154	F	1.11	67	F	1.16	71	F
Blue Hill/Univ Av Overall	Boston, MA	See Table 9-22 B			0.69	12	B	0.78	15	B
Smith/Gaspee/State Overall	Providence, RI	See Table 9-22 B			0.7	19	C	0.72	20	C
Francis/Gaspee Overall	Providence, RI	0.56	9	B	0.9	22	C	0.94	31	D

LOS=Level-of-Service   V/C = Volume to Capacity Ratio   Delay = Average Delay Per Vehicle in Seconds

Blue Hill Drive/University Avenue. This is an unsignalized T-type intersection. A previous study (Goody & Clancy, 1991) recommended signalization and geometric improvements with the following geometry:

Eastbound	1 left turn lane 2 through lanes 1 right turn lane
Westbound	1 left turn lane 2 through lanes
Northbound	2 left turn lanes 2 through lanes
Southbound	1 left turn lane 2 through lanes

As these improvement were incorporated in the future no-build analysis, no-build LOS improves to B (over existing F) for both AM and PM peak hours. Under the electrification conditions the LOS does not change; however, average delay per vehicle increases from 12 seconds to 15 seconds. Since the proposed action would have only minor impacts at the above intersections no mitigation measures are considered necessary.

South Station. One intersection, Summer/Atlantic Streets, could be potentially impacted by the project.

Summer/Atlantic Streets. This intersection would be improved as part of the Central Artery project. Extensive reconstruction of I-93 in the vicinity of South station will result in changes in traffic flow patterns in this area which would also result in reduced traffic volumes at this intersection. As a result, traffic operations at this location show improvement under the no-build and electrification conditions over the existing conditions; average vehicle delay drops from 154 seconds to 67 seconds under the no-build condition and 71 seconds under the electrification conditions.
Since the proposed action would have only minor impacts at the above intersection and the electrification LOS is within the acceptable range for urban areas, no mitigation measures are considered necessary.

9.4.4.2 Parking Impacts. The projected increase in Amtrak ridership will occur primarily with the express service and would generate additional parking demand at all express stations. The existing, no-build and electrification parking demand created by Amtrak service, along with existing parking supply, is shown in Table 9-23. It should be pointed out that the demand shown in this table is created by Amtrak service only and additional parking spaces may be required for commuter rail service.

TABLE 9-23
AMTRAK-GENERATED PARKING
DEMAND AT RAILROAD STATIONS[1]

STATION	EXISTING SUPPLY	CURRENT DEMAND	2010 NO-BUILD DEMAND	ELECTRIFICATION DEMAND
South Station	0	110	145	225
Back Bay	0	15	35	70
Route 128	820[2]	170	550	1,260
Providence	360[3]	200	415	665
New Haven	1,207[4]	240	425	470

SOURCES:

[1] Demand: Estimates by DMJM/Harris

[2] MBTA

[3] RIDOT

[4] ConnDOT-125 spaces reserved for Police Department

Except for the New Haven Station, electrification-generated parking demand would exceed the existing supply. At Back Bay and South Stations in Boston, no parking is available and the City of Boston parking freeze does not permit the provision of additional parking spaces. At Providence Station, electrification-generated parking demand is nearly double the existing parking supply, without including commuter demand, generating a substantial need for additional parking. Likewise, at Route 128 station, the electrification-generated parking demand alone exceeds by 50 percent the existing available parking, and there is substantial commuter-generated parking demand at this station.

It is estimated that intercity plus commuter rail parking demand at all express stations would far exceed the existing supply in 2010. Additional parking would be required to accommodate the increased ridership at all express stations. Lack of adequate off-street parking could discourage ridership and would be contrary to the goal of attracting passengers to Amtrak service. Amtrak is currently discussing station and parking improvements at Route 128 station with the MBTA.

9.4.4.3 Impacts of Bridge Modifications. In order to obtain adequate clearance for the installation of the overhead catenary, seventeen overhead bridges would be raised or replaced. Of these, eight are programmed for replacement or reconstruction by the states and are being evaluated in other environmental documents. However, nine bridges would be modified as part of this project, as shown in Table 9.11 , and the impacts on local traffic patterns during construction at these locations are discussed below. Out of these nine bridges, one bridge

(Johnnycake Hill Road) is a pedestrian bridge and would not have any impact on vehicular traffic.

Bridges With Staged Construction. The Millstone Point Road, Burdickville Road and Main Street bridges in Waterford, CT; Charleston, RI and South Kingstown, RI, respectively, would be modified in stages such that vehicular traffic flow will be maintained during construction, generally through one-way traffic flow. The duration of this construction would be from 2.5 to 4 months. Traffic voiumes at these bridge locations are shown below.

	Traffic Volumes		
Bridge	Daily	AM Peak	PM Peak
Millstone Point Road	4,287	874	793
Burdickville Road	151	13	10
Main Street	4,315	962	982

Although traffic at these locations may be somewhat delayed, this inconvenience would be of short term. In order to minimize delays and provide safe traffic operations, traffic signals would be installed for the duration of construction. Traffic signals would be installed at each end of the bridge and would be coordinated. At any given time, only one way traffic would be permitted on a bridge.

Bridges With Unstaged Construction: Construction at the remaining 5 bridges, ranging from two to nine months in duration, cannot be staged and traffic detours would be required. An alternative route (detour) for traffic to use during the construction on each of the five bridges was located. These detour routes are shown in Figures 9-1 to 9-5. Traffic operations at 8 intersections along the detour routes were then analyzed to determine the impacts of diverted traffic. The results of this analysis are summarized below and in Table 9-24.

Kenyon School Road: Kenyon School Road traffic would be diverted to the Route 2 bridge. Two intersections along the Kenyon School Road bridge detour route were analyzed. As shown in Table 9-24, the LOS would not change after the detour traffic is added to the existing traffic and thus no mitigation measures would be required.

Pettaconsett Avenue: Pettaconsett Avenue detour will be analyzed in the FEIS/R due to a recent release of information on the proposed detour route for this bridge.

Park Avenue: Park Avenue traffic would be diverted to Huntington Expressway bridge. Two intersections along the Park Avenue bridge detour route were analyzed. As shown in Table 9-24, the LOS improves from LOS C to B at the Park Avenue/Elmwood Avenue intersection and degrades from LOS D to E at the Park Avenue/Reservoir

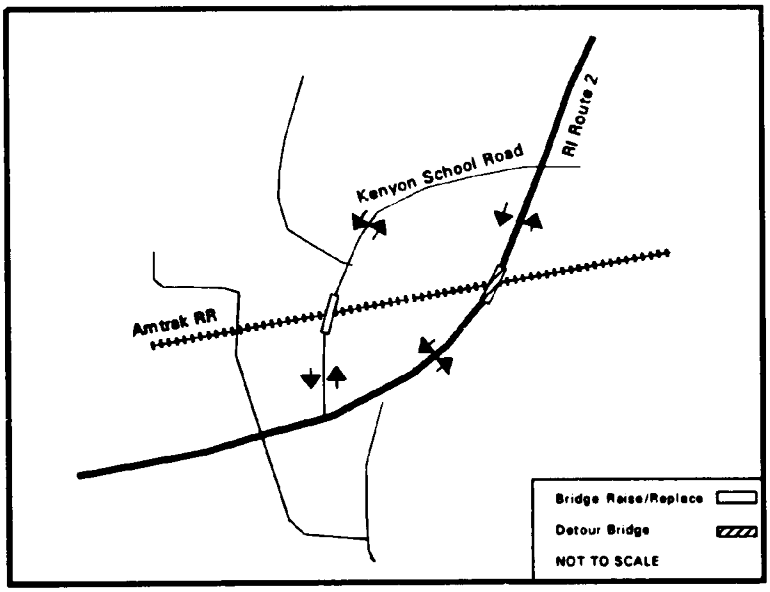

FIGURE 9-1. KENYON SCHOOL ROAD DETOUR

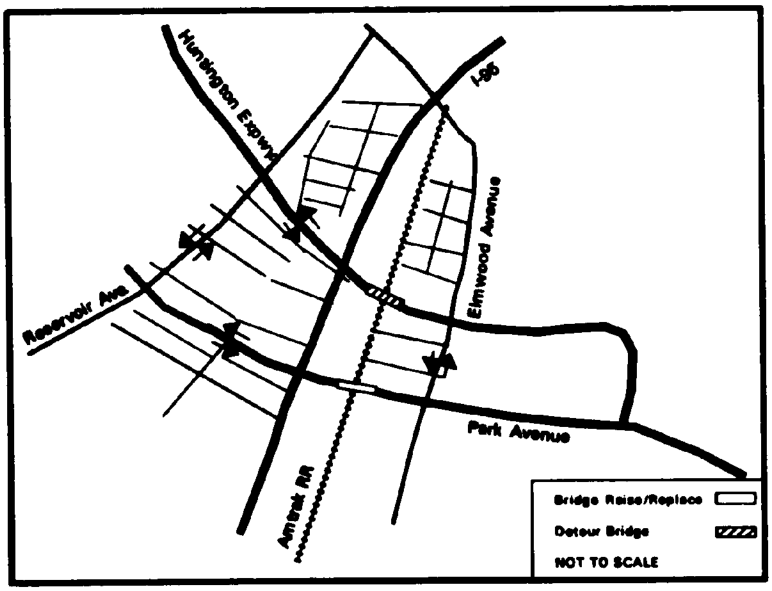

FIGURE 9-2. PARK AVENUE DETOUR

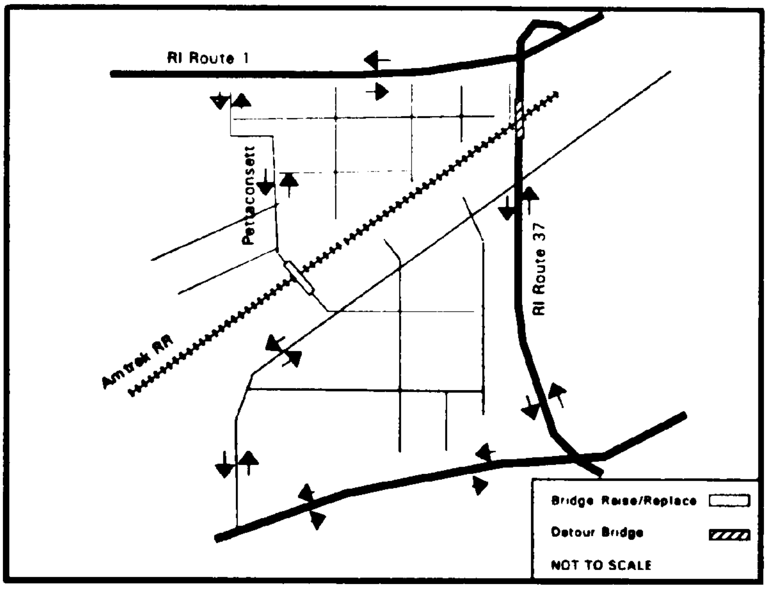

FIGURE 9-3. PETTACONSETT AVENUE DETOUR

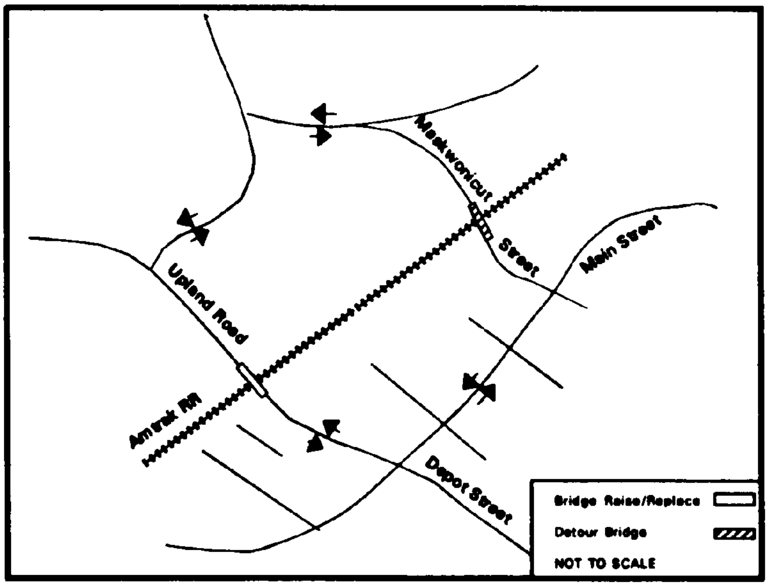

FIGURE 9-4. DEPOT STREET DETOUR

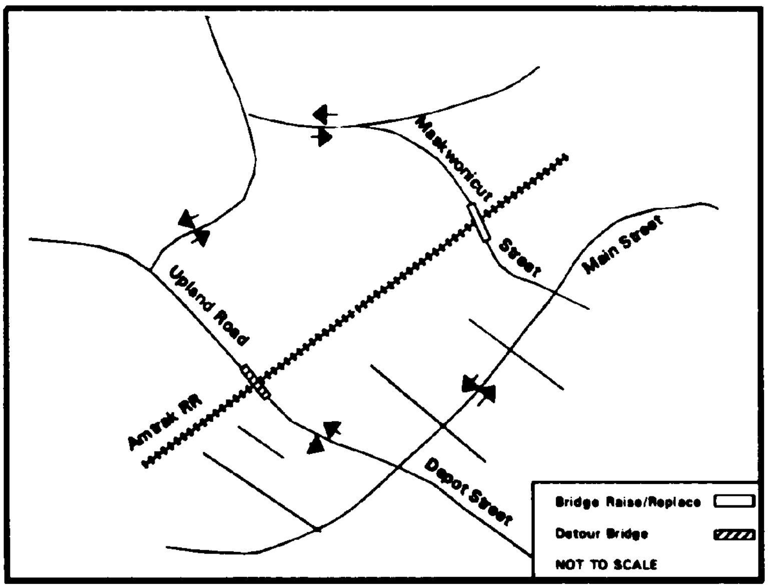

FIGURE 9-5. MASKWONICUT STREET DETOUR

TABLE 9-24
DETOUR INTERSECTION ANALYSIS

BRIDGE	INTERSECTION AFFECTED BY DETOUR	MOVEMENT AFFECTED BY DETOUR	LEVELS OF SERVICE (Existing/Detour)
Kenyon School Road Richmond, RI	Kenyon School Road/Route 2	eastbound rights	A/A
		eastbound lefts	A/A
		northbound lefts	A/A
	Main Street/Route 2	southbound rights	A/A
		southbound lefts	A/A
		eastbound lefts	A/A
Park Avenue Cranston, RI	Park Avenue/Elmwood Avenue	all	C/B
	Park Avenue/Reservoir Avenue	all	D/E
Depot Street Sharon, MA	Depot Street/Upland Avenue/N. Main Street	all	B/C
	Maskwonicut Street/N. Main Street	eastbound rights	A/D
		northbound lefts	A/B
Maskwonicut Street Sharon, MA	Maskwonicut Street/N. Main Street	eastbound rights	A/A
		northbound lefts	A/A
	Depot Street/Upland Street/N. Main Street	all	B/B

Avenue intersection. At Park Avenue/Reservoir Avenue intersection, reassigning the eastbound left and through lane of Park Avenue to left turn only along with appropriate signal phasing to support the change would alleviate the congestion which would be created by the detour.

Depot Street: Depot Street traffic would be diverted to the Maskwonicut Street bridge. At the two intersections analyzed along the Depot Street bridge detour route, the LOS drops slightly when the detoured bridge traffic is added to the existing traffic volumes. At Depot Street/Upland Avenue/N. Main Street intersection the LOS drops from B to C and at the Maskwonicut Street/N. Main Street intersection the LOS drops from A to D. At the Maskwonicut Street/N. Main Street intersection, installation of a signal, or the presence of a police officer or other individual to direct traffic during peak periods is recommended to improve circulation.

Maskwonicut Street: Maskwonicut Street traffic would be diverted to Depot Street bridge. The LOS remains unchanged at the two intersections analyzed along the Maskwonicut Street bridge detour route. Traffic impacts created at this bridge are minor and therefore no mitigation measures would be needed.

9.4.5 Delay at Grade Crossings

The impact of the proposed Amtrak service on the vehicles crossing the tracks at highway-railroad grade crossings is presented in Table 9-25 for the no-build conditions and in Table 9-26 for the proposed electrification conditions. No significant change in delay is anticipated from the two additional round trip trains proposed for the no-build alternative.

The addition of more Amtrak trains and more cars per train would have the effect of increasing both the frequency and length of delays experienced by motorists. Conversely, the faster speeds of the electrified trains would tend to reduce the delay to crossing vehicles. Tables 9-25 and 9-26 show the estimated delay for each gated grade crossing for the 2010 no-build and electrification alternatives. The tables provide the train speed, frequency, delay per train event and average delay per vehicle. An average delay for each vehicle per train event is calculated as one-half the delay per train event. This assumes that vehicles may encounter the closed gate at any time during the period they are down, from the moment they close to just before they open.

Comparisons were made between the projected delays shown in Table 9-25 and the existing delays shown in Table 9-14. No significant effect on delay is anticipated as a result of either the no-build alternative (which generates no change in average delay), or the electrification alternative. For the electrification alternative, the greatest increase in delay per vehicle is from 17 seconds to 22 seconds at State Street, Bank Street and Governor Winthrop Boulevard. This increase in projected delay is not sufficiently significant to require any mitigation measures.

TABLE 9-25
PROJECTED VEHICLE DELAY AT GRADE CROSSINGS
2010 WITHOUT ELECTRIFICATION
(in seconds)

GRADE CROSSING	SPEED (mph)	# TRAINS /DAY	DELAY PER TRAIN EVENT	DELAY PER VEHICLE[1]
Miners Lane[2]	60	28	25	13
Bank Street[2]	25	28	33	17
State Street[2]	25	28	33	17
Gov. Winthrop Blvd.[2]	25	28	33	17
School Street[2]	70	28	25	12
Broadway Ext.	50	28	27	13
Latimer Point Rd.	70	28	25	12
Wampassuc	70	28	25	12
Walkers Dock Rd.	70	28	25	12
Freemans Crossing	70	28	25	12
Palmer Street	80	28	24	12

SOURCE: Amtrak.
NOTES: [1] Computed based on 0.5 x time grade crossing gates in down position.
[2] Does not includes Montrealer, freight, or commuter rail service.
[3] Wolf Rocks crossing programmed for grade separation by RIDOT in 1993

9.6 SUMMARY OF IMPACTS AND MITIGATION MEASURES

This section summarizes effects of the proposed electrification project that could require mitigation and proposes mitigation measures for them. No adverse impacts are anticipated as a result of the no-build alternative. Likewise, it is estimated that the maximum increase in the average delay experienced by motorists at grade crossings would be 5 seconds for the electrification alternative. This change would not require any mitigation.

9.6.1 Intercity Travel and Service

Although no new travel is anticipated as a result of the proposed action, a large portion of the intercity travelers in 2010 are expected to choose intercity rail over air travel as a result of the proposed electrification. The shift is on the order of nearly 2 million, a near doubling in the number of rail passengers over the no-build conditions. This shift also represents a decrease in air ridership of approximately one third. No significant improvements in vehicular congestion around airports is anticipated as a result of this shift. Impacts around the railroad stations, as a result of increased Amtrak ridership, is discussed in section 9.6.3.

TABLE 9-26
PROJECTED VEHICLE DELAY AT GRADE CROSSINGS
2010 WITH ELECTRIFICATION
(in seconds)

GRADE CROSSING	SPEED (mph)	# TRAINS /DAY	DELAY PER TRAIN EVENT	DELAY PER VEHICLE[1]
Miners Lane[2]	80	52	31	15
Bank Street[2]	35	52	44	22
State Street[2]	35	52	44	22
Gov. Winthrop Blvd.[2]	35	52	44	22
School Street[2]	85	52	30	15
Broadway Ext.	80	52	31	15
Latimer Point Rd.	85	52	30	15
Wampassuc	80	52	30	15
Walkers Dock Rd.	100	52	28	14
Freemans Crossing	100	52	28	14
Palmer Street	100	52	28	14

SOURCE: Amtrak.
NOTES: [1] Computed based on 0.5 x time grade crossing gates in down position.
[2] Does not includes Montrealer, freight or commuter rail service.
[3] Wolf Rocks crossing programmed for grade separation by RIDOT in 1993

9.6.2 Effects on Other Northeast Corridor Rail Operations

All of the projected 2010 intercity, freight and commuter operations can be accommodated on the corridor, with no adverse impacts to commuter service expected. The combination of added costs, inconvenience, and limitations of the type of freight rail cars that can be used could have a serious impact on existing and future freight rail movement. Some existing shippers may divert shipments to transportation alternatives and some potential shippers may locate in other areas with more favorable transportation services. This latter impact has implications for the State of Rhode Island's plans to develop a commercial port to be served by the Providence & Worcester Company (P&W) at Quonset Point. This port would be in competition with port facilities in Boston, the New York City area, and other east coast ports which have service via rail lines that can accommodate the larger dimension rail cars. According to estimates developed by the P&W, the additional operating costs and potential loss of new business related to schedule and height restrictions could result in an annual revenue loss of $900,000 to the P&W and could cause P&W to cease operations on the NEC (P&W General Counsel letter to FRA dated January 12, 1993).

Section 4 of the Amtrak Authorization and Development Act (Public Law 102-533, October 27, 1992) directs FRA to prepare a Program Master Plan for the NEC between New York City and Boston. The purpose of this master plan is to develop a strategy to coordinate the improvements necessary for Amtrak to achieve a three-hour trip time between New York and Boston while meeting the needs of other rail operators on the NEC Main Line. As part of this master plan, FRA and the Rhode Island DOT are cooperating in an evaluation of the future rail freight needs in Rhode Island and the best means to meet these needs. Should this study identify other needed improvements to the NEC, these improvements will be evaluated in a separate environmental review.

9.6.3 Traffic and Parking at Railroad Stations

Due to planned improvements around the three railroad stations that could be most affected by increased traffic as a result of increased Amtrak ridership (South Station, Route 128 and Providence Station), no adverse effects on traffic levels of service in the vicinity of these stations is expected. Likewise, with far lower traffic levels anticipated, no effects that could require mitigation are expected at New Haven and Back Bay stations.

To accommodate expected increases in ridership at the express stations, capacity should be expanded as listed below:

	Amtrak-Generated Parking Demand	
Station	Current	Electrification
South Sta.	110	225
Back Bay	15	70
Route 128	170	1,260
Providence	200	665
New Haven	240	470

At Route 128 station, evaluations prepared by the Massachusetts Bay Transportation Authority (MBTA) estimate a projected total need by 2010 of 2,300 spaces for both intercity and rail passengers. Amtrak is currently coordinating the expansion of parking at this station with the MBTA. Likewise, Amtrak should work with the Rhode Island and Connecticut Departments of Transportation (RIDOT and ConnDOT) to develop additional parking at Providence and New Haven stations, as well. In Boston, a citywide parking freeze limits the potential for expanded facilities at Back Bay and South Stations.

9.6.4 Bridge Modifications

There would be no adverse impacts at the following bridges proposed for modification: Johnnycake Hill Road footbridge and the Millstone Point Road, Burdickville Road and Route 138/Main Street bridges. The latter three would be modified in stages, requiring closure of only one lane at a time. No significant traffic impacts are anticipated.

Each of the other five bridges would require closure during construction, ranging from one to nine months duration. Analysis of proposed construction detours indicated no adverse traffic impacts along the Kenyon School Road or Maskwonicut Street detour routes. However, significant impacts would occur along the Park Avenue and Depot Street detours.

Park Avenue Detour. As indicated in Table 9-24, the intersection of Park Avenue and Reservoir Avenue would change from an existing LOS of D to E during bridge construction. Reassigning the eastbound left and through lane of Park Avenue to left turn only along with appropriate signal phasing to support the change would alleviate the substantial congestion which would be created by the detour.

Depot Street Detour. Eastbound right turning movements at the unsignalized intersection of Maskwonicut Street and North Main Street would be significantly impacted by the bridge construction resulting in a LOS change from A to D. Installation of a signal, or the presence of a police officer to direct traffic during peak periods is recommended to improve circulation.

REFERENCES

Amtrak, 1992. National Railroad Passenger Corporation (Amtrak), Philadelphia, PA. 1992.

CRA, 1993. Charles River Associates, Boston, MA. 1993.

Goody & Clancy, 1991.

TSB, 1985. Transportation Research Board, National Research Council. Highway Capacity Manual. Washington, D.C., 1985.

LOGIC, 1993. Logan Growth and Impact Control Study, Phase II, Final Report. April 1993. Prepared for the Massachusetts Port Authority by Frederic R. Harris, Inc. April 1993.

Rand McNally, 1993. Official Airline Guide for North America. Oak Brook, IL. January 1993.

Volpe, 1992. U.S. Department of Transportation Volpe Center, Commuter-Intercity Rail Improvement Study (Boston - New York). Cambridge, MA. 1992.

TECHNICAL STUDY 10
AIR QUALITY

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AIR QUALITY

10.1 INTRODUCTION

The Northeast Corridor (NEC) is the main line passenger railroad route between Union Station in Washington, DC and South Station in Boston, MA via Philadelphia, PA, New York City, NY, New Haven, CT, and Providence, RI. As the NEC is already electrified between New Haven and Washington, Amtrak's proposed project, the subject of this study, involves electrification of the remainder of the corridor between New Haven and Boston.

Following this section is a discussion of the regulatory setting governing the project and the affected (or existing) environment. Then a description of the analysis methods is followed by the evaluation of environmental consequences of the build and no-build alternatives, including the assessment of both long-term and construction impacts. Finally, control strategies to mitigate potential adverse impacts are discussed.

Air pollution is of concern because of its demonstrated effects on human health. Of primary concern are the respiratory effects of particular pollutants, as well as the general toxic effects of pollutants such as carbon monoxide. Air pollutants of concern in the assessment of impacts from transportation sources are listed below, with a general description of their potential health effects:

- **Volatile Organic Compounds (VOCs):** VOCs are a precursor to ozone and are a general class of compounds containing hydrogen and carbon. VOCs are emitted from fuels through evaporation and combustion. Two main types of VOCs are aromatics and olefins. Some aromatics are carcinogenic, while olefins are harmful to plants. At levels typically found in the ambient air, VOCs are not known to be toxic. However, VOCs in the air will react with oxides of nitrogen (NOx) in the presence of sunlight to form photochemical oxidants (ozone) which are toxic.

- **Oxides of Nitrogen (NOx):** NOx are products of fuel combustion. Nitric oxide, a colorless gas, is formed during combustion of fuels at high temperatures and pressures. Although it is relatively harmless, it can readily convert to nitrogen dioxide (NO_2) which can reduce the oxygen-carrying capacity of the blood. Exposure to high concentrations of NO_2 can lead to respiratory illnesses such as bronchitis and pneumonia. NO_2 is also a major constituent of ozone formation. In most areas, motor vehicle exhaust is the largest single source of NOx.

- **Carbon Monoxide (CO):** CO, a colorless and odorless gas, is a by-product of incomplete combustion. It is a toxic gas which, at elevated concentrations, can cause headaches and nausea. At much higher concentrations, prolonged exposure to CO can lead to coma and death. The primary sources of ambient CO are automobile exhaust, power plant emissions, and incineration.

- **PM10:** PM10 indicates particulate matter that are ten microns and smaller. PM10 have health implications because of their potential to penetrate deep into the respiratory tract. PM10 is emitted mostly by stationary fuel burning sources (such as power plants and industry sources) and to a smaller extent by transportation sources.

10.2 REGULATORY SETTING

This section describes the applicable regulations that govern air quality in the project corridor at both the Federal and state levels. This section also describes the procedures that will be needed to demonstrate compliance with these regulations and related criteria.

10.2.1 Federal Regulations

10.2.1.1 National Ambient Air Quality Standards. Under the authority of the Clean Air Act[1] and the 1990 Clean Air Act Amendments[2], a set of ambient air quality standards for various criteria pollutants were established. These standards are intended to protect the public health and welfare. The standards that are particularly relevant to transportation sources include carbon monoxide (CO), ozone, and nitrogen dioxide (NO_2). These standards are summarized in Table 10.1.

10.2.1.2 Clean Air Act Amendments (CAAA) Title I. Title I of the CAAA addresses non-attainment issues related to ozone and CO. It classifies non-attainment areas and specifies compliance deadlines for these areas. Within the project corridor, New Haven, Providence, and Boston were classified as serious non-attainment areas. With this classification, each of these areas must demonstrate a total net reduction in volatile organic compound (VOC) emissions of 15 percent by 1996, when compared to their corresponding baseline emissions in 1990. These same areas must also reduce VOC emissions by 3 percent per year following the 1996 deadline.

Boston and New Haven have been classified as CO non-attainment areas. With this classification, these areas will be required to establish transportation controls (for instance, Transportation System Measures/Transportation Demand Measures or TSM/TDM), and implement an oxygenated fuel program.

10.2.1.3 Clean Air Act Amendments (CAAA) Title II. Title II addresses mobile sources and stipulates more stringent emission standards for cars, trucks, and buses. This Title will also regulate fuel quality (such as gasoline volatility and diesel sulfur content); require reformulated gasoline in worst ozone areas and oxygenated fuels in worst CO areas; and require clean-fueled vehicles for certain fleets and other pilot programs.

TABLE 10.1
FEDERAL AND STATE AMBIENT AIR QUALITY STANDARDS[1]

Pollutant	Average Time Period	Units	Federal	CT	RI	MA
Carbon Monoxide	8-hour	ppm[1]	9[2]	9	9	9
	1-hour	ppm	35	35	35	35
Ozone	1-hour	ppm	0.12	0.12	0.12	0.12
NO_2	Annual	$\mu g/m^3$[3,2]	100	100	100	100
Lead	3-months	$\mu g/m^3$	1.5	1.5	1.5	1.5
SO^2	Annual	$\mu g/m^3$	80	80	80	80
	24-hour	$\mu g/m^3$	365	365	365	365
	3-hour	$\mu g/m^3$	1300[3]	1300	1300	1300
PM10	Annual	$\mu g/m^3$	50	50	50	50
	24-hour	$\mu g/m^3$	150	150	150	150

[1] Federal and state standards, except for annual means, are not to be exceeded more tahn once per year.

[2] Concentrations are given in parts per million (ppm) or in micrograms per cubic meter ($\mu g/m^3$).

[3] The tabulated thresholds are for primary standards which are for protection of public health. Secondary standards are for protection of public welfare. All secondary standards are the same as the primary standards, except for the 3-hour SO_2 which is secondary standard only.

10.2.1.4 DOT 5610.1C. In September 1979, the U.S. Department of Transportation (U.S. DOT) published Order DOT 5610.1C, Procedures for Considering Environmental Impacts.[3] Within the format and contents of Environmental Impact Statements, these procedures require a determination as to the consistency of the proposed project with state plans for the implementation of ambient air quality standards. This requirement has subsequently evolved to mean consistency with applicable State Implementation Plan (SIP) provisions to attain and maintain air quality standards.

10.2.1.5 U.S. DOT Federal Railroad Administration's Procedures for Considering Environmental Impacts. According to the FRA procedures,[4] there should be an assessment of the project alternatives with both Federal and state plans for the attainment and maintenance of air quality standards. This requirement is also included within the non-attainment provision of the SIPs described below.

10.2.2 Connecticut Regulations

10.2.2.1 State Air Quality Standards. Connecticut's Ambient Air Quality Standards, as given in its Regulation Section 22a-174-24,[5] are identical to the Federal standards for CO, ozone, and NO_2. These standards are shown in Table 10.1.

10.2.2.2 State Implementation Plan (SIP) Provisions. The non-attainment provisions in Connecticut's SIP Section SIP 6-B[6] require that a transportation project must not result in an increase in VOC emissions when compared to the no-build in both the short- and long-term. The proposed project must also not result in any violations of the air quality standards. The SIP also requires compliance with the Regional Transportation Plan, the Regional Transportation Improvement Program (TIP), and the State Master Transportation Plan. The Connecticut SIP for transportation projects is currently being revised for submittal to EPA in November 1993, and the revision is expected to include significant emissions reduction requirements for the transportation sector and for new transportation projects.

10.2.2.3 Indirect Source Permit. Projects that are expected to result in traffic generation or in changes in traffic demands and patterns are required to be permitted. The permitting process involves a detailed modeling analysis of CO concentrations in areas of high traffic congestion. This process will insure compliance with the state CO standards by requiring mitigation measures in areas with anticipated excessive CO levels. The indirect source permit process is being revamped, and it appears that the permit process will be restricted to only highway sources.

10.2.2.4 Demonstrating Compliance. To demonstrate consistency with the SIP provision for attainment and maintenance of the ozone standard, the VOC emissions for the proposed project must be less than the corresponding no-build (or no-action) alternative for both the long- and short-term bases.

To estimate the emissions, a project-affected study area must be defined and agreed upon by the appropriate state and Federal oversight agencies. These agencies should also be consulted to reach concurrence in the analysis methods, data bases, and modeling assumptions. VOC emissions are then estimated for the project completion year (the long-term basis). If the project appears to be inconsistent with the SIP provisions, then mitigation measures must be evaluated to achieve this consistency by reducing emissions.

Demonstrating consistency with the CO provisions follows a similar process, except that dispersion modeling is used to estimate both one- and eight-hour CO concentrations. If the project entails Federal review, the US EPA Region I, which presides over Connecticut (and Rhode Island and Massachusetts) would require a more stringent threshold to include mitigation measures. This lower threshold is set at 10 percent of the CO standards.

10.2.3 Rhode Island Regulations

10.2.3.1 State Air Quality Standards. As stated in Rhode Island's Regulation 9,[7] the state's Ambient Air Quality Standards are the same as the Federal standards listed in Table 10.1.

10.2.3.2 State Implementation Plan (SIP) Provisions. The ozone non-attainment provisions of Rhode Island's SIP[8] require that the proposed project will not result in an increase in VOC emissions over the no-build alternative for both the short- and long-term. For CO, the SIP requires that the project must not lead to a new violation of the CO standards or exacerbate an existing violation.

The SIP also requires consistency with the state Transportation Improvement Program (TIP). The Rhode Island SIP for transportation projects is currently being revised for submittal to EPA, and the revision is expected to include significant emissions reduction for the transportation sector.

10.2.3.3 Demonstrating Compliance. Consistency with the state's SIP for ozone is demonstrated by ensuring that the VOC emissions associated with the proposed project are less than the corresponding emissions from the no-build alternative in both the short- and long-term. Consistency with the SIP for CO is demonstrated by estimating one- and eight-hour CO concentrations and ensuring that no new violations are created or existing violations are made worse.

10.2.4 Massachusetts Regulations

10.2.4.1 State Air Quality Standards. The Massachusetts Ambient Air Quality Standards, as described in Section 310 CMR 6.00[9] for CO, ozone, and annual NO_2, are identical to the Federal standards and are listed in Table 10.1. The state also has a one-hour NO_2 policy level which has been used to evaluate impacts from transportation and power generation projects.

10.2.4.2 State Implementation Plan (SIP) Provisions. The SIP provisions for Massachusetts are very similar to those of Connecticut and Rhode Island. Specifically, for ozone standard compliance, the Massachusetts SIP requires that the VOC emissions from the proposed project must be less than the corresponding emissions from the no-build alternative for both the short- and long-term. For CO standards compliance, the SIP requires that the project must not result in any new violations or exacerbate an existing violation.

The state is in the process of revising its SIP. The revisions are expected to include an enhanced Inspection and Maintenance program for motor vehicles, and increasing emphasis on TSM/TDM for all transportation projects.

10.2.4.3 Demonstrating Compliance. Consistency with the Massachusetts SIP for ozone is accomplished by ensuring that the VOC emissions for the proposed project are less than the emissions from the no-build alternative. Consistency with the SIP for CO is demonstrated by ensuring that there are no new CO standards violations, and that no existing violations are made worse.

10.3 AFFECTED ENVIRONMENT

Potential air quality impacts of the proposed electrification project include potential changes in: 1) the regional ambient air quality due to the switch from diesel-fueled to electric-powered locomotives, 2) the overall emissions from transportation sources, and 3) changes in local or microscale ambient air quality concentrations. This last category of impacts includes potential changes around railroad stations due to increased traffic resulting from increased ridership and changes from locomotive passbys. These changes are evaluated in Section 10.4 of this report.

In this section, ambient or existing air quality conditions and emissions in the corridor and at particular locations are identified. Section 10.3.1 describes general ambient air quality conditions throughout the study area and Section 10.3.2 describes the various sources of all existing emissions on a corridor-wide basis and by state. Section 10.3.3 identifies the emissions attributable to various transportation sources, including automobiles, buses, trains, and aircraft. Section 10.3.4 describes existing concentrations on a microscale basis for four representative sites in the corridor - the railroad station anticipated to experience the greatest increase in automobile traffic and three locations that represent different train passby scenarios. Each of these sections contains a description of the methodology used to determine or estimate the existing conditions.

10.3.1 Ambient Air Quality in the Northeast Corridor

Each of the states along the project corridor (Connecticut, Rhode Island, and Massachusetts) maintains a network of monitoring stations which sample ambient air concentrations and provide data to assess the impact of control strategies. The pollutants of concern are those pollutants which are primarily emitted from transportation sources. These include CO, ozone, NO_2, and PM10. In this section, the most recent information available from the monitoring stations for a full year (1991) is presented and compared to the Federal and state air quality standards presented in Table 10.1. This information is summarized in Table 10.2.

10.3.1.1 Connecticut. There is one monitoring station each for CO, ozone, and NO_2 and ten PM10 stations located in the New Haven area. The information presented here from these stations is based on data provided by the Connecticut Department of Environmental Protection (ConnDEP)[10].

As shown in Table 10.2, the measured maximum one-hour CO concentration in New Haven in 1991 is 10.8 parts per million (ppm). This level is well below the one-hour CO standard of 35 ppm. The measured maximum eight-hour CO concentration in 1991 is 6.5 ppm and this level is well below the eight-hour CO standard of 9 ppm. Although there are currently no violations of the CO standards in this area of Connecticut, the region is presently classified as a non-attainment area for CO due to violations in the recent past.

The measured maximum one-hour ozone concentration in New Haven in 1991 is 0.161 ppm. This level is above the one-hour ozone standard of 0.125 ppm. This area of Connecticut is presently classified as a serious ozone non-attainment area.

The measured annual NO_2 concentration in New Haven in 1991 is 0.028 ppm. This level is well below the annual NO_2 standard of 0.05 ppm. This area of Connecticut is presently classified as in attainment for NO_2.

The New Haven area of Connecticut is in non-attainment for PM10. The measured maximum 24-hour PM10 concentration in New Haven in 1991 is 186 micrograms per cubic meter ($\mu g/m^3$). This level is above the 24-hour PM10 standard of 150 $\mu g/m^3$. The measured maximum annual PM10 concentration in 1991 is 47 $\mu g/m^3$ and this level is below the annual standard of 50 $\mu g/m^3$.

10.3.1.2 Rhode Island. There are two CO monitoring stations in the Providence area and one each for ozone, NO_2, and PM10. Based on data from the Rhode Island Department of Environmental Management (RIDEM)[11], information from these stations is presented here and is summarized in Table 10.2.

Rhode Island is in attainment for CO throughout the state. The measured maximum one-hour CO concentration in Providence in 1991 is 14.7 ppm. This level is well below the one-hour CO standard of 35 ppm. The measured maximum eight-hour CO concentration in 1991 is 8.2 ppm and this level is below the eight-hour CO standard of 9 ppm.

The measured maximum one-hour ozone concentration in Providence in 1991 is 0.116 ppm. Although this level is below the one-hour ozone standard of 0.125 ppm, Rhode Island is presently classified as a serious ozone non-attainment area due to violations of the ozone standard in the state in the past.

The measured annual NO_2 concentration in Providence in 1991 is 0.028 ppm. This level is well below the annual NO_2 standard of 0.05 ppm. Rhode Island is presently classified as in attainment for NO_2.

Rhode Island is in attainment for PM10 throughout the state. The measured maximum 24-hour PM10 concentration in Providence in 1991 is 87 μg/m3. This level is well below the 24-hour PM10 standard of 150 $\mu g/m^3$. The results of the 1991 measurements are summarized in Table 10.2. The measured maximum annual PM10 concentration in 1991 is 36 $\mu g/m^3$ and this level is below the corresponding standard of 50 $\mu g/m^3$.

10.3.1.3 Massachusetts. There are four CO, two NO_2, and five PM10 monitoring stations located in the Metropolitan Boston area, as well as one ozone monitoring station located in Chelsea, MA just outside of Boston. Based on data from the Massachusetts Department of Environmental Protection (MADEP)[12], information from these stations is presented here and is summarized in Table 10.2.

TABLE 10.2
1991 MONITORING RESULTS FOR THE PROJECT CORRIDOR[1]

Site ID	Location	Max. 1-Hr.		Max. 8-Hr.		Max. 24-Hr.		Annual	No. Obs. > Std.[2]
		1st	2nd	1st	2nd	1st	2nd		
Carbon Monoxide[3]									
09-009-0019	New Haven, CT[4]	10.8	9.7	6.5	6.3	--	--	--	0
44-007-0015	Providence, RI[5]	14.7	11.2	7.1	6.8	--	--	--	0
44-007-0015	Providence, RI	11.8	11.3	8.2	7.4	--	--	--	0
25-025-0002	Boston, MA[6]	7.4	6.5	4.9	4.2	--	--	--	0
25-025-0016	Boston, MA[6]	7.9	7.2	5.3	4.2	--	--	--	0
25-025-0021	Boston, MA[6]	7.9	6.5	3.7	3.6	--	--	--	0
25-025-0038	Boston, MA[6]	8.0	6.7	4.3	4.2	--	--	--	0
Ozone[7]									
09-0009-1123	New Haven, CT	0.161[4]	0.147	--	--	--	--	--	7
44-007-0012	Providence, RI	0.116[5]	0.114	--	--	--	--	--	0
25-025-1003	Chelsea, MA	0.126[6]	0.122	--	--	--	--	--	1
Nitrogen Dioxide[8]									
09-009-0021	New Haven, CT	--	--	--	--	--	--	0.028	0
44-007-0012	Providence, RI	--	--	--	--	--	--	0.025	0
25-025-0002	Boston, MA	0.154[6]	0.150	--	--	--	--	0.035	0
25-025-0021	Boston, MA	0.092	0.089	--	--	--	--	0.032	0

TABLE 10.2
1991 MONITORING RESULTS FOR THE PROJECT CORRIDOR (CONTINUED)

Site ID	Location	Max. 1-Hr. 1st	Max. 1-Hr. 2nd	Max. 8-Hr. 1st	Max. 8-Hr. 2nd	Max. 24-Hr. 1st	Max. 24-Hr. 2nd	Annual	No. Obs. > Std.[2]
PM10[9]									
09-009-0021	New Haven, CT	--	--	--	--	186	152	47	2
44-007-0020	Providence, RI	--	--	--	--	87	69	36	0
25-025-002	Boston, MA	--	--	--	--	51	51	27	0

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1. All concentrations are in parts per million (ppm)
2. The number of observations exceeding the standard shown in Table 10.1.
3. The carbon monoxide 1-hour standard is 35 ppm and the 8-hour standard is 9 ppm.
4. Source: 1991 Air Quality Data Summary - CT Department of Environmental Protection.
5. Source: 1991 Air Quality Data Summary - RI Department of Environmental Management.
6. Source: 1991 Air Quality Data Summary - MA Department of Environmental Protection.
7. The ozone 1-hour standard is 0.125 ppm.
8. The nitrogen dioxide annual standard is 0.05 ppm and the Massachusetts 1-hour NO_2 Policy level is 0.170 ppm.
9. PM10 means particulate matter of 10 microns in diameter or smaller. The PM10 24-hour standard is 150 $\mu g/m^3$ and the Annual standard is 50 $\mu g/m^3$.

Portions of Massachusetts are in attainment for CO. The measured maximum one-hour CO concentration in Boston in 1991 is 8.0 ppm. This level is well below the one-hour CO standard of 35 ppm. The measured maximum eight-hour CO concentration in 1991 is 5.3 ppm and this level is below the eight-hour CO standard of 9 ppm. Although there are currently no violations of the CO standard in this area of Massachusetts, the region is still classified as a non-attainment area for CO due to violations in the recent past.

The measured maximum one-hour ozone concentration in Boston in 1991 is 0.126 ppm. This level is above the one-hour ozone standard of 0.125 ppm. This area of Massachusetts is presently classified as a serious ozone non-attainment area.

The measured annual NO_2 concentrations for the two stations in 1991 range from 0.032 to 0.035 ppm. These levels are well below the annual NO_2 standard of 0.05 ppm. Massachusetts is presently classified as in attainment for NO_2. The state of Massachusetts also has a one-hour NO_2 policy level of 0.17 ppm. This level is not a standard that mandates compliance, rather, it is a health guideline or criterion that is used to assess the impact of both transportation and stationary source projects. The measured maximum one-hour NO_2 concentration in Boston in 1991 is 0.154 ppm, which is below the one-hour NO_2 MA policy level.

Massachusetts is in attainment for PM10 throughout the state. The measured maximum 24-hour PM10 concentration in Boston in 1991 is 51 $\mu g/m^3$. This level is well below the 24-hour PM10 standard of 150 $\mu g/m^3$. The results of the 1991 measurements for the PM10 station with the highest concentrations are summarized in Table 10.2. The measured annual PM10 concentration in 1991 is 27 $\mu g/m^3$ and this level is below the corresponding standard of 50 $\mu g/m^3$.

10.3.2 Total Existing Emissions in the Northeast Corridor

Total existing levels of VOC, NOx and CO emissions in the NEC are described below for the relevant counties in each of the three states. There are four general sources of emissions in the region and the proportion of the total emissions attributable to each is presented below. These include mobile (transportation), point (identifiable, non-mobile sources such as power plants), area (non-point and other sources) and biogenic (or natural) sources. Tables 10.3 through 10.5 summarize the emissions by source for VOCs, NOx and CO, respectively.

10.3.2.1 Volatile Organic Compounds (VOCs). Total VOC emissions in New Haven County of Connecticut was estimated at close to 170 tons/day.[13] As shown in Table 10.3, mobile, biogenic and area (non-point and other) sources contribute approximately equally to this total inventory.

For Providence and Kent Counties in Rhode Island, transportation and biogenic sources each contribute approximately 31 percent to the total of 232 tons/day of VOCs.[14]

In the Norfolk and Suffolk Counties of Massachusetts, area sources, such as residences and other non-point sources, are responsible for over 40 percent of the total VOC emissions of 216 tons/day.[15] As shown in Table 10.3, transportation sources represent the second largest group, contributing close to 37 percent of the total emissions.

10.3.2.2 Nitrogen Oxides (NOx). Table 10.4 shows the existing emissions of NOx for Connecticut, Rhode Island, and Massachusetts. In all three states, transportation sources are the major contributors to the NOx inventories, ranging from 55 percent in Massachusetts to over 80 percent in Rhode Island.

10.3.2.3 Carbon Monoxide (CO). Existing CO emissions in the counties affected by the project corridor range from approximately 386 tons/day in Connecticut to over 570 tons/day in Massachusetts. As shown in Table 10.5, transportation sources are the principal contributors to these CO inventories, accounting for more than 95 percent of the total emissions in each of the three states.

10.3.3 Inventory of Existing Transportation Emissions in the Northeast Corridor

This section provides an estimate of existing emissions that can be attributed to transportation sources, in order to provide a basis for the emissions inventory analysis in the evaluation of build and no-build alternatives in Section 10.4.2. Estimates are made for the source-modes that may be affected by the proposed project, including automobiles, intercity bus, Amtrak, other trains (commuter and freight) and aircraft. In the sections below, the methodology for making these estimates is presented, followed by a discussion of the estimated proportions contributed by each source mode of VOCs, NOx and CO in 1992.

10.3.3.1 Methodology. Emission inventories are quantities of pollutants emitted over a given time period, which provide information about contributions from various sources. Emissions are estimated by multiplying emission factors by source activity. Emission factors are the emissions from one source unit (e.g. a locomotive on a single trip from New Haven to Boston). The source activity to be multiplied by such a factor would be the scheduled number of trips in a given period, such as one day or 24 hours. Emission factors for all sources are based on U.S. EPA methodologies. Emission inventories are presented here for a 24-hour period using average summer temperatures to reflect conditions during the ozone season. The sources taken into account include the following project-related transportation sources:

Railroad Locomotives. Data on the number and types of passenger and freight railroad locomotives using the NEC was obtained from Amtrak, freight and commuter operators on the corridor. Emissions from existing diesel-powered Amtrak locomotives, other diesel-powered passenger service locomotives, commuter and diesel-powered freight locomotives were used to characterize the existing 1992 emissions in this section, as well as to characterize the 2010 no-build condition in Section 10.4.2. Locomotive emissions were determined based on the procedures and data in EPA's Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources.[16]

TABLE 10.3 SOURCES OF EXISTING VOC EMISSIONS

	Connecticut		Rhode Island		Massachusetts		Total	
Source Category	Emissions tons/day	% of Total	Emissions tons/day	% of Total	Emissions tons/day	% of Total	Emissions tons/day	% of Total
Mobile	50	30	73	31	79	37	202	33
Area	53	32	64	28	93	43	210	34
Point	16	9	22	0	18	8	56	9
Biogenic	49	29	73	31	26	12	148	24
Total	168	100	232	100	216	100	616	100

Source: See References 13, 14 and 15

TABLE 10.4 SOURCES OF EXISTING NOX EMISSIONS

	Connecticut		Rhode Island		Massachusetts		Total	
Source Category	Emissions tons/day	% of total	Emissions tons/day	% of Total	Emissions tons/day	% of Total	Emissions tons/day	% of Total
Mobile	75	74	68	86	101	55	244	67
Area	3	3	4	5	29	16	36	10
Point	23	23	7	9	53	29	83	23
Biogenic	-	-	-	-	-	-	-	-
Total	101	100	79	100	183	100	363	100

Source: See References 13, 14 and 15

TABLE 10.5 SOURCES OF EXISTING CO EMISSIONS

	Connecticut		Rhode Island		Massachusetts		Total	
Source Category	Emissions tons/day	% of total	Emissions tons/day	% of Total	Emissions tons/day	% of Total	Emissions tons/day	% of Total
Mobile	379	98	556	99	555	96	1490	98
Area	3	1	2	<1	16	3	21	1
Point	4	1	6	1	6	1	16	1
Biogenic	-	-	-	-	-	-	-	-
Total	386	100	564	100	577	100	1527	100

Source: See References 13, 14 and 15

Motor Vehicle Sources. Emissions were calculated based on vehicle-miles-travelled (VMTs) for automobiles and intercity buses in the Northeast Corridor. The emission factors which were used to estimate the automotive emissions were obtained from the EPA's MOBILE5A program.[17] Emissions from automobiles in each of the three states were determined separately, using the state specific MOBILE5A inputs agreed to in discussions with the three state agencies involved.

Aircraft Sources. Data on the types of aircraft using Logan Airport, New York City, Providence, and New Haven airports were obtained from a memorandum to DMJM/Harris[18] and from the Official Airline Guide. Emissions were determined based on the procedures and data in EPA's Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources.

10.3.3.2 Existing VOC Transportation Emissions. As shown in Table 10.6, automobiles account for the overwhelming proportion of VOCs attributable to project-related transportation sources (83.8 percent corridor-wide), with aircraft responsible for the second largest proportion (12.7 percent corridor-wide), particularly in the Massachusetts portion of the NEC. Amtrak, other trains and intercity buses are responsible for approximately one percent each corridor-wide and in each state. In Connecticut and Rhode Island, automobiles are responsible for nearly all transportation VOCs in the NEC (93 percent in each state). In Massachusetts, the only state with a major airport in the corridor, aircraft (35 percent) and automobiles (59 percent) account for approximately the same proportion as automobiles in other states.

10.3.3.3 Existing NOx Transportation Emissions. Automobiles account for nearly half of all project-related NOx emissions in the total corridor, and for over 60 percent each in Connecticut and Rhode Island (Table 10.7). In Massachusetts, where a significant commuter rail system exists, trains other than Amtrak are accountable for the majority of NOx (40 percent), with automobiles accountable for the second largest proportion (24 percent). Amtrak trains are responsible for the second largest proportion of NOx in Connecticut and Rhode Island (19.4 and 29.6 percent respectively), where commuter train operations a· much smaller. As a result, trains other than Amtrak, and Amtrak trains are responsible for 40 percent of corridor-wide NOx emissions from project-related transportation sources.

10.3.3.4 Existing CO Transportation Emissions. In all three states and corridor-wide, automobiles are responsible for the overwhelming majority of project-related CO emissions, as shown in Table 10.8. Only in Massachusetts are other sources responsible for more than three percent. Again, this is due to the presence of a major airport in Boston, making aircraft responsible for 13 percent of CO emissions.

10.3.4 Existing Ambient Concentrations at Selected Sites.

This section provides the existing or ambient conditions for the dispersion modeling analysis in Section 10.4.4. Ambient concentrations analysis is a microscale assessment for a particular, small-scale area. Two different types of evaluations are made in this study. The first is a microscale CO concentration assessment for two intersections in the vicinity of the Route 128 express station in Dedham, MA, anticipated to be the most congested express station in terms of project-generated automobile traffic. The second is an assessment of the impact of locomotive passbys at three representative sections of track along the NEC. This section provides the estimated existing ambient concentrations in order to provide a basis for evaluation for each of these factors.

TABLE 10.6 EXISTING PROJECT-RELATED VOC EMISSIONS IN THE NEC BY STATE

Source	Connecticut		Rhode Island		Massachusetts		Corridor Total	
	Kg/day	%	Kg/day	%	Kg/day	%	Kg/day	%
Automobiles	2,230	93.0	839	92.8	709	58.6	3,778	83.8
Aircraft	108	4.5	42	4.7	422	35.0	572	12.7
Amtrak	28	1.2	18	2.0	14	1.2	60	1.3
Other Trains	16	0.7	2	0.2	48	4.0	66	1.5
Buses	15	0.6	3	0.3	14	1.2	32	0.7
Power Generation	0	0.0	0	0.0	0	0.0	0	0.0
TOTAL	2,397	100	904	100	1,207	100	4,508	100

TABLE 10.7 EXISTING PROJECT-RELATED NOX EMISSIONS IN THE NEC BY STATE

Source	Connecticut		Rhode Island		Massachusetts		Corridor Total	
	Kg/day	%	Kg/day	%	Kg/day	%	Kg/day	%
Automobiles	2,990	64.0	1,176	60.5	951	24.3	5,117	48.6
Aircraft	34	0.7	60	3.1	703	17.9	797	7.6
Amtrak	909	19.4	576	29.6	469	12.0	1,954	18.5
Other Trains	505	10.8	80	4.1	1,568	40.0	2,153	20.4
Buses	236	5.1	52	2.7	229	5.8	517	4.9
Power Generation	0	0.0	0	0.0	0	0.0	0	0.0
TOTAL	4,674	100	1,944	100	3,920	100	10,538	100

TABLE 10.8 EXISTING PROJECT-RELATED CO EMISSIONS IN THE NEC BY STATE

Source	Connecticut		Rhode Island		Massachusetts		Corridor Total	
	Kg/day	%	Kg/day	%	Kg/day	%	Kg/day	%
Automobiles	27,490	98.9	11,236	97.5	8,742	84.7	47,468	95.6
Aircraft	102	0.4	211	1.8	1,338	13.0	1,651	3.3
Amtrak	80	0.3	51	0.5	41	0.4	172	0.4
Other Trains	45	0.2	7	0.1	138	1.3	190	0.4
Buses	69	0.2	15	0.1	67	0.6	151	0.3
Power Generation	0	0.0	0	0.0	0	0.0	0	0.0
TOTAL	27,786	100	11,520	100	10,326	100	49,632	100

10.3.4.1 Existing CO Concentrations near the Route 128 Express Station. The focus of this analysis is on CO concentrations at sensitive receptor locations in the vicinity of potentially congested intersections near the "worst case" express station, which is the one anticipated to experience the largest volumes of project-generated traffic.

Methodology. Based on level-of-service (LOS), parking demands, and other appropriate traffic indicators, the five express stations were rank ordered with respect to traffic congestion potential, associated emissions potential, and existing air quality levels. The highest ranked station, representing the worst case condition, was determined to be the Route 128 Station in Dedham, MA. This station was selected for the detailed modeling analysis.

The analysis estimated maximum eight-hour CO concentrations at receptor locations that may be affected by emissions from key intersections, access and egress roads, and the parking facilities. These receptors included sidewalk locations, residences, and places of business where the public has access.

EPA's CAL3QHC model[19] was used to estimate ambient eight-hour CO concentrations from roadway and intersection sources. For parking area sources, EPA's PAL2.1 program[20] was used to estimate contributions from this source. Free-flow CO emission rates were developed from the factors in EPA's MOBILE5A program. Idle CO emission rates were developed from EPA's MOBILE4.1 program.[21]

To run the CAL3QHC model, signal cycles were developed for each intersection. These cycles include total cycle time and red phase time for each approach to all intersections. Where an intersection is not signalized, equivalent cycle times were developed so that the same CAL3QHC model could still be exercised to estimate CO from queuing vehicles.

The meteorology conditions that were assumed for the CO analysis include the following:

Ambient temperatures:	30° F
Wind speed:	1 m/sec
Stability:	D
Mixing height:	1000 m
Wind direction:	Scan at 10° increments

The eight-hour background CO concentration is assumed to be 3 parts per million (ppm) and the one-hour background CO concentration is assumed to be 5 ppm. Existing background levels were adjusted for the 2010 design year conditions based on the ratio of the future to the existing emissions inventories.

A persistence factor to convert eight- to one-hour concentrations was developed from observed monitoring data. The ratio of the second highest eight-hour to the second highest one-hour concentrations recorded in the most recent year of available data (1991) was determined to be 1.7.

Evaluation of Existing Ambient Concentrations. Two intersections near the Route 128 express station were modeled: University Avenue and Blue Hill Drive, and Blue Hill Drive and the ramps for Route 128 South. Figure 10.1 shows the location of these two intersections. The detail of the roadway geometries and the locations of the selected receptors in the vicinity of the intersection of University Avenue and Blue Hill Drive are illustrated schematically in Figure 10.2. Similar information for the intersection of Blue Hill Drive and the Route 128 Ramps is shown in Figure 10.3.

Estimated eight-hour CO concentrations for 1992 are exhibited in Table 10.9 for the intersection of University Avenue and Blue Hill Drive, and in Table 10.10 for the intersection of Blue Hill Drive and Route 128 South ramps. With the exception of some sidewalk receptors on Blue Hill Drive and University Avenue, the eight-hour CO concentrations in 1992 were estimated to be less than the 9-ppm standard. At some of the sidewalk receptors on Blue Hill Drive eastbound and University Avenue northbound, eight-hour CO concentrations were estimated to be slightly over the standard.

Maximum one-hour CO concentrations in 1992 were estimated from the eight-hour results by the use of an inverse persistence factor. The one-hour results for the intersections of University Avenue and Blue Hill Drive, and Blue Hill Drive and the Route 128 ramps are shown in Table 10.9 and 10.10, respectively. No violations of the one-hour standard of 35 ppm were encountered in 1992.

10.3.4.2 Existing Air Quality Effect of Locomotive Passbys. The purpose of this information is to demonstrate the effect of existing diesel locomotive passbys on air quality so that it can be compared to the impacts of the project alternatives. Three prototypical sections of track along the NEC were identified and selected for the modeling analysis. The selection was based on evaluating combinations of train operating characteristics (for example, power settings and train speeds) and the density of nearby sensitive receptors.

Methodology. The effects of individual locomotive passbys were evaluated to determine what the peak, transitory pollution levels could be under the worst meteorology conditions. The analysis was accomplished by using EPA's INPUFF model[22] and exhaust characteristics from General Motors for the F40PH locomotive.[23]

The effects of locomotive passbys were also assessed with respect to peak one-hour concentrations of CO and NO_2. These one-hour results were estimated by adding the contributions from all passbys in the peak hour and averaging the total contribution over an one-hour period.

Figure 10.1
Locations of Modeled Intersections in the Vicinity of Route 128 Station

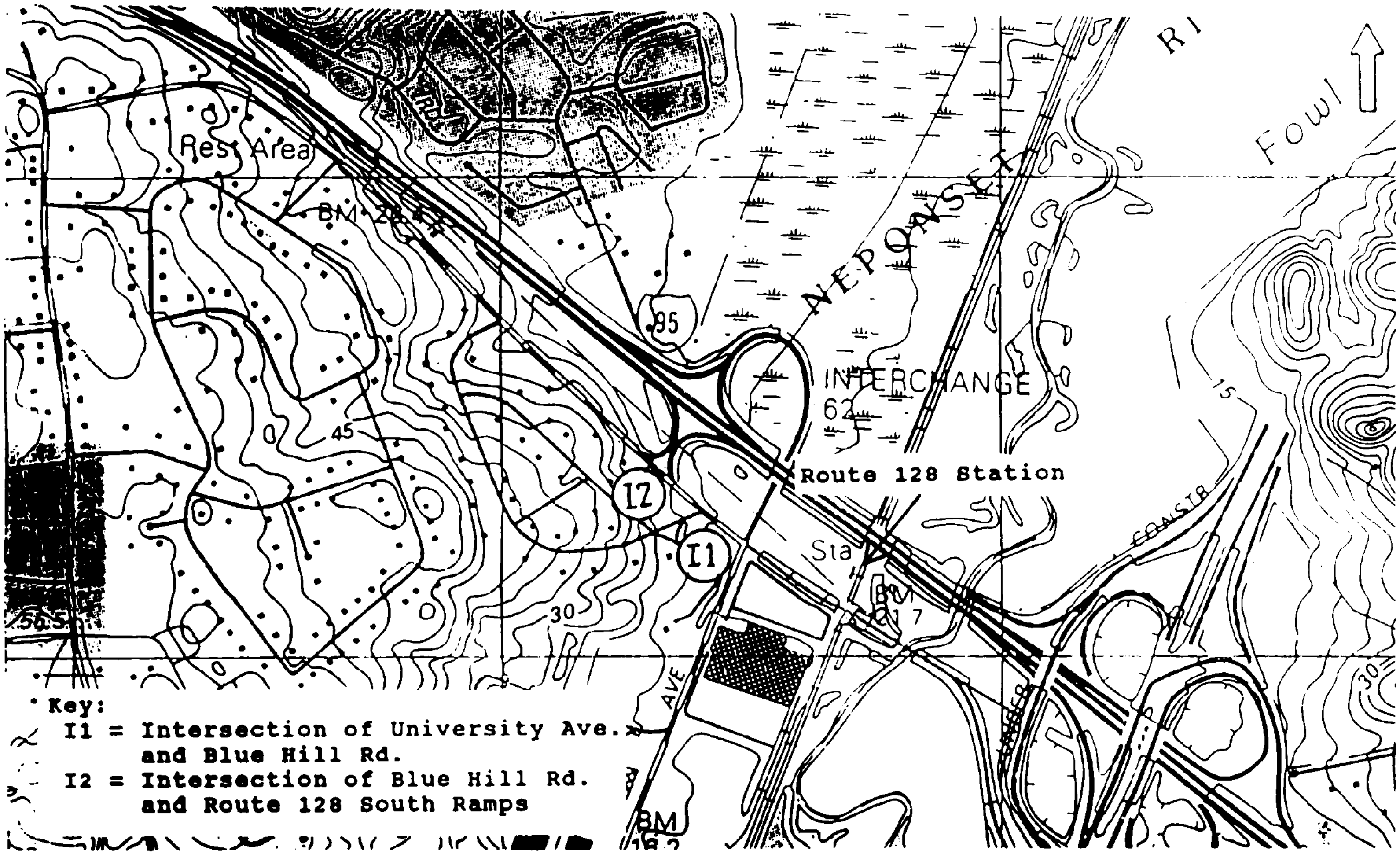


Figure 10.2
Receptor Locations Near the Intersection of University Avenue and Blue Hill Drive

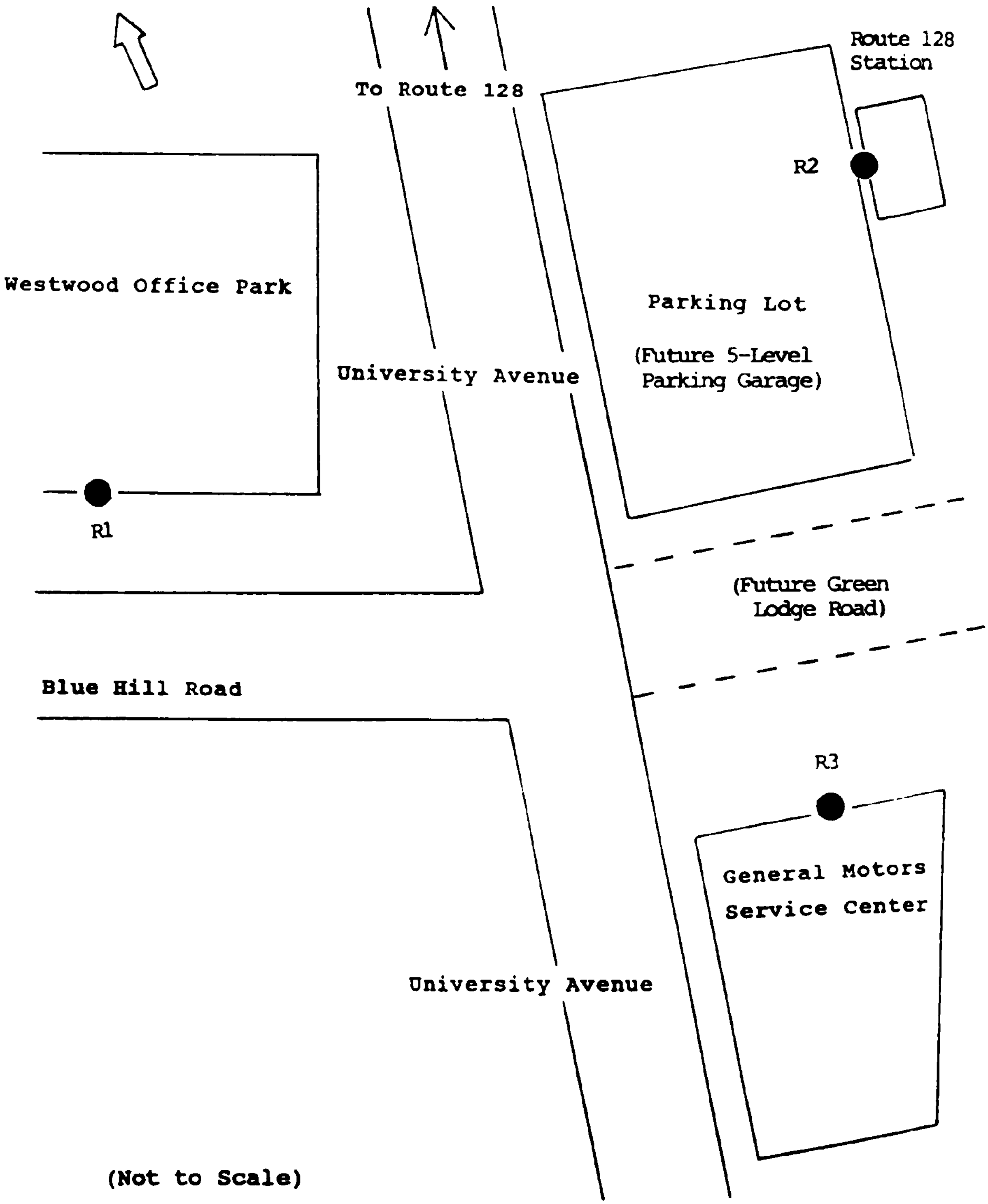


Figure 10.3
Receptor Locations Near the Intersection of Blue Hill Drive and the Route 128 South Ramps

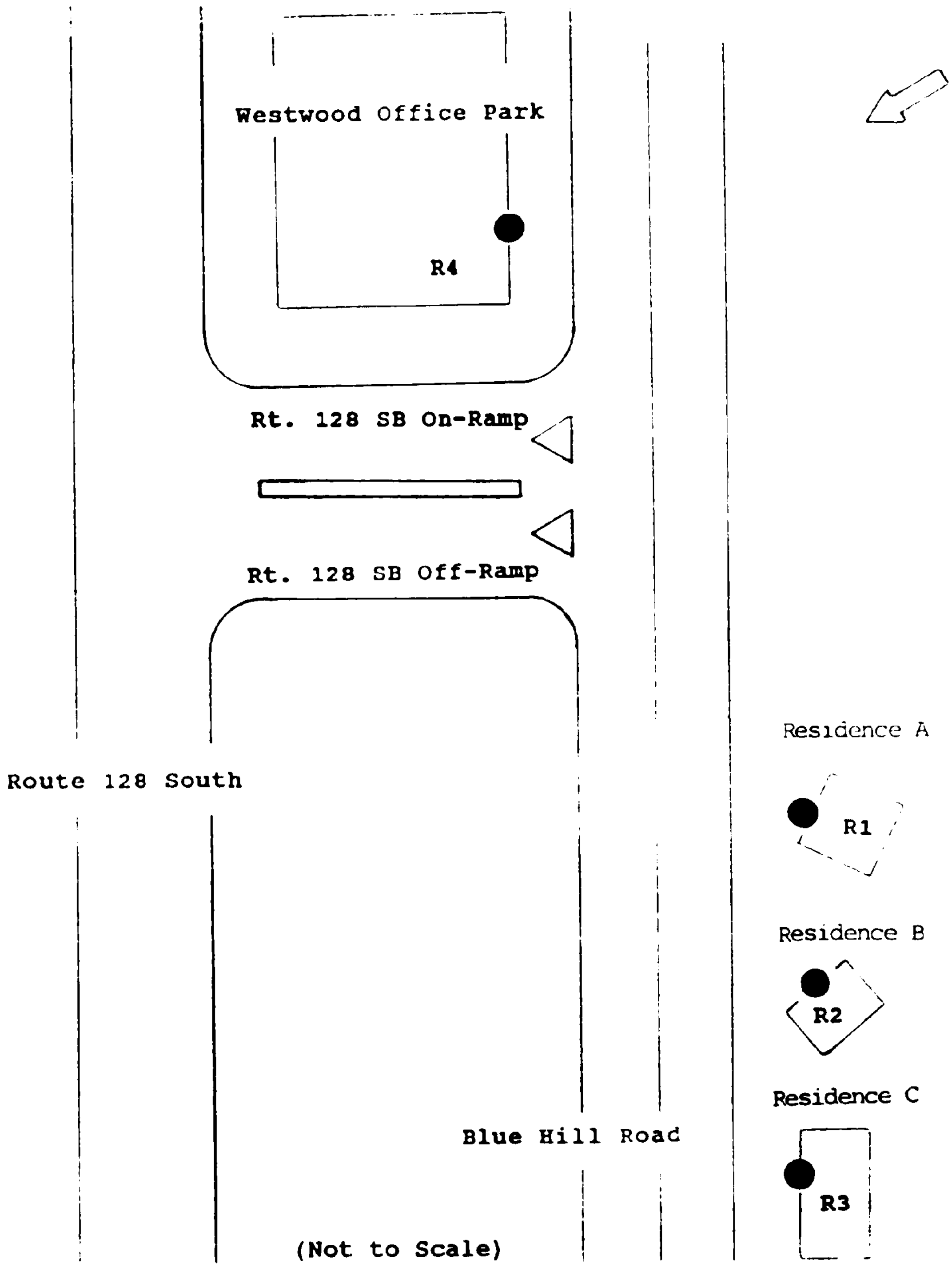


TABLE 10.9

ESTIMATED MAXIMUM 1992 EIGHT- AND ONE-HOUR CO CONCENTRATIONS[1] AT THE INTERSECTION OF UNIVERSITY AVENUE AND BLUE HILL DRIVE

	Receptor Location	Eight-Hour	One-Hour
R1	Westwood Office Park	5.7	2.7
R2	Rt. 128 Train Station	4.0	1.9
R3	General Motors Bldg.	4.3	2.2
R4	Blue Hill Rd. EB @ 10m	9.4[2]	4.5
R5	Blue Hill Rd. EB @ 20m	9.4[2]	4.0
R6	Blue Hill Rd. EB @ 40m	9.4[2]	3.4
R7	University Ave. SB @ 10m	6.1	6.7
R8	University Ave. SB @ 20m	6.7	6.0
R9	University Ave. SB @ 40m	6.0	4.2
R10	University Ave. NB @ 10m	9.3[2]	4.8
R11	University Ave. NB @ 20m	8.7	4.6
R12	University Ave. NB @ 40m	7.9	4.2
R13	Green Lodge Rd. WB @ 10m	NA[3]	5.2
R14	Green Lodge Rd. WB @ 20m	NA	4.0
R15	Green Lodge Rd. WB @ 40m	NA	3.2

[1] Concentrations are in parts per million (ppm). The Federal/Massachusetts eight- and one-hour standards are respectively 9 and 35 ppm.

[2] Represents violations of the standards

[3] NA means not applicable

TABLE 10.10

ESTIMATED MAXIMUM 1992 BASELINE EIGHT-AND ONE-HOUR CO CONCENTRATIONS[1] AT THE INTERSECTION OF BLUE HILL DRIVE AND THE ROUTE 128 SOUTH RAMPS

	Receptor Location	Eight-Hour	One-Hour
R1	Residence A	4.7	2.7
R2	Residence B	3.7	2.5
R3	Residence C	3.3	2.5
R4	Westwood Office Park	3.8	2.5
R5	Blue Hill Rd. EB @ 10m	7.0	4.0
R6	Blue Hill Rd. EB @ 20m	7.3	3.9
R7	Blue Hill Rd. EB @ 40m	6.2	3.7
R8	Rt. 128 SB Off-Ramp @ 10m	4.7	3.2
R9	Rt. 128 SB Off-Ramp @ 20m	4.2	3.3
R10	Rt. 128 SB Off-Ramp @ 40m	3.8	3.1
R11	Blue Hill Rd. WB @ 10m	5.2	3.8
R12	Blue Hill Rd. WB @ 20m	5.1	3.6
R13	Blue Hill Rd. WB @ 40m	4.7	3.5

[1] Concentrations are in ppm. The Federal/Massachusetts eight- and one-hour standards are 9 and 35 ppm, respectively.

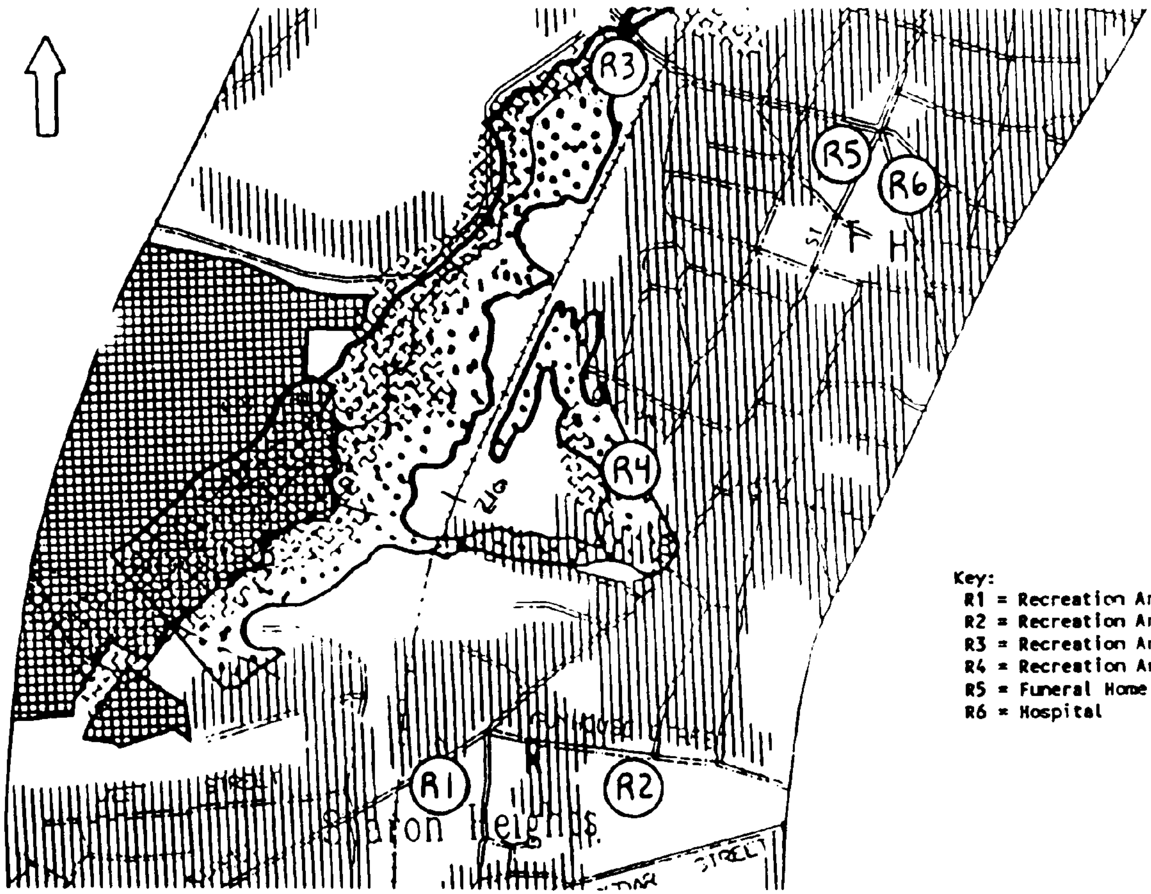
The instantaneous peaks of CO and NO_2 concentrations from individual existing diesel locomotive passbys were estimated using EPA's INPUFF model.[22] From the effects of the individual passbys, the average peak one-hour concentrations of CO and NO_2 were also computed. The impacts of diesel locomotive passbys were evaluated at three representative locations along the corridor. Track sections in Sharon, MA, North Kingstown, RI, and Clinton, CT were chosen based on the density of sensitive receptors within one-half mile of the tracks and locomotive operating characteristics, including throttle setting and speed.

Existing Diesel Locomotive Passbys in Sharon, MA. The track section selected for analysis is located between Mileposts 209 and 211 in Sharon, MA. This track section was selected because there are six sensitive receptors in the two-mile section (one hospital, one funeral home, and four recreation areas). Figure 10.4 shows this track section and the sensitive receptors which were modeled. The express locomotives maintain an average speed of 95 miles per hour (MPH) through this section, and there are six locomotives which pass by in the peak hour. The time variation of CO concentrations for a representative site (using receptor SR6, a hospital, located at approximately 56 meters from the track) is illustrated in Figure 10.5. With the locomotive passby, the CO quickly increases from the background level to a peak level of $3x10^{-3}$ (or 0.003) ppm; and just as quickly, the level drops back to background level again. The whole event was estimated to last approximately 120 seconds. No violations of any standards are expected at this exposure. The impacts of individual locomotive passbys in one hour were aggregated and the one-hour average CO concentrations were then estimated. For the same SR6 receptor, the maximum one-hour CO concentration was estimated to be less than 0.001 ppm above the background.

The time variation of NO_2 associated with a single locomotive passby is illustrated in Figure 10.5. The pattern for NO_2 is very similar to that of the CO pattern. Maximum NO_2 concentration encountered with this passby was estimated at a little over 100 $\mu g/m^3$. No exceedance of any NO_2 standard or health criteria is anticipated. The contributions from individual locomotive passbys were similarly aggregated to estimate the average one-hour NO_2 concentrations. For the same SR6 location, the maximum one-hour NO_2 concentration from these passbys was estimated at 8 $\mu g/m^3$. There are no short-term NO_2 standards that mandate compliance. There is, however, a Massachusetts one-hour policy level of 320 $\mu g/m^3$. This policy level is a health criterion which is used to assess project impacts. The existing one-hour concentration of 8 $\mu g/m^3$ is far lower than this criterion.

Existing Diesel Locomotive Passbys in North Kingstown, RI. The track section selected for analysis is located between Milepost 165 and 167 in North Kingstown, RI. This track section was selected because there are eleven sensitive receptors in this two-mile section (two schools, four churches, two nursing homes, and three recreation areas). Figure 10.6 shows this track section and the locations of the sensitive receptors which were modeled. The express locomotives maintain an average speed of approximately 100 MPH through this section, and there are four existing locomotives which pass by in the peak hour.

Figure 10.4
Sensitive Receptors at the Modeled Track Section in Sharon, MA



Key:
R1 = Recreation Area A
R2 = Recreation Area B
R3 = Recreation Area C
R4 = Recreation Area D
R5 = Funeral Home
R6 = Hospital

Figure 10.5
Time Variations of NO_2 and CO at Selected Receptor Locations at Three Track Sections

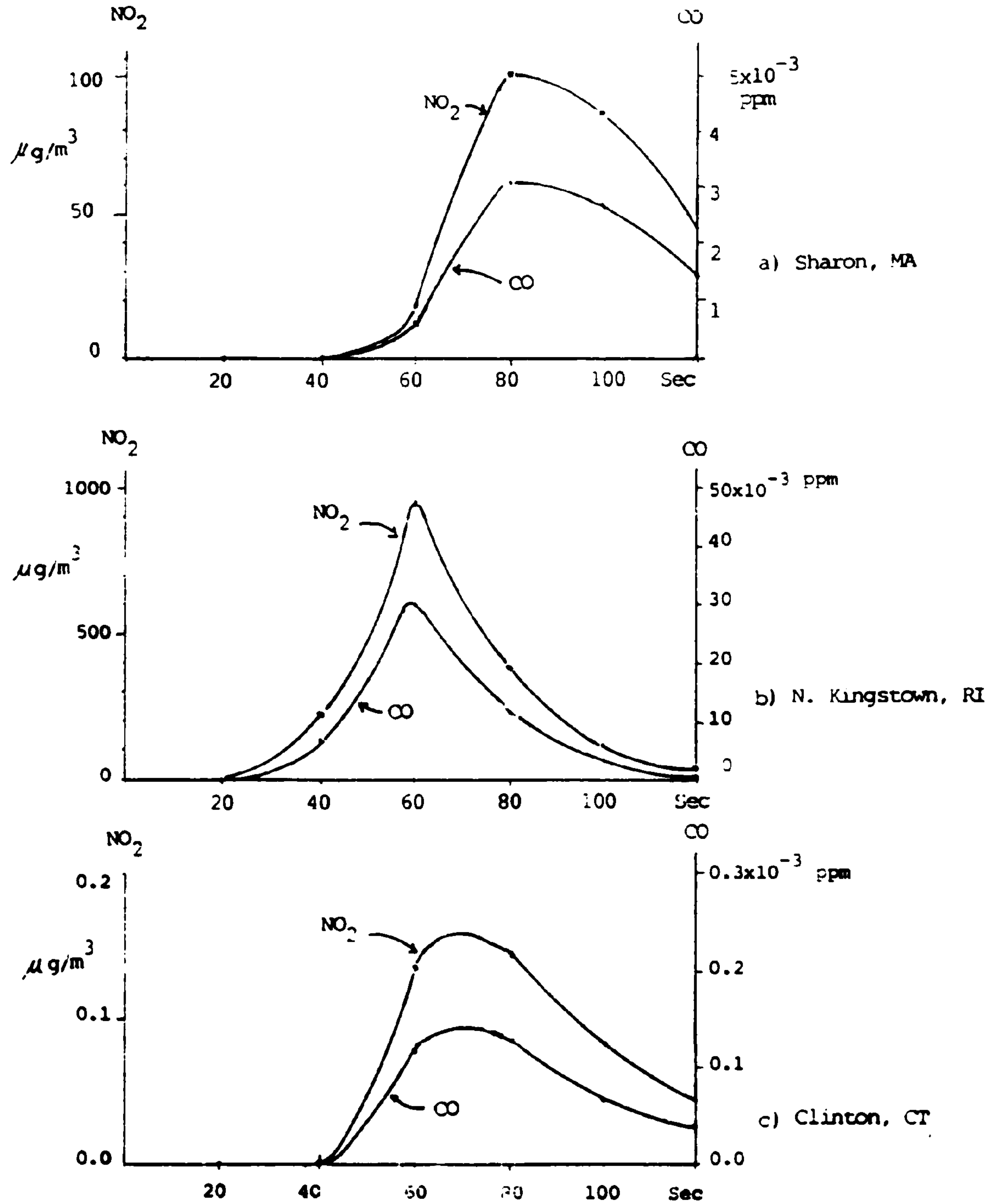
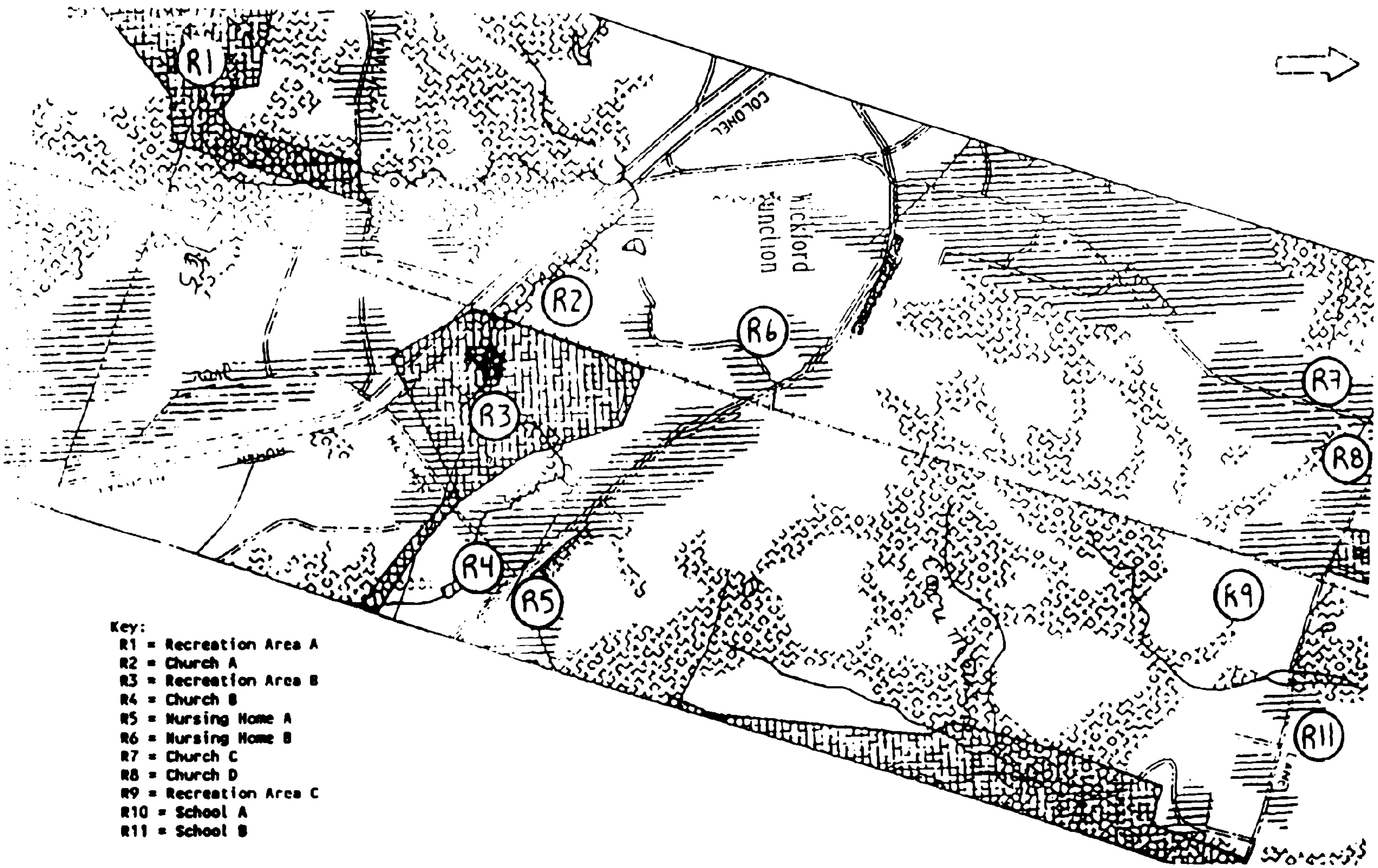


Figure 10.6
Sensitive Receptors at the Modeled Track Section in North Kingstown, RI



The peak, instantaneous CO concentration associated with a single existing diesel locomotive passby was estimated at approximately 0.03 ppm. As illustrated in Figure 10.5, this peak event is not expected to last more than 100 seconds. The maximum one-hour CO concentration that results from multiple locomotive passbys in a peak hour was estimated at less the 0.01 ppm above the background, much lower than, measured against the one-hour standard of 35 ppm.

The peak, instantaneous NO_2 concentration due to a single locomotive passby was estimated at a little over 1,000 $\mu g/m^3$. As illustrated in Figure 10.5, this event typically lasts no more the 100 seconds. The maximum one-hour NO_2 concentrations from locomotive passbys were estimated at 41 $\mu g/m^3$. There are no short-term NO_2 standards or criteria in Rhode Island.

However, when compared with other health criteria (such as the Massachusetts' policy level of 320 $\mu g/m^3$), these estimated concentrations are well within the guideline.

Existing Diesel Locomotive passbys in Clinton, CT. The track section selected for analysis in Connecticut is located between Milepost 96 and 98 in Clinton, CT. This track section was selected because there are ten sensitive receptors in this two-mile section one school, one library, five churches, one funeral home, and two cemeteries). Figure 10.7 shows this track section and the locations of the sensitive receptors which were modeled. The express locomotives maintain an average speed of 85 MPH through this section, and there are six locomotives which pass by in the peak hour.

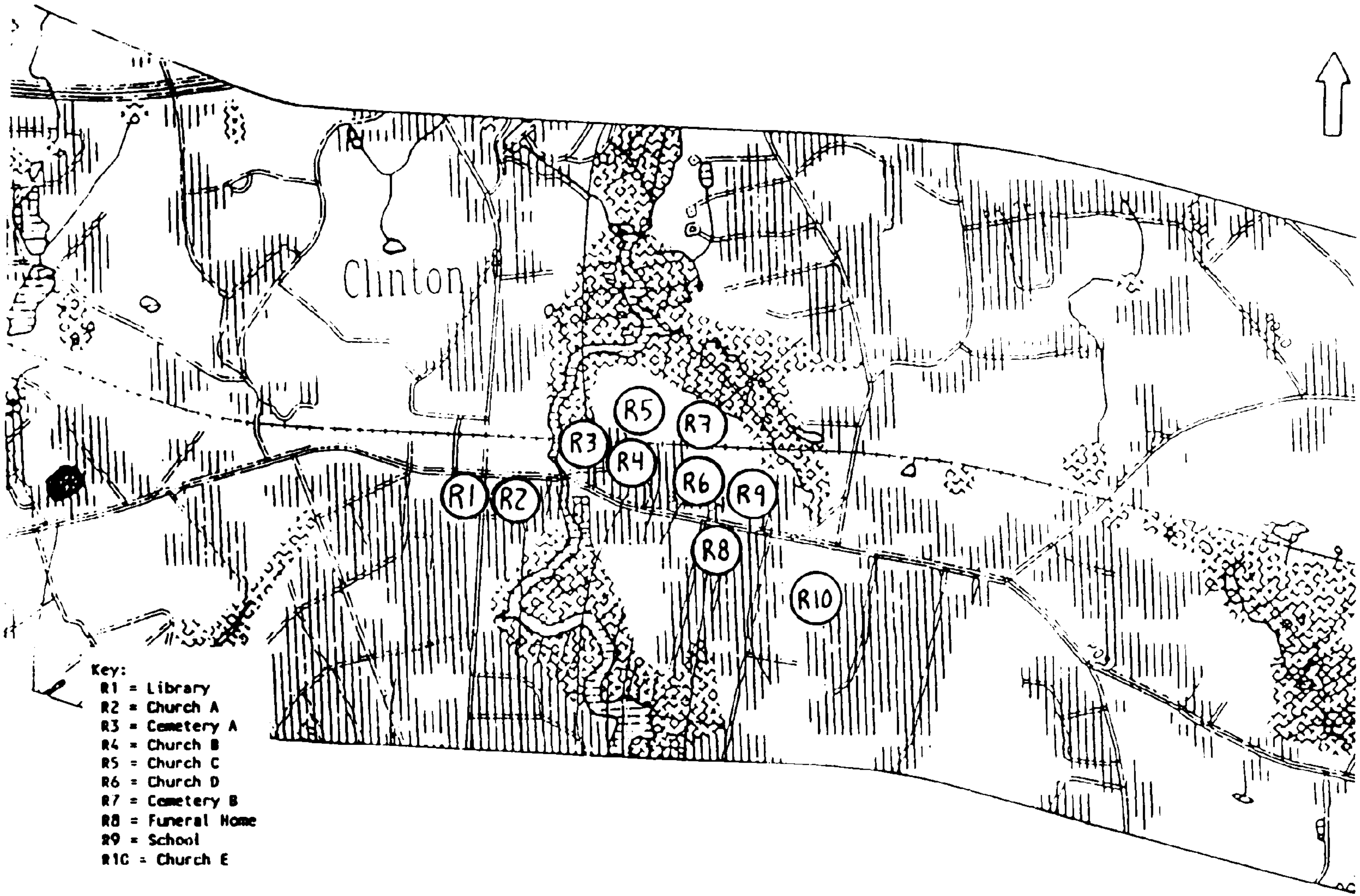
The peak, instantaneous CO concentration associated with a single, locomotive passby was estimated at 0.25×10^{-3} ppm. This is a very low concentration and the impact of the passby is negligible. The variation of CO with time for such a passby is illustrated in Figure 10.5. The maximum one-hour CO concentration that results from multiple locomotive passbys was estimated to be less that 0.001 ppm above the background. Relative to the 35-ppm standard, therefore, the impact of these passbys is quite minimal.

The peak, instantaneous NO_2 levels due to a single, locomotive passby are shown in Figure 10.5. This event typically lasts no more than 120 seconds. The maximum one-hour NO_2 concentration due to locomotive passbys was estimated at less than 0.1 $\mu g/m^3$. There are no short-term NO_2 standards in Connecticut at this time. When compared with other health criteria (such as the Massachusetts' policy level), these one-hour NO_2 levels are well within the guidelines.

10.3.5 Existing Odor Conditions

An odor condition can result from the evaporation of the unburned fuel or from the exhaust of the diesel engines of a locomotive. The typical exhaust is generally made up of many different VOC compounds including paraffins, acetylene, olefins, aldehydes, and aromatics. Most of the odor-causing compounds in diesel exhaust can be grouped into major categories, namely the aromatic or fuel-related fraction and the oxygenated or partially burned fraction.

Figure 10.7
Sensitive Receptors at the Modeled Track Section in Clinton, CT



adverse impacts, such as dust emissions, at sensitive receptor locations along the corridor. Where adverse construction impacts are anticipated, candidate mitigation measures are identified and their potential to alleviate these impacts are described qualitatively.

10.4.1 Evaluation Criteria

The significance of air quality impacts will be assessed using the following criteria: 1) Federal and state ambient air quality standards, 2) Federal and state non-attainment regulations, and 3) compliance with emissions limits required by the State Implementation Plans (SIPs).

Federal and state ambient air quality standards (NAAQS) are definitive, pollutant-specific concentration limits shown in Table 10.1. Any exceedance of the standards is considered a significant impact.

The SIPs require that transportation projects not result in increased VOC (ozone) emissions over the no-build scenario and comply with the NAAQS. Any increase in VOCs generated by the proposed project over the 2010 no-build or the existing condition is considered a significant impacts. In addition, the SIPs require that the NAAQS for CO is not violated.

Construction impacts will be assessed qualitatively based on the level of activity at each particular site, as well as the presence and distance to sensitive receptors.

10.4.2 Emissions Inventory Analysis

The impact of the alternatives are discussed with respect to projected VOC, NOx, and CO emissions. The emission inventories are described with respect to the entire NEC and on a state-by-state basis. A description of the methods and components of this analysis is provided in Section 10.3.3.

In addition to the emissions sources described in Section 10.3.3, this inventory includes electrical power necessary to run the proposed electrified Amtrak service. Electrical power necessary to run the electrified rail corridor was translated into energy needs and fuel use equivalents. Fuel use was distributed by fuel type so that appropriate emission factors could be used to estimate the anticipated emissions from the proposed power plants along the NEC. Emission factors for these sources were taken from U.S. EPA's Compilation of Air Pollutant Emissions Factors[24] and combined with the fuel use data to obtain power plant emissions.

10.4.2.1 Volatile Organic Compounds

Corridor-wide Inventory. VOC emissions in 1992 from transportation sources in the NEC were estimated at 4,737 kilograms per day (kg/day). Automobiles are the primary source of such emissions, with aircraft a distant second, as shown in Table 10.11. Between 1992 and 2010, with a no-build scenario, vehicle-miles-traveled (VMTs) in the NEC are projected to expected to decrease by over 40 percent. Similarly, even though aircraft flights are not expected to significantly change between 1992 and 2010, the change in the fleet mix (the future mix is expected to have more fuel-efficient engines which emit lower VOCs) is expected to lead to an overall decrease in aircraft emissions. As shown in Table 10.11 these two sources are responsible for a decrease in the total VOC emissions in the NEC of approximately 44 percent and 52 percent, respectively in 2010, when compared with the 1992 emissions.

The electrification project is expected to reduce total VOCs in the NEC by an additional 174 kg/day, or a savings of 7 percent from the No-Build emissions. This reduction is due in part to the elimination of the Amtrak diesel locomotives, and in part to modal shifts from aircraft and automobiles. With the proposed electrification, a new source of emissions associated with power generation (to provide the electrical power for the train) is introduced. But the estimated 8 kg/day of VOCs from this source is quite minimal when measured against the total of 2,508 kg/day.

State-by-State Inventories. Table 10.12 presents project related VOC emissions separated by state for the 1992 Existing, the 2010 no-build, and the 2010 build scenarios. This data shows that, in each state, VOC emissions for the Build Condition are estimated to be lower than the corresponding emissions for the No-Build Condition. Project related VOC emissions in Connecticut for the build scenario in 2010 of 1,375 kg/day are lower than the corresponding emissions for the 2010 no-build scenario of 1,430 kg/day. Therefore, the proposed electrification is beneficial to air quality and is consistent with the Connecticut SIP provision to achieve the ozone standard in the state's ozone non-attainment area.

In Rhode Island, VOC emissions in 2010 for the no-build scenario are estimated to be 541 kg/day versus 486 kg/day for the build scenario. Since the estimated emissions for the build scenario are less than the predicted emissions for the no-build scenario, this project is consistent with the Rhode Island SIP provision to achieve the ozone standard in the state-wide ozone non-attainment area. As shown in Table 10.12, the air quality benefits to be derived by Rhode Island from the proposed project amount to a reduction of 55 kg/day of VOC emissions.

As shown in Table 10.12, VOC emissions in Massachusetts for the Build Condition are estimated to be lower than the corresponding emissions for the no-build scenario (647 kg/day versus 711 kg/day). Thus, this project is consistent with the Massachusetts SIP provision to achieve the ozone standard in the state's ozone non-attainment area.

10.4.2.2 Oxides of Nitrogen

Corridor-wide Inventory. VMTs with the 2010 no-build scenario are projected to increase from the 1992 conditions. But, due to the effects of the FMVCP and the state I/M programs, NOx emissions from automobile and bus sources were estimated to decrease. This decrease is offset, however, by large increases in aircraft emissions (from 821 to 1,925 kg/day), and Amtrak and other trains emissions (from 1,954 to 2,221 kg/day and 2,153 to 5,041 kg/day, respectively).

TABLE 10.11 VOC EMISSIONS IN THE PROJECT CORRIDOR BY TRANSPORTATION MODE

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	3,778	2,110	2,068	-1,668	-44	-42	-2
Aircraft	679	328	256	-351	-52	-72	-22
Amtrak	60	68	0	8	13	-68	-100
Other Trains	66	154	154	88	133	0	0
Buses	32	22	22	-10	-31	0	0
Power Generation	0	0	8	0	0	8	N/A
TOTAL	4,737	2,682	2,508	-2,055	-43	-174	-7

TABLE 10.12 VOC EMISSIONS IN THE PROJECT CORRIDOR BY TRANSPORTATION MODE

a) Connecticut

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	2,230	1,303	1,276	-927	-42	-27	-2
Aircraft	42	42	42	0	0	0	0
Amtrak	28	32	0	4	14	-32	-100
Other Trains	16	43	43	27	169	0	0
Buses	15	10	10	-5	-33	0	0
Power Generation	0	0	4	0	0	4	N/A
TOTAL	2,331	1,430	1,375	-901	-38	-55	-4

TABLE 10.12 VOC EMISSIONS IN THE PROJECT CORRIDOR BY TRANSPORTATION MODE
(Continued)

b) Rhode Island

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	839	392	384	-447	-53	-8	-2
Aircraft	230	107	78	-123	-53	-29	-27
Amtrak	18	20	0	2	11	-20	-100
Other Trains	2	20	20	18	900	0	0
Buses	3	2	2	-1	-33	0	0
Power Generation	0	0	2	0	0	2	N/A
TOTAL	1,092	541	486	-551	-50	-55	-10

c) Massachusetts

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	709	415	408	-294	-41	-7	-2
Aircraft	407	179	136	-228	-56	-43	-24
Amtrak	14	16	0	2	14	-16	-100
Other Trains	48	91	91	43	90	0	0
Buses	14	10	10	-4	-29	0	0
Power Generation	0	0	2	0	0	2	N/A
TOTAL	1,192	711	647	-481	-40	-64	-9

The increase in aircraft emissions is due to a change in the fleet mix. The new fleet, with their more fuel-efficient engines, are also expected to emit more NOx. The overall impact of these changes is a projected increase of approximately 25 percent in the total NOx emissions in the NEC for the 2010 no-build scenario, when compared with the 1992 Existing Condition, as shown in Table 10.13.

As shown in Table 10.13, the proposed electrification project would eliminate over 2,200 kg/day of NOx emissions in the NEC due to a switch by Amtrak from diesel-powered locomotives to the proposed electrically-powered locomotives. The proposed project will further reduce emissio by another 691 kg/day by diverting automobile and aircraft travelers to the train. These savings, however, are partially offset by a new source of emissions from power generation. Compared with the corresponding no-build emissions, NOx emissions in the NEC with the build scenario are approximately 1,658 kg/day or 13 percent lower.

State-by-State Inventories. Table 10.14 presents the 1992 existing, the 2010 no-build, and the 2010 build scenario project-related NOx emissions estimated for each state. This data shows that, in each state, NOx emissions for the build scenario are estimated to be lower than the corresponding emissions for the no-build scenario.

As shown in Table 10.14, NOx emissions in Connecticut for the build scenario are estimated to be lower than the corresponding emissions for the no-build scenario. Therefore, the proposed project will not cause or contribute to a violation of the state's annual NO_2 standard.

NOx emissions in Rhode Island are presented in Table 10.14 for the no-build scenario (2,178 kg/day) and for the build scenario (1,805 kg/day). Since the estimated emissions for the build scenario are less than the predicted emissions for the no-build scenario, this project will not cause or contribute to a violation of the state's annual NO_2 standard. As shown in Table 10.14, overall NOx emissions in Rhode Island will be reduced by 373 kg/day or 17 percent due to the proposed project.

Project-related NOx emissions in Massachusetts for the build scenario in 2010 are estimated to be 792 kg/day or 13 percent lower than the corresponding emissions for the 2010 no-build scenario. The proposed project, therefore, is not expected to cause or contribute to a violation of the state's annual NO_2 standard.

10.4.2.3 Carbon Monoxide

Corridor-wide Inventory. Between the 1992 Existing and the 2010 no-build scenario, CO emissions in the NEC are expected to decrease by approximately 50 percent. This dramatic decrease is attributed to the benefits of the FMVCP and the state I/M programs. As shown in Table 10.15, savings of over 25,200 kg/day from automobile sources were estimated between 1992 and the 2010 no-build scenario.

TABLE 10.13 NOX EMISSIONS IN THE PROJECT CORRIDOR BY TRANSPORTATION MODE

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	5,117	3,815	3,739	-1,309	-2	-76	-2
Aircraft	821	1,925	1,310	1,104	134	-615	-32
Amtrak	1,954	2,221	0	267	14	-2,221	-100
Other Trains	2,153	5,041	5,041	2,888	134	0	0
Buses	517	196	196	-321	-62	0	0
Power Generation	0	0	1,254	0	0	1,254	N/A
TOTAL	10,562	13,198	11,540	2,636	25	-1,658	-13

TABLE 10.14 NOX EMISSIONS IN THE PROJECT CORRIDOR BY TRANSPORTATION MODE

a) Connecticut

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	2,990	2,332	2,274	-668	-22	-48	-2
Aircraft	34	34	34	0	0	0	0
Amtrak	909	1,033	0	124	14	-1,033	-100
Other Trains	505	1,404	1,404	899	178	0	0
Buses	236	89	89	-147	-62	0	0
Power Generation	0	0	588	0	0	588	N/A
TOTAL	4,674	4,882	4,389	208	4	-493	-10

TABLE 10.14 NOX EMISSIONS IN THE PROJECT CORRIDOR BY TRANSPORTATION MODE
CONTINUED

b) Rhode Island

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	1,176	753	738	-423	-36	-15	-2
Aircraft	87	84	45	-3	-3	-39	-46
Amtrak	576	655	0	79	14	-655	-100
Other Trains	80	665	665	585	731	0	0
Buses	52	21	21	-31	-60	0	0
Power Generation	0	0	336	0	0	336	N/A
TOTAL	1,971	2,178	1,805	207	11	-373	-17

c) Massachusetts

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	951	740	727	-211	-22	-13	-2
Aircraft	700	1,807	1,231	1,107	158	-576	-32
Amtrak	469	533	0	64	14	-533	-100
Other Trains	1,568	2,972	2,972	1,404	90	0	0
Buses	229	86	86	-143	-62	0	0
Power Generation	0	0	330	0	0	330	N/A
TOTAL	3,917	6,138	5,346	2,221	57	-792	-13

The proposed electrification is expected to further reduce the total CO emissions in the NEC by another 1,038 kg/day. This reduction is due in part to the elimination of the Amtrak diesel locomotives (savings of 196 kg/day), and in part to the projected diversion from automobiles (savings of 449 kg/day) and from aircraft (savings of 485 kg/day). No diversion is anticipated from intercity buses to rail. The proposed electrification will, however, introduce a new source of CO associated with power generation. The new emissions of 92 kg/day from power generation, however, represent less than one percent of the total NEC emissions in the 2010 build scenario. Compared with the corresponding no-build emissions, CO emissions in the NEC with the build scenario are approximately 4 percent lower.

State-by-State Inventories. Table 10.16 presents project related CO emissions separately for each state for the 1992 Existing, the 2010 no-build, and the 2010 build scenario. This data shows that, in each state, CO emissions for the 2010 build scenario are estimated to be lower than the corresponding emissions for the 2010 no-build scenario.

Project-related CO emissions in Connecticut for the build scenario are 13,971 kg/day, which is approximately 2 percent lower than the corresponding emissions for the no-build scenario. The proposed project is consistent with the Connecticut SIP provision to achieve and maintain the state's CO standards because it is not expected to result in a new violation or exacerbate an existing violation of the CO standards in the New Haven CO non-attainment area.

In Rhode Island, CO emissions for the no-build scenario are estimated at 4,205 kg/day versus 4,014 kg/day for the build scenario, a reduction of 5 percent. Since the estimated emissions for the build scenario, are less than the predicted emissions from the no-build scenario, this project is consistent with the Rhode Island SIP provision to achieve and maintain the state's CO standards. As shown in Table 10.16, Rhode Island will have 191 kg/day less CO emissions due to the proposed project.

Project-related CO emissions in Massachusetts for the no-build and build scenarios are shown in Table 10.16. The CO emissions for the build scenario are estimated to be lower than the corresponding emissions for the no-build scenario (5,639 kg/day versus 6,150 kg/day or 8 percent). Therefore, this project is consistent with the Massachusetts SIP provision to attain and maintain the state's CO standards because it is not expected to cause a new violation or exacerbate an existing violation of the state's CO standards in the Boston CO non-attainment area.

10.4.3 Dispersion Modeling Analysis

The dispersion modeling analysis is made up of two components. The first is a microscale assessment of the change in CO concentration for two intersections in the vicinity of the Route 128 express station in Dedham, MA, anticipated to be the most congested express station in terms of project-generated automobile traffic. The second is an assessment of the change in the impact of locomotive passbys at three representative sections along the NEC.

TABLE 10.15 CO EMISSIONS IN THE PROJECT CORRIDOR BY TRANSPORTATION MODE

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	47,468	22,230	21,781	-25,238	-53	-449	-2
Aircraft	1,820	1,665	1,180	-155	-9	-485	-29
Amtrak	172	196	0	24	14	-196	-100
Other Trains	190	442	442	252	133	0	0
Buses	151	129	129	-22	-15	0	0
Power Generation	0	0	92	0	0	92	N/A
TOTAL	49,801	24,662	23,624	-25,139	-50	-1,038	-4

TABLE 10.16 CO EMISSIONS IN THE PROJECT CORRIDOR BY TRANSPORTATION MODE

a) Connecticut

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	27,490	13,932	13,644	-13,558	-49	-288	-2
Aircraft	102	102	102	0	0	0	0
Amtrak	80	91	0	11	14	-91	-100
Other Trains	45	123	123	78	173	0	0
Buses	69	59	59	-10	-15	0	0
Power Generation	0	0	43	0	0	43	N/A
TOTAL	27,786	14,307	13,971	-13,479	-49	-336	-2

TABLE 10.16 CO EMISSIONS IN THE PROJECT CORRIDOR BY TRANSPORTATION MODE
CONTINUED

b) Rhode Island

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	11,236	3,858	3,777	-7,378	-66	-81	-2
Aircraft	403	218	141	-185	-46	-77	-35
Amtrak	51	58	0	7	14	-58	-100
Other Trains	7	58	58	51	729	0	0
Buses	15	13	13	-2	-13	0	0
Power Generation	0	0	25	0	0	25	N/A
TOTAL	11,712	4,205	4,014	-7,507	-64	-191	-5

c) Massachusetts

Source	1992 Existing Kg/day	2010 No Build Kg/day	2010 Build Kg/day	Change in Emissions			
				Existing to No Build		No Build to Build	
				Kg/day	% change	Kg/day	% change
Auto	8,742	4,440	4,360	-4,302	-49	-80	-2
Aircraft	1,315	1,345	937	30	2	-408	-30
Amtrak	41	47	0	6	15	-47	-100
Other Trains	138	261	261	123	89	0	0
Buses	67	57	57	-10	-15	0	0
Power Generation	0	0	24	0	0	24	N/A
TOTAL	10,303	6,150	5,639	-4,153	-40	-511	-8

These assessments are provided below. The methods for these analyses are presented in Sections 10.3.4.1 and 10.3.4.2, respectively.

10.4.3.1 CO Impacts near the Route 128 Express Station. Estimated maximum eight-hour CO concentrations for the no-build and build scenarios in 2010 are exhibited in Table 10.17 for the intersection of University Avenue and Blue Hill Drive, and in Table 10.18 for the intersection of Blue Hill Drive and Route 128 South ramps. Eight-hour CO concentrations were expected to decrease quite dramatically between 1992 and the no-build scenarios in 2010. This decrease is due to major reductions in emissions that are the result of the FMVCP and the Massachusetts I/M programs described in Section 10.4.2.1. No violations of the eight-hour standard are anticipated anywhere.

With the build scenario, traffic volumes at both intersections are expected to increase. This will lead, in turn, to a small increase in eight-hour CO concentrations. But, as shown in Table 10.17 and 10.18, the increase is very small, and no violations of the 9-ppm standard are expected. Maximum one-hour CO concentrations were estimated from the eight-hour results by use of an inverse persistence factor. The one-hour results for the intersections of University Avenue and Blue Hill Drive, and Blue Hill Drive and Route 128 South ramps are shown in Tables 10.19 and 10.20, respectively. No violations of the one-hour standard of 35 ppm are anticipated in 2010 with or without the proposed electrification.

10.4.3.2 Air Quality Impacts from Locomotive Passbys. The impacts associated with the 2010 no-build scenario are described for each of the three track sections in the NEC. With the proposed electrification, the Amtrak diesel locomotives will be replaced by the electrically-powered locomotives, thereby eliminating this particular source of impact completely.

Locomotive Passbys in Sharon, MA. With the no-build scenario, the impact from a single locomotive passby is the same as the impact in the 1992 condition. This impact is described in Section 10.3.3.2.

Locomotive Passbys in North Kingstown, RI. The impact from an individual passby for the 2010 no-build scenario is the same for the 1992 condition as described in Section 10.3.3.2.

Locomotive Passbys in Clinton, CT. For individual passbys, the impacts for the 2010 no-build scenario are the same as for the 1992 condition. These impacts are described in Section 10.3.4.2.

10.4.4 Construction Impacts and Mitigation

Construction-related activities can result in short-term impacts on ambient air quality. These potential impacts include fugitive dust emissions, direct emissions from construction equipment and truck exhausts, and increased emissions from motor vehicles on the streets due to traffic disruption. These types of impacts could occur during construction of substations, switching stations, paralleling stations, and bridges.

TABLE 10.17
ESTIMATED MAXIMUM EIGHT-HOUR CO CONCENTRATIONS[1]
AT THE INTERSECTION OF UNIVERSITY AVENUE AND BLUE HILL DRIVE

	Receptor Location	1992 Baseline	2010 No-Build	2010 Build
R1	Westwood Office Park	5.7	2.7	2.8
R2	Rt. 128 Train Station	4.0	1.9	2.0
R3	General Motors Bldg.	4.3	2.2	2.2
R4	Blue Hill Rd. EB @ 10m	9.4[2]	4.5	4.8
R5	Blue Hill Rd. EB @ 20m	9.4[2]	4.0	4.3
R6	Blue Hill Rd. EB @ 40m	9.4[2]	3.4	3.7
R7	University Ave. SB @ 10m	6.1	6.7	7.1
R8	University Ave. SB @ 20m	6.7	6.0	6.8
R9	University Ave. SB @ 40m	6.0	4.2	4.6
R10	University Ave. NB @ 10m	9.3[2]	4.8	4.9
R11	University Ave. NB @ 20m	8.7	4.6	4.7
R12	University Ave. NB @ 40m	7.9	4.2	4.4
R13	Green Lodge Rd. WB @ 10m	NA[3]	5.2	5.4
R14	Green Lodge Rd. WB @ 20m	NA	4.0	5.1
R15	Green Lodge Rd. WB @ 40m	NA	3.2	4.1

1 Concentrations are in parts per million (ppm). The Federal and Massachusetts eight-hour standard is 9 ppm.
2 These entries represent violations of the standards.
3 NA means not applicable.

TABLE 10.18
ESTIMATED MAXIMUM EIGHT-HOUR CO CONCENTRATIONS[1]
AT THE INTERSECTION OF BLUE HILL DRIVE AND THE ROUTE 128 SOUTH RAMPS

	Receptor Location	1992 Baseline	2010 No-Build	2010 Build
R1	Residence A	4.7	2.7	2.8
R2	Residence B	3.7	2.5	2.6
R3	Residence C	3.3	2.5	2.6
R4	Westwood Office Park	3.8	2.5	2.5
R5	Blue Hill Rd. EB @ 10m	7.0	4.0	4.1
R6	Blue Hill Rd. EB @ 20m	7.3	3.9	3.9
R7	Blue Hill Rd. EB @ 40m	6.2	3.7	3.8
R8	Rt. 128 SB Off-Ramp @ 10m	4.7	3.2	3.3
R9	Rt. 128 SB Off-Ramp @ 20m	4.2	3.3	3.3
R10	Rt. 128 SB Off-Ramp @ 40m	3.8	3.1	3.2
R11	Blue Hill Rd. WB @ 10m	5.2	3.8	3.9
R12	Blue Hill Rd. WB @ 20m	5.1	3.6	3.7
R13	Blue Hill Rd. WB @ 40m	4.7	3.5	3.6

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1 Concentrations are in parts per million (ppm). The Federal and Massachusetts eight-hour standard is 9 ppm.

TABLE 10.19
ESTIMATED MAXIMUM ONE-HOUR CO CONCENTRATIONS[1]
AT THE INTERSECTION OF UNIVERSITY AVENUE AND BLUE HILL ROAD

	Receptor Location	1992 Baseline	2010 No-Build	2010 Build
R1	Westwood Office Park	9.6	4.6	4.8
R2	Rt. 128 Train Station	6.7	3.3	3.5
R3	General Motors Bldg.	7.2	3.8	3.8
R4	Blue Hill Rd. EB @ 10m	15.9	7.7	8.2
R5	Blue Hill Rd. EB @ 20m	15.9	6.9	7.4
R6	Blue Hill Rd. EB @ 40m	15.9	5.8	6.3
R7	University Ave. SB @ 10m	10.3	11.4	12.1
R8	University Ave. SB @ 20m	11.3	10.3	11.6
R9	University Ave. SB @ 40m	10.1	7.2	7.9
R10	University Ave. NB @ 10m	15.7	8.2	8.4
R11	University Ave. NB @ 20m	14.7	7.9	8.0
R12	University Ave. NB @ 40m	13.3	7.2	7.5
R13	Green Lodge Rd. WB @ 10m	NA[2]	8.9	9.2
R14	Green Lodge Rd. WB @ 20m	NA	6.9	8.7
R15	Green Lodge Rd. WB @ 40m	NA	5.5	7.0

1 Concentrations are in parts per million (ppm). The Federal and Massachusetts one-hour standard is 35 ppm.
2 NA means not applicable.

TABLE 10.20

ESTIMATED MAXIMUM ONE-HOUR CO CONCENTRATIONS[1] AT THE INTERSECTION OF BLUE HILL ROAD AND THE ROUTE 128 SOUTH RAMPS

	Receptor Location	1992 Baseline	2010 No-Build	2010 Build
R1	Residence A	7.8	4.6	4.8
R2	Residence B	6.2	4.3	4.5
R3	Residence C	5.5	4.3	4.5
R4	Westwood Office Park	6.4	4.3	4.3
R5	Blue Hill Rd. EB @ 10m	11.8	6.9	7.0
R6	Blue Hill Rd. EB @ 20m	12.3	6.7	6.7
R7	Blue Hill Rd. EB @ 40m	10.4	6.3	6.5
R8	Rt. 128 SB Off-Ramp @ 10m	7.9	5.5	5.7
R9	Rt. 128 SB Off-Ramp @ 20m	7.0	5.7	5.7
R10	Rt. 128 SB Off-Ramp @ 40m	6.4	5.3	5.5
R11	Blue Hill Rd. WB @ 10m	8.7	6.5	6.7
R12	Blue Hill Rd. WB @ 20m	8.6	6.2	6.3
R13	Blue Hill Rd. WB @ 40m	7.9	6.0	6.2

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1 Concentrations are in parts per million (ppm). The Federal and Massachusetts one-hour standard is 35 ppm.

Fugitive dust emissions can occur during site preparation such as grubbing and removing of vegetation to prepare a site for construction. Dust emissions can result from movement of construction equipment at staging areas and transport of materials to and from a construction site. Fugitive dust would generally be a problem during periods of intense construction activity and would be accentuated by windy and/or dry conditions.

There are six proposed sites for electrification facilities that are located fairly close to residences and other sensitive receptors. These are: Madison, Grove Beach, Westbrook and Noank, CT; and East Foxboro and Roxbury Crossing, MA. In addition, five bridge modifications, Millstone Point Road, CT; Kenyon School Road, Main Street and Pettaconsett Avenue, RI; and Maskwonicut Street, MA, are close to sensitive receptors. Under certain wind conditions, these sites could potentially lead to adverse dust impacts at the sensitive receptors nearby. Good 'housekeeping' practices, such as wetting or chemically treating exposed earth areas, covering dust-producing materials during transport, and limiting construction activities during high wind conditions, should minimize the dust impacts. Direct emissions from construction equipment and trucks are generally not expected to be significant. However, exhaust emissions from diesel-powered trucks are a distinct source of odor. Trucks are also a source of fugitive dust emissions. Keeping the trucks clean and routing them away from residential and other sensitive receptor locations will alleviate these potential adverse impacts. Trucks can be kept cleaner by installing a grating at the entrance and exit ways to the construction site to 'shake' loose some of the dust that adheres to the truck surfaces, and by watering down the trucks on an as-needed basis. Covering trucks or rail cars carrying excavated material on the affected roadways will further reduce fugitive dust emissions.

Bridge structure modifications can result in traffic disruption and rerouting. Traffic disruption, such as decreased roadway capacity or detouring, can lead to increased traffic congestion and attendant increases in motor vehicle exhaust emissions on the bridges and alternate routes. These potential adverse effects can be mitigated by proper traffic management during the construction period. This could include finding less congested routes for construction-related truck traffic, creating temporary detours for regular roadways where capacities have been diminished, routing trucks away from residential neighborhoods, and restricting construction activities during normal hours of high traffic volumes on the existing roadways.

10.4.5 Odor Impacts

Emissions of odor compounds, if any, under the 2010 no-build scenario will be substantially similar to the 1992 existing condition, because the number of trains is not anticipated to increase by more than two or three per day. Because the human olfactory perception of odor is related to the concentrations of these compounds in a logarithmic manner, no perceptible change in the odor condition is expected between the existing and the future no-build scenarios.
With the proposed electrification, the Amtrak diesel locomotives will be replaced by electrically-powered locomotives, eliminating any potential odor situations from this source.

10.4.6 Summary of Impacts and Mitigation

There will be no adverse impacts from operation of Amtrak's proposed electrification project. The 2010 no-build alternative will also not have adverse impacts due to mandatory motor vehicle emissions reductions caused by implementing the FMVCP and the state I/M programs. In fact, both the no-build and build alternatives show significant improvements over the existing conditions. The 2010 no-build scenario will have lower emission levels for all pollutants than the 1992 condition, and the build alternative will have lower emissions than the 2010 no-build scenario.

VOC emissions for the build scenario in each of the three states are expected to be less than the corresponding emissions for a no-build scenario. The proposed project is, therefore, consistent with the SIP provisions in each of the three states to attain and maintain the ozone standard, and therefore no mitigation measures are proposed at this time. The NOx emissions for the build scenario are also lower than the corresponding emissions for the no-build scenario, and in compliance with the SIPs.

There would be no one-hour CO standard violations from the no-build or the build scenarios. There are a number of receptors that are expected to have maximum eight-hour CO concentrations in the 1992 conditions that exceeded the 9-ppm standard. But by 2010, with or without the proposed project, maximum eight-hour CO concentrations are estimated to improve to well below the corresponding standard. Since the project is not expected to create any new violations or to exacerbate an existing violation, the proposed project is consistent with the three states' SIP provisions to attain and maintain the CO standards.

As no adverse air quality impacts are anticipated to result from the operation of the proposed project, no mitigation measures are required. In fact, the proposed project will have beneficial effects on the air quality in the corridor, including the following:

- Reduction of total VOC, NOx, and CO emissions from all transportation sources in the project corridor; and

- Elimination of any potential impacts (such as instantaneous peak CO and NO_2 levels and perceived odor condition) from Amtrak's locomotive passbys.

As described in Section 10.4.4, construction activities could potentially lead to temporary impacts due to fugitive dust emissions and to increased CO at local areas of congestions due to traffic disruption. Mitigation measures to alleviate these impacts are described for each of these impact sources in Section 10.4.4.

REFERENCES

1. Clean Air Act of 1970 and the 1977 Clean Air Act Amendments.

2. 1990 Clean air Act Amendments, November 1990.

3. "Procedures for Considering Environmental Impacts," U.S. Department of Transportation, Order DOT 5610.1C, September 1979.

4. "Procedures for Considering Environmental Impacts," U.S. Department of Transportation, Federal Railroad Administration.

5. State of Connecticut, Department of Environmental Protection, Regulation Section 22a-174-24.

6. State of Connecticut, Department of Environmental Protection, State Implementation Plan Section SIP 6-B.

7. State of Rhode Island, Department of Environmental Management, Division of Air and Hazardous Materials, Air Pollution Control Regulation 9 "Approval to Construct, Install, Modify, or Operate".

8. State of Rhode Island, Department of Environmental Management, Division of Air and Hazardous Materials, State Implementation Plan, 1982.

9. State of Massachusetts, Department of Environmental Protection, Code of Massachusetts Regulations, 310 CMR 6.00, Ambient Air Quality Standards for the Commonwealth of Massachusetts.

10. "1991 Ambient Air Quality Data," State of Connecticut, Department of Environmental Protection, 1992.

11. "Air Quality Data Summary Calendar Year 1991," State of Rhode Island, Department of Environmental Management, Division of Air and Hazardous Materials, 1992.

12. "1991 Air Quality Report," State of Massachusetts, Department of Environmental Protection, Division of Air Quality Control, 1992.

13. Personal Communication from the State of Connecticut, Department of Environmental Protection (Simpson) to KM Chng Environmental Inc., December 17, 1992.

14. "1990 Base Year Emissions Inventory for the Rhode Island Nonattainment Area," State of Rhode Island, Department of Environmental Management, Division of Air and Hazardous Materials, November 1992.

15. "Massachusetts 1990 Base Year Emissions Inventories," State of Massachusetts, Department of Environmental Protection, Division of Air Quality Control, May 1992.

16. "Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources," U.S. Environmental Protection Agency, Ann Arbor, MI, 1992.

17. "MOBILE4.1 - User's Guide (Mobile Source Emissions Factor Model)," U.S. Environmental Protection Agency, Ann Arbor, MI, 1991. Revised March 26, 1993 as MOBILE5A.

18. Memorandum to DMJM/Harris from Dayle Cohen Associates " Northeast Corridor Improvement Project Electrification - New Haven Ct, to Boston, MA Aircraft Fleet Projections for the Boston - New York Corridor. May 7, 1993.

19. "User's Guide to CAL3QHC, A Modeling Methodology for Predicting Pollutant Concentration Near Roadway Intersections", U.S. EPA, Research Triangle Park, NC, September, 1990. Revised November 27, 1991 as CAL3QHC, Version 2.

20. "User's Guide for PAL 2.0, A Gaussian-Plume Algorithm for Point, Area, and Line Sources," U.S. EPA, Research Triangle Park, NC, March 1987. Revised September 29, 1989 as PAL2.1.

21. "MOBILE4.1 - User's Guide (Mobile Source Emissions Factor Model)," U.S. Environmental Protection Agency, Ann Arbor, MI, 1991.

22. "INPUFF 2.0 - A Multiple Source Gaussian Puff Dispersion Algorithm. User's Guide," U.S. EPA, Research Triangle Park, NC EPA/600/8-86/024, August 1986. Revised March 28, 1990 as INPUFF 2.3.

23. Personal Communication from General Motors Corporation, Electro-Motive Division (D. Brann) to KM Chng Environmental Inc., June 1, 1993.

24. "Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources," AP-42, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1985.

TECHNICAL STUDY 11
NATURAL RESOURCES

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TECHNICAL STUDY 11
NATURAL RESOURCES

11.1 INTRODUCTION

This technical report was prepared to document both the existing natural resources within the project area, as well as the potential impacts of proposed activities on these resources. Resources evaluated include wetlands, critical wildlife habitat, endangered species, floodplains, coastal resources and water resources. Tables 1-4 in Appendix A provide a summary of the occurrence of these resources at the proposed facilities sites. This study addresses the regulatory requirements relating to these resources, as well as an assessment of the impacts created by the proposed activities. The mitigation of adverse impacts is discussed, including the steps taken to avoid impacts, minimization of adverse impacts and what steps can be taken to compensate for these impacts. This section serves as the basis for the corresponding sections of the Draft Environmental Impact Statement/Report (DEIS/R).

11.2 REGULATORY SETTING

This section describes Federal, state and local regulations that govern the effects of the proposed project on natural resources, including wetlands, wildlife, floodplain, water quality, and special protected areas. The Federal government, as well as all three states, provide protection for the unique values provided by these resources, as described below.

11.2.1 Federal Regulations

11.2.1.1 Section 404 (b)(1) of the Clean Water Act of 1977 (33 U.S.C. 1344). This Act requires a "Section 404 Permit" for the discharge of dredged or fill materials into all waters of the U.S. (to the territorial limits of U.S. jurisdiction, approximately 3 miles from shore). "Waters of the U.S." include wetlands, rivers, streams, tributaries and floodplains. This program is administered by the Army Corps of Engineers (Corps) with the assistance of the Environmental Protection Agency (EPA). Wetlands must be delineated using the three-parameter approach outlined in the U.S. Army Corps of Engineers Wetlands Delineation Manual (1987). A memorandum of agreement (MOA) between the Corps and EPA clarifies procedures to be used in determining the type and level of mitigation necessary to demonstrate compliance with the Section 404 guidelines (February 7, 1990). Before a project may proceed with either dredging or filling of a wetland, it must be shown that efforts have been made to: 1) avoid the impacts, 2) minimize the impacts, and 3) if impacts are unavoidable, compensate for the impacts. Compensation for wetland losses must attempt to replace the wetland types and functions lost as a result of the project.

11.2.1.2 Section 10 of Rivers and Harbors Act of 1899 (33 U.S.C. 403). This Act requires a permit from the Corps for any work which could obstruct or alter navigable waters of the U.S., including wetlands. The construction of any structure in, on or over navigable waters, the excavation from or depositing of material in such waters, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters requires a Section 10 Permit from the Corps.

11.2.1.3 Section 9 of the Rivers and Harbor Act of 1899 (33 U.S.C. 401). This act requires Corps approval and either state legislative (where a water body lies wholly within a single state) or congressional consent to construct dams or dikes across any navigable water of the U.S. In the case of bridges or causeways, U.S. Department of Transportation approval is required, rather than Corps approval.

11.2.1.4 Executive Order 11990 - Protection of Wetlands. The Order requires that Federal agencies take action to minimize the destruction, loss, or degradation of wetlands. Agencies are also prohibited from providing assistance for new construction located in wetlands unless no practical alternative is found and the harm which may result to the wetland is minimized. The public must also be given the opportunity to review any new construction plans or proposals. The Federal Railroad Administration (FRA), as the lead Federal agency, is required to make appropriate findings documenting compliance with the Order.

11.2.1.5 The Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq.). This Act is designed to encourage the protection of natural resources in coastal areas, including wetlands, floodplains, and fish and wildlife; and to encourage states to establish coastal zone management plans, which are subject to approval by the Federal government. Once a state plan is approved, Federal actions should be consistent with the state plans and the state plans must be consistent with applicable water and air quality laws, hence the state's programs are called the Federal Consistency Programs or Reviews. Connecticut, Rhode Island and Massachusetts each have such an approved program, which is described in the appropriate sections below.

11.2.1.6 Fish and Wildlife Coordination Act (16 U.S.C. 661-666, as amended by P.L. 89-72). This Act requires Federal departments and agencies, or any public or private agency requiring any Federal permit or license, to consult with the U.S. Fish and Wildlife Service (USFWS) and with the state agency responsible for administering wildlife resources, regarding proposed actions which could affect such resources. The goal of agency consultation is to eliminate, minimize, and/or mitigate adverse environmental impacts to fish and wildlife. The Act also authorized the USFWS and the responsible state agency to conduct studies for the purpose of determining possible damage to fish and wildlife resources as a consequence of proposed Federal actions. USFWS and state agency recommendations must be given "full consideration" by the Federal agency proposing or permitting the project.

11.2.1.7 The Endangered Species Act of 1973 (16 U.S.C. 1531 et seq., as amended). The Act requires that Federal agency actions or actions which require a Federal permit do not jeopardize the continued existence of, or result in the destruction of any designated critical habitat for, threatened or endangered species (as listed in 50 CFR 17.11 and 17.12). In accordance with Section 7 of the Act, formal consultation with the USFWS or the National Marine Fisheries Service (NMFS) may be required if adverse impact may occur to any Federally listed species or critical habitat as a result of a proposed Federal action. This consultation may require an assessment of the potential impacts of the project on a listed species. Based upon this assessment, the USFWS or NMFS issues a biological opinion, which is binding, permitting the project to proceed with or without conditions, or prohibiting the project from proceeding.

11.2.1.8 Executive Order 11988 - Floodplain Protection. This Order directs Federal agencies to determine whether or not a proposed action will occur in the floodplain and, if it is in the floodplain, to determine the potential effects. Actions must be designed to avoid adverse effects and incompatible development in floodplains.

11.2.1.9 Section 401 of the Clean Water Act (33 U.S.C. 1341). This Act requires that any action that requires a Federal license or permit and that may result in a discharge of a pollutant into waters of the U.S. also requires water quality certification. This program is administered by the states and is designed to ensure that the discharge will comply with applicable Federal and state effluent limitations and water quality standards. Certification applies to both construction and operation.

11.2.2 Connecticut Regulations

The State of Connecticut regulates fresh water wetlands and tidal wetlands through different divisions within the Connecticut Department of Environmental Protection (ConnDEP), as described below. Wetlands regulations also address wildlife, fisheries and shellfish habitat; endangered species are addressed separately. Floodplain regulations govern only state-funded activities, and therefore are not applicable to this project. State water quality certification is required for point or non-point source discharges to surface water resources.

11.2.2.1 Inland Wetlands and Watercourses Act (C.G.S. sections 22a- 36 to 22a-45, as amended). Permits are required from the Inland Water Resources Protection Division of ConnDEP for regulated activities, which include deposition, excavation, obstruction, construction, alteration, and pollution of wetland areas. Wetland areas include banks, bogs, swamps, meadows and submerged land. Soil types designated as poorly drained, very poorly drained, alluvial and floodplain by the National Cooperative Soil Survey define inland wetlands.

11.2.2.2 Coastal Management Act (C.G.S. sections 22a, as amended). The Coastal Resources Management Division (CRMD) of ConnDEP administers the Federal CZM Act and regulates activities in tidal wetlands through three programs: 1) the statutes regulating structures, dredging and fill, 2) the tidal wetlands statutes, and 3) the statutes regulating the removal of sand and gravel. These statutes, together with the policies and standards of the Connecticut coastal management statutes form the basis of the permit programs administered by CRMD and are known as the "The Coastal Management Act", which defines legislative goals for policies concerning development, facilities and uses within the coastal boundaries.

Permits are required from CRMD for activities in tidal or coastal wetlands. These activities include erection of structures; placement of fill; encroachment; dredging; draining; excavation; removal of soil, mud, sand, or gravel; and driving piles in tidal wetlands. Tidal wetlands are areas which border on or lie beneath tidal waters, such as banks, salt marshes, swamps, meadows, flats or other low lands subject to tidal action; including those areas now or formerly connected to tidal waters, and where the surface is at or below an elevation of one foot below extreme high water; and upon which saltwater tolerant plants may grow or be capable of growing and as designated upon official state mapping for tidal wetlands.

These regulations also identify effects on marine fisheries, shell fisheries and wildlife as criteria for review in granting, limiting or denying permits. The intent of the regulation is to prohibit the existing bioproductivity of any wetland from being adversely and unreasonably affected.

11.2.2.3 Connecticut Endangered Species Act (Title 26, Chapter 495, sec. 26, 303-315). This Act directs state agencies to minimize impacts to state-listed threatened and endangered species, species of special concern and essential habitats.

11.2.2.4 Connecticut Water Quality Standards (C.G.L. 22qa-426). Regulations regarding implementation of the Federal water quality certification program are contained within these regulations. The proposed activities are reviewed for their impacts on both inland and tidal waters before issuance of a Section 401 Water Quality Certificate.

11.2.3 Rhode Island Regulations

Rhode Island wetlands are regulated by two separate agencies. The Rhode Island Department of Environmental Management (RIDEM), Division of Freshwater Wetlands governs freshwater wetlands, while coastal wetlands and contiguous freshwater areas are regulated by the Coastal Resources Management Council (CRMC). Effects on floodplains and wildlife are also governed within these regulations, as described below.

11.2.3.1 Freshwater Wetlands Act (RIGL Sec. 2-1-18 through 2-1-24). Freshwater wetlands are defined as areas including bogs, marshes, swamps, ponds and land within fifty feet of the edge of wetlands, as well as river and stream floodplains and banks and areas subject to flooding or storm flowage and "other freshwater wetlands." Wetlands are determined by a predominance of wetland vegetation. Permitting is required for activities such as filling, draining, excavating, running a ditch or drain into, or otherwise altering the flow of water into or from a wetland.

The Act also considers the effect on wildlife habitat and floodplains in reviewing permit applications. Alteration of a wetland can be denied if the values of "valuable" wildlife habitat is reduced. Valuable habitat is defined as those marshes, swamps, and bogs characterized by high diversity and wildlife production. In addition, it is a policy of the Act to prohibit net reduction in flood holding capacity of floodplains.

11.2.3.2 Coastal Resources Management Program (RIGL Section 46-23). The CRMC administers the Rhode Island Coastal Resource Management Program (CRMP), as well as the Federal Coastal Zone Management Act. CRMC reviews all activities which may impact the coastal zone or its resources. Among the regulated features are beaches and dunes, barrier beaches, coastal wetlands, coastal cliffs and banks, rocky shores and man-made structures. In addition, inland activities which may affect the coastal region are subject to CRMC approval.

Coastal wetlands are determined by the presence of a predominance of plants adapted to livin g in soils saturated by salt water. Coastal wetlands and contiguous freshwater wetlands are regulated by the CRMC through a permit program. The CRMP also requires that permit applications address effects of a project on flood storage capacity and wildlife.

11.2.3.3 Endangered Species of Animals and Plants Act (RIGL Title 20, Chapter 37). This law provides protection for listed endangered species, a mechanism for state listing of species and enforcement authorization.

11.2.3.4 Water Quality Standards (RIGL Chapter 46-12, 42-17.1 and 42.53). These regulations, administered by the RIDEM Division of Water Resources require Water Quality Certification for Federally permitted activities which results in a point or non-point source discharge to a surface water resource.

11.2.4 Massachusetts Regulations

In Massachusetts, freshwater and coastal wetlands are governed by the Wetlands Protection Act, which is administered by the municipal conservation commissions, with overview by the Massachusetts Department of Environmental Protection (MDEP) Division of Wetlands and Water Resources (DWWR). Regulations implementing the act also address floodplains. The Massachusetts Coastal Zone Management Program (MCZMP) is administered by the state's Executive Office of Environmental Affairs (EOEA).

11.2.4.1 Wetlands Protection Act (M.G.L. c. 131 s.40). Part I of the regulations implementing this Act (310 C.M.R. 10.00) govern both inland and coastal areas, while Part II provides specific standards for activity within coastal areas and Part III relates specifically to activity in inland areas only. The regulations identify "Areas Subject to Protection Under the Act" and locally issued permits are required for any activity that involves filling, dredging, removing or altering these areas. Areas subject to protection include any bank, marsh, meadow, swamp, bog, creek, river, stream, pond, lake, land under these waterways, or land subject to flooding (floodplain). Coastal areas similarly protected include any coastal wetland, coastal dune, tidal flat, coastal bank, land subject to coastal storm flowage or tidal action, or land under an estuary, a salt pond, or the ocean or under certain streams, ponds, lakes, or creeks within the coastal zone that are anadromous/catadromous fish runs. The boundary of coastal wetlands is characterized by the presence of plants that are well adapted to or prefer living in saline soils and are subject to tidal action. Freshwater wetlands are defined as those areas in which at least 50 percent of the vegetative species present are wetlands species, as identified in the regulations.

The wetlands regulations also identify wildlife habitat as an Area Subject to Protection Under the Act; sections 10.37 and 10.59 of the regulations deal with Rare species, while section 10.60 outlines Wildlife habitat evaluation procedures including restoration of habitats. General performance standards outline work allowed within Land Subject to Flooding (floodplain), as well as requiring compensatory storage for any lost flood storage volumes, and protection of wildlife habitat functions.

11.2.4.2 Coastal Zone Management Program (301 CMR 20.00). The CZMP regulations are established to comply with the requirements of the Federal Coastal Zone Management Act of 1972 and require Federal consistency concurrence.

11.2.4.3 Massachusetts Endangered Species Act (321 CMR 10.00). These regulations list threatened and endangered species and species of special concern, the methods for designation of adverse habitat and the responsibilities of state agencies. It requires that agencies shall review, evaluate and determine the impact on such species and use all practicable means and measures to avoid or minimize damage to such species or their habitats.

11.2.4.4 Certification for Dredging, Dredged Material Disposal and Filling in Waters (314 CMR 9.00). The Massachusetts regulations pursuant to the Section 401 of the Federal Clean Water Act, require water quality certification for any Federally permitted activity which results in a point or non point source discharge to a surface water resource. The MDEP Division of Water Pollution Control (DWPC) is responsible for administering the certification program.

11.2.4.5 Areas of Critical Environmental Concern (301 CMR 12.00). Areas of Critical Environmental Concern (ACECs) are regulated sensitive or unique habitats. The regulations indicate that agencies are to ensure activities in or impacting on the ACECs, are carried out so as to minimize effects on marine and aquatic productivity, surface and groundwater quality, habitat values, storm damage prevention or flood control, historic and archeological resources, scenic and recreational resources, and other natural resource values of the area.

11.3 METHODS OF IDENTIFICATION AND EVALUATION OF EXISTING RESOURCES

This section describes the methods used for identifying and evaluating existing natural resources in the Northeast Corridor (NEC) that may be affected by Amtrak's proposed project or the no-build alternative. The study area includes all those areas affected by Amtrak's proposal and consists of the substation, switching station and paralleling station sites (collectively referred to as the "electrical facilities sites"), as well as bridges to be modified (raised) and moveable bridges where subsurface cables will be installed. All of these locations are collectively referred to throughout this report as the "project sites".

11.3.1 Wetlands

11.3.1.1 Wetlands Identification. Wetlands within the study area were identified by the interpretation of available data including National Wetlands Inventory (NWI) maps prepared by the U.S. Fish and Wildlife Service (USFWS); U.S. Soil Conservation Service (SCS) Soil

Surveys; and state and local wetlands and soil maps, as well as field verification of the presence of wetlands during site walks of the proposed facilities sites.

The approximate location of all wetlands located within 100 feet of any proposed facilities sites were verified to account for impacts to buffer zones. All wetland systems noted were classified according to the standards set forth in Cowardin *et al.* (1979). The wetland system, class, subclass and water regime were identified for each wetland.

11.3.1.2 Wetlands Impact Assessments. Section 404 of the Clean Water Act requires consideration of impacts to wetland acreage as well as the loss of wetland functions and values as outlined above. Executive Order 11990 requires all federal agencies to avoid wetlands where practicable, and to mitigate impacts to the extent practicable.

The direct loss of wetland acreage can take the form of dredging and filling activities. The assessment of wetland acreage lost is based on measurements utilizing design plans and surveyed wetland delineations. Since the facilities sites occur adjacent to the existing railroad tracks a nd are relatively small (no more than one-half acre each), encroachment into or further fragmentation of wildlife habitat should be relatively minor For this project, the primary wetlands impacts of concern are related to the effects of runoff, hydrological modification an d temporary disturbances associated with the construction activities which may adversely affect wetlands. Runoff impacts include sedimentation, erosion and flooding. Hydrological modifications include impounding, drainage, flooding or changes to the water regime. Temporary disturbances may affect water quality and cause impacts on vegetated wetlands. Such impacts are difficult to quantify prior to completion of final designs, and thus they are dealt with qualitatively in this study. For the purpose of this evaluation any facility site or bridge modification located in a wetland or buffer zone as defined by Federal or the appropriate state regulations will be considered to have adverse impact.

11.3.1.3 Mitigation Measures. Wetland mitigation is a three-step process involving first, avoidance of impacts; second, minimization of impacts that cannot be avoided; and finally, compensation for the unavoidable loss of wetlands. As there are no direct impacts involving the loss of wetlands associated with this project, this last step will not be required.

The first step, avoidance, involves avoiding unnecessary impacts to the wetlands and may include steps such as selecting alternative sites. The second step, minimizing impacts, involves design changes to reduce the impact of the project, *e.g.* reducing slopes or measures taken to avoid indirect impacts such as erosion.

No dredging or filling of wetlands is proposed for any of the sites associated with the NEC Project, as such the mitigation effort will focus on minimization of slopes and maximization of the distance to any adjacent wetlands. None of the substations will affect wetlands, but all three of the switching stations are located in the wetlands buffer zone. The Grove Beach, Millstone, Noank, Bradford and Attleboro paralleling station sites are also located in the wetlands buffer zone, as are the work areas of the Millstone Point Road and Depot Street bridges. The utilization of proper erosion and sedimentation control measures and stormwater management practices at these sites will further minimize potential impacts to adjacent wetlands and waterways.

11.3.2 Critical Wildlife Habitat

Fish and wildlife resources in the NEC project study area include amphibians, reptiles, birds, and mammals. Previous studies, contact with government agencies, and existing as well as field review data were utilized to make determinations if species or habitat types occur in the study area.

Wildlife in any habitat are directly dependent on the availability of the appropriate plant community to provide food and cover, and will utilize an area only if the necessary elements are present. Herbivorous wildlife species require the presence of the plant species which will provide a food source, while carnivores require the presence of prey species. Soils, topography, land use, and moisture all combine to affect the characteristics of the vegetation, thereby influencing the species of animals that occur within a particular area. Some species of wildlife may also require a number of different habitat types within their range, increasing the value of areas of high natural diversity, which may include the presence of adjacent open fields or wetlands, stream corridors, and forested habitats.

The project study area includes a broad range of potential wildlife habitats. The vegetation communities across the study area can be characterized as being primarily forested, with area s of emergent marsh and a variety of other habitats as well as urban/industrial land use. Additional features which may be important to wildlife considerations are the numerous river and stream crossings, wetlands, and areas of farmland/open meadow available in the area. Agencies contacted for habitat information include the USFWS, and the Connecticut, Rhode Island, and Massachusetts offices of the Natural Heritage Inventory, known as the State of Connecticut Natural Diversity Database, the Rhode Island Natural Heritage Program Review and the Massachusetts Natural Heritage Database.

11.3.2.1 Methodology. The sites reviewed for this project were evaluated for available habitat utilizing the Wildlife Habitat Inventory Checklist developed by C. Bridges (NH Fish and Game). The information gathered for the checklist describes the habitat characteristics of each site. These features include overstory and understory negatative composition, percent canopy closure, adjacent wetlands and openings, surrounding forest types, and observed wildlife signs. The terms overstory and understory refer to vertical zones within each habitat. For the purposes of this study overstory refers to the zone above the low shrub layer of approximately 6 feet. The understory below this point would refer to low growing shrubs, grasses and herbaceous species such as wildflowers.

In addition, the abundance of habitat elements is noted including ground cover, shrub and sapling layers, fruiting or nut producing trees and shrubs, standing or downed dead trees, and the presence of tree cavities or vernal pools. The evaluation of available habitats associated with a site was based on:

- surrounding land use and adjacent available habitats
- the size of the habitat unit
- available open water
- isolation and accessibility of the site
- the interspersion of different habitats including suitable edge habitats

11.3.2.2 Initial Findings. This section describes generally the types of wildlife found in the corridor region.

Amphibians and Reptiles. DeGraaf and Rudis (1986) indicate 56 species of amphibians and reptiles occur in New England. The project study area appears to be within the range of 42 species, including 20 species of amphibians and 22 species of reptiles from this group. Sixteen of these species would be at the limit of their range, meaning they generally are found north or south of the study area. This area represents an extreme location at the edge of their habitat, which may relate to the presence of a physical feature such as a vegetative community or a climatic change. Table 1 in Appendix E lists these species and notes rare and uncommon species within the study area. Rare and endangered species are further discussed in Section 11.3.3.

Specific studies or information on the distribution of reptiles and amphibians within the study area is limited. Habitat information outlined in DeGraaf and Rudis (1986) would indicate all of the turtle, most of the amphibian and some of the snake species require water for breeding purposes at some stage in their life cycle. The information indicates most turtles prefer aquatic habitats with eggs deposited near the water's edge, while shallow muddy-bottomed ponds are especially important to Blandings turtle *(Emydoidea blandingi)* and the spotted turtle *(Clemmys guttata)*. Sandy nesting areas are preferred by the wood turtle *(Clemmys insculpta)*.

Ponds are important to bullfrogs (*Rana catesbeiana*), pickerel frogs (*Rana palustris*), and red-spotted newts (*Notophthalmus viridenscens viridescens*). Other species require varied habitats including vernal pools for wood frogs *(Rana sylvatica)* and streamside habitat for the norther n dusky salamander (*Desmognathus fuscus*). Most species of reptiles and amphibians found in the study area also require terrestrial forested sites of moist woodlands. Logs, stumps, and rocks are important habitat to salamanders as well (DeGraaf and Rudis, 1986).

Birds. DeGraaf and Rudis (1986) indicate 220 species of birds occur in New England. The project area would appear to be within the range of 177 species from this group, as listed in Table 2 in Appendix E. Thirty-eight of these species would be at the limit of their range. Birds which are noted by DeGraaf and Rudis (1986) as occurring at the edge of their range are more susceptible or sensitive to habitat changes.

Mammals. DeGraaf and Rudis (1986) indicate 62 species of mammals occur in New England. The project area would appear to be within the range of 45 species from this group. Six of these species would be at the limit of their range and as such are considered to be more susceptible or sensitive to habitat changes. Table 3 in Appendix E lists these species as well as noting rare and uncommon species within the study area.

Fisheries. The study area crosses a number of aquatic habitats including streams, rivers, and coastal areas. The freshwater habitats encountered are typically warm-water systems. Due to the scope of the project, the size of the study area and the limited work outside the existing right-of-way, the presence of fisheries and/or important aquatic habitats are examined on a site by site basis in Section 11.4 and 11.5. Information was obtained through state and federal agencies responsible for inland and marine fisheries.

11.3.2.3 Impact Assessment. The impact of any activity on the wildlife of an area depends on the habitat to be impacted and the types of habitat available in a given area. Most construction activities result in both long-term and short-term consequences to wildlife. Short-term impacts are a direct result of construction activities, while long-term impacts are related to disturbance of wildlife distribution patterns and barriers created (fencing) for wildlife travel or migration routes.

Short-term impacts could include the direct mortality of fossorial species, animals adapted to subterranean habitats, or those species whose nests may be disturbed such as birds or ground-dwelling species including woodchucks (*Marmot monax*) and red fox (*Vulpes fulva*). Generally, the more mobile species will migrate to other suitable habitats, if available. Those species unable to locate a substitute source of food and/or shelter may not survive or reproduce. Short-term impacts may also include impacts caused by construction activities, including traffic and noise. Although temporary in nature, impacts would be expected to include interference with breeding, nesting, and rearing activities.

Long-term impacts reflect changes to the adjacent habitats and interruption of traditional travel routes. The loss of a particular habitat type such as a forested habitat, would result in impact to species which tend to specialize in that habitat or have a small home range, especially small mammals such as shrews or amphibians.

Interference by the proposed activities with the movement of mammals, amphibians, and reptiles from one habitat to another is generally considered an important factor with any new construction. The small scale facilities associated with the proposed NEC project would be assumed to have greater impact on small mammals, reptiles, and amphibians since medium-sized and large mammals would be expected to continue moving around the sites. Similarly, the presence of the proposed activities along the existing rail corridor and the small scale of the facilities (one half acre maximum) minimizes the potential for any further fragmentation of existing habitats. For the purpose of this evaluation, any degradation of wildlife habitat considered to be of high value will be considered a adverse impact, including the construction of facilities within the high value habitat. A high incidence of electrocution for birds perching on catenary wires would not be expected.

11.3.2.4 Mitigation Measures. To mitigate for potential impacts to wildlife and their habitats, the general process followed is the same as for wetland impacts: avoidance, minimization and replacement, or restoration.

Avoidance involves the selection of alternatives that eliminate direct impacts to essential wildlife habitats.
Minimization of potential impacts includes the refinement of designs and timing of construction activities to avoid the impacts of construction noise and disruption during the breeding and nesting season for sensitive species of wildlife.

Creation of new wetlands as mitigation for those lost to proposed activities should incorporate wildlife habitat mitigation which can include active habitat management and preservation of valuable habitats. Additional measures undertaken to mitigate for impacts can include structures to maintain access for wildlife including bridges or culverts.

Activities associated with the project include substations, switching stations or paralleling stations which require small areas (less than 1/2 acre) of site disturbance immediately adjacent to the existing railroad tracks. Most sites are partially located within the right-of-way and include previous disturbance of habitat characteristics. In addition nine overhead bridges will be modified in order to accommodate catenary structures and provide a minimum clearance. Reconstruction of these facilities will for the most part create limited disturbance of habitat features away from the bridge site. In addition, the quality of the wildlife habitat at these sites is generally limited. The habitat is of high quality only at the Kingston parallelling station site and the Connecticut River movable bridge. The habitat is of moderate quality at the Norton switching station site; the Old Lyme, Millstone, Stonington, Exeter and East Foxboro paralleling station sites; and the Johnnycake Hill Road, Burdickville Road, Route 138 and Maskwonicut Street Bridges. Therefore, it is not anticipated that replacement or restoration will be required and that mitigation measures will focus on avoidance and minimization.

11.3.3 Endangered Species

Protected species are defined as species which are currently listed on state or federal lists as endangered, threatened or a species of special concern. The USFWS has been delegated the responsibility of administrating the Endangered Species Act (1973), and maintains a list of species which are:

- Endangered - Any species which is in danger of extinction throughout all or a adverse portion of its range other than a species of the class Insecta determined to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man; or

- **Threatened** Any species which is likely to become an endangered species within the foreseeable future throughout all or a adverse part of its range.

The responsibility for identifying protected species on the state level is held by the Natural Heritage and Endangered Species Program in Massachusetts, the Natural Heritage Program in Rhode Island, and the Natural Diversity Data Base Program in Connecticut. Each program documents and maintains a database of threatened and endangered species, rare plants, and rare or noteworthy natural communities.

The presence of protected species in the study area was noted through database searches at the state and federal levels. The individual sites reviewed for this project were also evaluated in the field for the presence of threatened or endangered species utilizing the list of protected species for Connecticut, Rhode Island and Massachusetts.

11.3.3.1 Impact Assessment. The review of database files and field evaluation of the sites indicates no direct impacts to protected species, as detailed below.

Federally Threatened or Endangered Species
The USFWS, in a letter dated February 25, 1993 (Appendix G), indicated no federally listed or proposed threatened and endangered species under its jurisdiction are known to occur in the project area except for occasional, transient endangered bald eagles (*Haliaeetus leucocephalus*) or peregrine falcons (*Falco peregrinus*). Further consultation with the National Marine Fisheries Service (NMFS) was recommended regarding the endangered short-nosed sturgeon *(Acipenser brevirostris)* which occurs in the Connecticut River. In their most recent communication NMFS indicated an Endangered Species Section 7 Consultation concerning the impact of the Connecticut River crossing on short-nosed sturgeon needs to be completed prior to issuing a permit for this activity.

State Threatened, Endangered or Special Concern Species
No direct impacts to state protected species was noted by the database review and field evaluation of each site, however in several instances state threatened, endangered or special concern species do occur near the sites investigated.

The Natural Diversity Data Base in Connecticut indicates a record exists of the American bittern (*Botaurus lentiginosus*), a state endangered species, occurring within close proximity to the Stonington paralleling station site (Dickson, 1993).

The Natural Heritage and Endangered Species Program in Massachusetts indicates that the following state protected species occur near the rail line as it traverses the Fowl Meadow and the Ponkapoag Bog ACECs.

Common Name	Scientific Name	State Rank
Spotted turtle	*Clemmys guttata*	Special Concern
Blanding's Turtle	*Emydoidea blandingii*	Threatened
Least Bittern	*Ixobrychus exilis*	Threatened
Elderberry Longhorn Beetle	*Desmocerus pallidus*	Special Concern

Any degradatio of the designated habitat for a Federal or state designated threatened or endangered species will be considered a adverse impact.

11.3.3.2 Mitigative Measures. To mitigate for the potential impacts to protected species or communities associated with the project sites, three measures are taken during design and scheduling of construction time periods to reduce potential impacts. These steps are:

(1) Avoidance
(2) Minimization, and
(3) Replacement

Avoidance of direct impacts to the rare species has been attained through site selection processes. Minimization of potential impacts to protected species adjacent to the Stonington paralleling station site, in the Connecticut River and in the Fowl Meadow/Ponkapoag Bog ACEC focus on avoiding disruptive activities during breeding and nesting seasons or critical activity periods. The current list of protected species associated with the project sites include two migratory marsh birds, two turtles and one beetle, all of which are associated with wetlands for a large portion of their life cycle and have periods of inactivity or migrate away from the site.

Mitigation of construction impacts involves the control of sedimentation and erosion and the development of protective measures to ensure impacts to wetlands and other protected resources are minimized. For the protected species identified, the mitigation of erosion and sedimentation will provide protection to the wetland habitats they require.

11.3.4 Floodplains

The study area crosses a variety of floodplains associated with rivers, streams, and surface waters. Since the electrification project may impact some portion of the floodplain, an evaluation of potential effects to the floodplains is required pursuant to the provisions of Executive Order 11988 (Floodplain Management), 23 CFR 650A, and the National Flood Insurance Program. The Federal Emergency Management Agency (FEMA), which is charged with the administration of floodplain requirements, has mandated that local and state agencies be notified prior to the commencement of work in any area that would be inundated by a 100-year storm event. A 100-year storm is defined as a storm having a one percent chance of occurring in any given year.

Data for the floodplain section of this report was taken from flood insurance studies conducted for the FEMA and the Department of Housing and Urban Development. The locations of the 100-year floodplains are taken from FEMA Flood Insurance Rate Maps (FIRM) for each site along the Corridor.

11.3.4.1 Impact Assessment. Assessment of impacts to the 100-year floodplain are taken directly from the appropriate FEMA/FIRM map for each site. A site is considered to have a adverse impact on floodplains if it occurs within a 100-year floodplain including a Zone A flood hazard area or Zone V coastal flood hazard area. The large scale of the FIRM maps prohibits a more detailed evaluation of impacts.

The following project sites are located in the 100-year floodplain: New London substation; Richmond switching station; Leetes Island, Noank and Stonington paralleling stations; and the Maskwonicut Street Bridge, as well as all five of the movable bridges.

11.3.4.2 Mitigative Measures. Where impacts to the 100-year floodplain are expected, Executive Order 11988 outlines an eight step process that has to be followed to demonstrate the site is the most practicable alternative.
This eight step process includes:

(1) determine if the site is within the floodplain
(2) provide for public review
(3) identify and evaluate practicable alternatives
(4) identify the impacts
(5) minimize threats to life, property and floodplain values
(6) re-evaluate alternatives
(7) issue findings
(8) implement the action.

If it is found to be in the floodplain, the proposed project will have to be flood-proofed or constructed above the 100-year flood elevation. Additional measures taken to minimize impacts can include reduction of slopes and reducing the footprint of the proposed project. Compensatory storage would be required as mitigation for any losses in the 100-year floodplain.

11.3.5 Coastal Resources

Each of the three NEC states delineates a coastal zone or coastal resources boundary (see Section 11.2). While portions of the NEC fall within this boundary in all three states, none of the facilities sites fall in the Massachusetts or Rhode Island coastal zone boundaries, which are delineated in accordance with 301 CMR 20.99 and RIGL 46-23, respectively. Many Connecticut project sites fall within the boundary. These include the New London substation, all of the Connecticut paralleling stations except Madison and the Millstone Point Bridge. This boundary is delineated in accordance with Section 22a-94(b) of the Connecticut General Statutes, as amended by Public Act 79-535. Coastal resources were identified through the Connecticut

Coastal Resource Maps and Tidal Wetland Maps, the Rhode Island Coastal Resources Management Program, the Massachusetts Coastal Zone Management Program, local resource maps, NWI maps and field observation. All coastal wetlands were identified, delineated, and classified according to the methods outlined in Section 11.3.1. Volume II - Land Use and Regulated Areas shows the regulated coastal boundaries for the three states.

Coastal resources include: coastal waters, related marine and wildlife habitat, and adjacent shorelands, both developed and undeveloped, which together constitute an ecosystem of both terrestrial and estuarine environments. Examples of these resources include coastal bluffs, shorefronts, beaches and dunes, intertidal flats, tidal wetlands, adjacent freshwater wetlands, estuarine embayments, coastal hazard areas, developed shorefront, nearshore waters, islands, shorelands and shellfish concentration areas (C.G.S. section 22a-93-7).

The Connecticut Coastal Management Act outlines goals and policies to ensure proper planning and regulation of these coastal resources. These policies cite the rehabilitation and improvement of existing transportation facilities as the primary means of meeting transportation needs in the coastal area. Policies are outlined concerning management and use of coastal land and water resources within the coastal boundary. These include prohibiting any fill in tidal wetlands to create new land and require that new or improved shoreline rail corridors be designed and constructed to prevent tidal and circulation restrictions. New or improved rail corridors should also have negligible effect on coastal access and not impair the visual quality of the shoreline.

As noted in chapter one of this DEIS/R, under the auspices of Coastal America, an interagency group coordinating Federal policy in coastal areas, the U.S. Army Corps of Engineers is presently undertaking a study of eight severely degraded tidal wetlands and coves along the Connecticut coast. Their objectives are to determine the source of the degradation - either the NEC embankment, an adjacent roadway, or upstream runoff - and assist in obtaining funds for restoration under existing authorities and programs. Although this study evaluates a situation that would not be impacted by the proposed action (and therefore not considered in this Natural Resources evaluation), coordination between Amtrak and Coastal America is anticipated to help restore tidal coves and wetlands degraded by the NEC. The tidal wetland restoration study is nearly complete with a report expected to be published in the fall of 1993.

11.3.5.1 Impact Assessment. The location of a site in the Coastal Zone was identified through state coastal zone mapping or boundary descriptions as noted earlier. Assessment of impacts to the protected resources described in the various coastal zone management regulations was based on field assessment of the sites and an assessment of the site plans in the context of these boundaries and resources.

No dredging or fill of coastal wetlands are proposed for any substations, switching stations or paralleling stations associated with the NEC project. The bridges to be raised to accommodate catenary structures are not expected to impact any coastal wetlands or resources other than those noted, although advanced design plans would be required to better assess the potential impacts.

Although nine of the thirteen facilities sites and bridges in Connecticut are located in the Coastal Zone, all are situated wholly or at least partially within Shorelands. These resource areas are designated as upland areas at elevations above the 100 year still water flood level. Additional resource areas impacted include coastal flood hazard areas, which have also been noted under Floodplains. The Old Lyme and State Line paralleling station sites have been classified freshwater wetlands due to the mapping of site soils as poorly drained or very poorly drained. However, field investigation at both of these sites did not substantiate the soil conditions cited and Amtrak will have to petition the state to reclassify the area as upland.

11.3.5.2 Mitigative Measures. The mitigation process for impacts to resources within the coastal zone should follow the three step process outlined in previous sections. This includes first avoidance, or avoiding unnecessary impacts to coastal resources; second, minimization of impacts that are unavoidable; and third, compensation for any unavoidable impacts.

Avoidance of any dredging or filling of tidal or freshwater wetlands within the coastal zone has been accomplished by siting these facilities in uplands. As outlined in C.G.S. 22a-93(15), siting these facilities in shorelands requires steps to be taken to minimize impacts to water quality, natural erosion or hydrologic circulation patterns, visual quality, and wildlife, finfish or shellfish habitat. The coastal hazard may not be increased through adverse alteration of shoreline configurations. To further mitigate for these adverse impacts, proper erosion and sedimentation control measures and storm water management practices should be maintained throughout the project.

Impacts to floodplains will be addressed through the process outlined in Executive Order 11988 and described in Section 11.3.4.2. This could include relocation or redesign of the project sites or, if necessary, compensation for any loss of flood storage volumes. Similarly, the impact of project sites to visual quality and wildlife habitat could be minimized and compensated for by landscaping and plantings which would provide screening as well as enhanced food, cover and resting opportunities for small animals and songbirds.

11.3.6 Water Resources

11.3.6.1 Ground Water Supplies. Groundwater is defined in the Dictionary of Geological Terms (1962) as "that part of the subsurface water which is in the zone of saturation". The construction of railroad improvements and associated structures such as those proposed for this project has the potential to adversely impact groundwater quality during the construction phase by the alteration of the terrain and the staging of construction equipment and supplies, and subsequently by increased urban runoff from paved areas. Shallow sand and gravel aquifers are susceptible to contamination by water quality contaminants in runoff. While less susceptible than consolidated aquifers, bedrock aquifers are also subject to contamination by polluted recharge. The addition of impervious surfaces and the potential for localized diversion of runoff may have some impact upon groundwater recharge. The East Greenwich parallelling station site and the Route 138, Depot Street and Maskwonicut Bridges are located in local groundwater protection districts.

The federal government regulates the quality of the nation's groundwater pursuant to the criteria described in the Safe Drinking Water Act of 1974 (SDWA), as amended in 1986. The amended version of the SDWA requires states to adopt programs that will protect water quality in proximity to municipal wells by establishing wellhead protection areas. The Sole Source Aquifer provision of the SDWA (Section 1424 (e)) gives the U.S. EPA the authority to designate aquifers that provide the principal or sole source of drinking water in an area as a Sole Source Aquifer. Once designated as a Sole Source Aquifer, no federal funds can be committed to any project that the U.S. EPA administrator finds would contaminate the aquifer and cause a adverse public health hazard. U.S. EPA's evaluation of such projects would include soliciting public comment, where appropriate. If a negative finding is made, no commitment for funding can be made, or the project may have to be redesigned (Jaffee and DiNovo, 1987). The Richmond switching station site; the State Line, Bradford, Kingston and Exeter paralleling station sites; and the Burdickville Road, Kenyon School Road and Route 138 bridges are in Sole Source Aquifer areas.

11.3.6.2 Surface Water. Surface water (ocean, lake, pond, river and stream) is an important resource not only for human consumption, but also for recreation and for wildlife consumption. Each of the three states provide water quality standards for evaluating impacts from activities (particularly dredge and fill) that may affect such resources. Detailed design plans, which will not be available within the time frame of the DEIS/R, would be required to assess impacts to water quality. This report will, however, identify surface waterbodies and waterways and surface water protection areas that may be affected by Amtrak's proposed action and the general types of impacts that can be anticipated due to work occurring in or in close proximity to the waterbody or waterway. The Norton switching station is in a surface water protection district.

11.3.6.3 Identification of Resources. To avoid unnecessary impacts and to assist the planning process, surface water supplies and municipal and private groundwater wells were located through existing records or field observation. Town, city, county, regional or water company records were reviewed to note the presence and/or location of any water wells in the vicinity of the proposed activities. The Rhode Island Department of Environmental Management provided draft copies of statewide maps which indicate the locations of Wellhead Protection Areas and Groundwater Classifications in the state. Most towns have limited information on private wells, the primary source of private well locations was field observation. Any surface water protection districts or groundwater protection districts in the vicinity of the sites were noted. The presence of surface waters adjacent to these sites was noted through existing records, visual observation or a review of available mapping including U.S.G.S. topographic maps.

11.3.6.4 Impact Assessment. The potential for impacts to water supplies and resources were assessed utilizing the available information as well as the information on the activity proposed for the site, *i.e.* the extent of road widening associated with a bridge raising or the area of impact expected for substations or switching stations.

Long-term impacts to groundwater and surface water supplies are generally the result of altering runoff and recharge relationships, *i.e.* altering surface terrain and runoff characteristics and redirecting waters which may under normal conditions have entered into the water supply. The introduction of contaminants during construction or site operations may also result in long-term impacts to water quality in groundwater or surface waters. Short-term impacts are more closely related to construction impacts, such as erosion and the staging of construction equipment and supplies.

The NEC crosses two watershed or aquifer areas designated by U.S. EPA as Sole Source Aquifers and one awaiting designation. In the North Kingstown, Rhode Island area is the Hunt-Annaquaticket-Pettaquamscott Sole Source Aquifer, while the southwestern area of Rhode Island contains the Wood and Pawtucket River Watershed Sole Source Aquifer. The area currently awaiting designation is the Canoe River Aquifer in the Sharon-Foxboro area of Massachusetts.

Direct impacts to water resources are not expected with the NEC project, although a number of sites are located in Sole Source Aquifers, wellhead protection areas and/or critical groundwater recharge areas. For the purpose of this evaluation, a adverse impact is any action that requires state water quality certification or is in a Federal, state or local aquifer protection district.

Work within the Sole Source Aquifer sites along the NEC will require following the Best Management Practices (BMPs) for working in aquifer protection areas. BMPs are structural or non-structural practices that are determined to be the most effective, practical means of preventing or reducing pollution inputs from nonpoint sources (e.g., stormwater runoff and construction development practices) in order to achieve water quality goals. The specific steps to be taken would be site specific according to the activity proposed, and could include the following:

<u>BMPs during construction</u>

- Stage equipment and construction materials on impervious surfaces or outside of the Aquifer Protection Area (APA)
- Perform all vehicle maintenance outside of APA
- Develop a spill contingency plan in case of an accidental release of potential contaminants

<u>BMP post construction</u>

Structural

- Swales to remove nutrients and suspended material
- Construction of infiltration trenches or basins as needed

Non-structural

- Implement an herbicide management plan, if appropriate
- Develop buffer areas around sensitive natural areas
- Maintain facilities to avoid accidental releases of potential contaminants.

11.3.6.5 Mitigative Measures. With water quality standards regulated by the federal government and sites within protected aquifers reviewed for impacts by the U.S. EPA, steps have been taken during the site selection process to avoid siting facilities in wetlands or sensitive areas where possible. Further development of site plans should focus on minimizing any potential impacts to the adjacent wetlands, wells, water protection districts or aquifer protection districts, through maximizing the distance to any wetlands, and minimizing any impermeable surfaces associated with the facilities which would increase runoff. Other steps to be taken include restricting the storage of hazardous materials on-site and quickly stabilizing any slopes or disturbed areas associates with site development. The potential for short-term impacts arising from construction activities should be minimized by off-site storage of construction supplies and vehicles, as well as restricting maintenance activities to off-site areas. If these steps cannot adequately protect the resources around a site, alternate areas may have to be examined.

The potential for erosion and sedimentation impacts can be assumed to occur at any of the sites associated with the NEC project, as such proper erosion control methods should be in place at each site before work begins and stormwater management practices incorporated in the site plans.

11.3.7 Areas of Critical Environmental Concern (Massachusetts)
The NEC passes through two land areas identified as Areas of Critical Environmental Concern (ACECs) by the Massachusetts Department of Environmental Management (MDEM), as shown in Volume II. These areas are considered to be unique clusters with natural and human resource values worthy of a high level of concern and protection (301 CMR 12.00).

11.3.7.1 Fowl Meadow ACEC. The rail corridor goes through the Fowl Meadow ACEC in the communities of Boston, Dedham, Westwood and Canton, Massachusetts. The central resource feature of the Fowl Meadow ACEC is the Neponset River. The river and its tributaries, the adjacent wetlands and floodplains, the associated aquifers and public water supplies, and the diverse habitats form the core resources of the Fowl Meadow ACEC. The northern portion of the Fowl Meadow was designated by the National Park Service in 1992 as a National Environmental Study Area.

The Massachusetts Natural Heritage and Endangered Species program noted several species of state importance near the rail line in this ACEC, as described in Section 11.3.3.1.

11.3.7.2 Impact Assessment. The director of the ACEC office for the MDEM indicated the important resources relating to the railroad as it passes through the Fowl Meadow ACEC are endangered species, wildlife and groundwater protection (Luchonok, 1992). Construction proposed in the Fowl Meadow ACEC includes a paralleling station in Readville, just inside the northern boundary of the ACEC, as well as the installation of catenary poles within the existing right of way. The Readville site is not associated with any wetlands or buffer zones and the City of Boston indicated no wells or water protection districts are located in the vicinity (personal communication, 1993). For the purpose of this evaluation, any facility sited within ACEC boundaries is considered to have a adverse impact. Installation of the catenary poles would not be expected to impact adjacent wetlands, groundwater supplies or any existing travel corridors or wildlife other than birds. It is assumed the existence of the track and railbed already restrict the movement of most amphibians and turtles. Concern was expressed by the Metropolitan District Commission and the USFWS regarding collisions by birds with the catenary wires. Concerns were also expressed regarding electrocution hazards to large birds that may be able to establish contact between the wires.

11.3.7.3 Canoe River Aquifer ACEC. The NEC passes along the western boundary of the Canoe River Aquifer ACEC in the communities of Sharon and Foxboro. The Canoe River Aquifer ACEC is generally defined by the Canoe River Watershed basin and the underlying aquifer, and includes surface waters, wetlands, floodplains and high-yield aquifers. The western boundary of the ACEC is the railroad right-of-way along most of the corridor. The boundary expands to the west in the vicinity of Wolomopoag Street in Sharon. The Massachusetts Natural Heritage Database search indicated no rare species or adverse natural communities near the rail line in the ACEC.

11.3.7.4. Impact Assessment. The director of the ACEC office for the MDEM indicated the important resources relating to the railroad as it passes through the Canoe River ACEC are surface waters and aquifers (Luchonok, 1993). Construction proposed in the Canoe River Aquifer ACEC includes a paralleling station in Foxboro and the installation of catenary poles within the existing right-of-way. The Foxboro site is not associated with any wetlands or buffer zones and the Town of Foxboro Conservation Commission Administrator indicated the site lies outside any existing or proposed aquifer protection districts (personal communications, 1993). The greatest potential impact associated with the development of this site would be to wildlife habitat, since the area includes vegetative diversity, however the extent of impacts to these resources would be limited in area.

For the purpose of this evaluation, any facility sited within ACEC boundaries is considered to have a adverse impact. Installation of the catenary poles within the existing rail right of way would not be expected to impact adjacent wetlands, surface waters or aquifers, the important resources noted by the director of the ACEC office. The impact of wildlife due to the installation of the powerlines would be similar to that noted at the Fowl Meadow ACEC, *i.e.*, the most likely impact is to winged wildlife. Potential impacts would be bird strikes and electrocution of large birds.

11.3.7.5 Mitigative Measures at ACEC's. Potential resource impacts within the Fowl Meadow ACEC and Canoe River Aquifer ACEC are restricted to two paralleling stations and the installation of catenary poles. The two paralleling stations are located immediately adjacent to the ACEC boundaries and would be expected to have little impact on surrounding resources.

The mitigation effort across these two areas will focus on minimizing the potential impacts to wetlands and water quality arising because of the installation of the catenary poles in the right-of-way. At the current time the method of installation or anchoring these poles is still being developed, however it is assumed the extent of impact arising from the project would be very limited in area and runoff into the surrounding area could be controlled by standard erosion control measures.

The impact arising from the installation of the wires includes but is not limited to bird collisions and electrocution hazards. The mitigation of these impacts should include design modifications to insure the distance between wires is sufficient to eliminate incidental contact by large birds, while bird strikes on these wires may require some form of deterrent to direct birds away from the wires.

11.3.8 Proposed Fencing and Noise Barrier Construction

As a result of analyses performed in the Noise and Vibration and Public Safety Studies (Technical Studies Four and Eight, respectively) mitigation measures which could pose potential impacts to wildlife have been proposed. Noise barriers, which would be comprised of solid materials and range from 8 to 16 feet high, have been suggested as a measure to reduce potential increases noise due to electrification. Fencing has also been proposed at existing illegal pedestrian crossings to safeguard pedestrians frcm high-speed and conventional train traffic.

11.3.8.1 Impact Assessment. Erection of solid and fencing barriers would be expected to impact wildlife habitat values if they restrict movement along traditional travel corridors, between important habitats, or if they restrict access or escape opportunities for wildlife within the right-of-way.

<u>Noise Barriers.</u> There are numerous locations along the NEC where adverse noise impacts could require the placement of solid noise barriers to reduce the effects of electrification.
As discussed in this Study, barriers which would be placed near wetlands would be of most concern due to the high value of these habitat sources. Barriers placed on the edges of wetlands would not impact wildlife as greatly as those placed in the middle or that split a wetland existing on both sides of the right-of-way (ROW).

11.3.8.2 Mitigative Measures at Noise Barrier and Fencing Locations. Where noise barrier or fencing construction is required certain considerations could be incorporated in order to limit impact on wildlife.

Noise Barriers. Noise barriers placement should consider the following:

- Restricting barriers to sensitive receptors.
- Limiting the length of barriers to the minimum extent applicable.
- Avoiding connecting barrier segments unless required by location.

Fencing. Fencing placement should incorporate the following:

- Fencing should be restricted to areas around sensitive receptors such as schools, recreation areas, libraries, hospitals, nursing homes or churches, as well as residential areas.
- The minimum length of fencing which would protect the area targeted would be preferable.
- If practical, fencing should be restricted to one side of the track.
- Areas which may provide wildlife habitat should have minimal fencing, including:
  1. Riparian corridors such as uplands along and adjacent to streams, and
  2. Wetlands and wetland buffers

11.3.9 Drainage

The proposed electrification facilities would create additional runoff due to impervious surfaces associated with them.

11.3.9.1 Impact Assessment

In order to determine the anticipated runoff which would be created by proposed electrification facilities the Rational Method for calculating runoff was applied. This method determines a volume of flow (Q) expressed in cubic feet per second by relating it to the intensity (i) in inches per hour, the tributary area (A) in acres, and a coefficient (C) which represents the combined effects of ponding percolation, and evaporation. The rational method formula is as follows: $Q_{cfs} = CiA$. Table 11-1 provides drainage calculations for proposed electrification facilities.

The storm event intensity curves shown in Figure 11-1 are produced by the National Weather Bureau and are used to represent the intensity values (i) for the 10, 25, and 100 year storm events. These curves represent an approximate quantity of rainfall which can be expected in a given area for a particular storm event, expressed in inches per hour.

Common runoff coefficients (C) for various drainage surfaces are listed in Table 11-2. As the C value approaches 1.00 the surface becomes less pervious, conversely, as the values approaches 0.00, the area becomes more pervious. A composite C value was employed for areas containing different drainage surfaces in order to obtain a more realistic value for Q.

TABLE 11-1 FACILITY DRAINAGE CHARACTERISTICS

FACILITY SITE	MILEPOST	Q (cfs)			DRAINAGE BY RESOURCE	POTENTIAL MITIGATION
		10 yr	25 yr	100 yr		
Branford SS	79.26	4.27	4.87	5.81	None	None, unless runoff potentially affects highway, then tie subsurface drainage to highway system
Leetes Island PS	85.99	0.16	0.18	N.A.	Floodplain	Move site upslope, floodproof equipment, relocated outside of 100 year floodplain, elevate equipment
Madison PS	92.41	0.16	0.18	0.22	None	
Grove Beach PS	99.11	0.16	0.18	0.22	None	
Westbrook SwS	103.53	0.43	0.49	0.58	None	
Old Lyme PS	109.50	0.16	0.18	0.22	None	
Millstone PS	117.56	0.16	0.18	0.22	None	
New London SS	123.55	1.33	1.51	N.A.	Floodplain	Move site upslope, floodproof equipment, relocate outside of 100 year floodplain, elev[illegible] equipment
Noank PS	129.46	0.16	0.18	N.A.	Floodplain	Move site upslope, floodproof equipment, relocate outside of 100 year floodplain, elevate equipment
Stonington PS	134.65	0.16	0.18	N.A.	Floodplain	Move site upslope, floodproof equipment, relocate outside of 100 year floodplain, elevate equipment
State Line PS	139.93	0.16	0.18	0.22	Sole Source Aquifer	Not expected to be significant because of small size of site; no mitigation necessary
Bradford PS	145.19	0.16	0.18	0.22	Sole Source Aquifer	Not expected to be significant because of small size of site; no mitigation necessary
Richmond SwS	150.35	0.43	0.49	N.A.	Floodplain, Water Resources	Maximize distance from Pawcatuck River, floodproof equipment, elevate equipment, relocate outside 100 year floodplain
Kingston PS	157.11	0.16	0.18	0.22	Sole Source Aquifer	Direct runoff away from wetland
Exeter PS	161.78	0.16	0.18	0.22	Sole Source Aquifer	Maximize distance to adjacent ponds, direct runoff away from ponds
East Greenwich PS	169.80	0.16	0.18	0.22	Sole Source Aquifer	Maximize distance to adjacent wells, direct runoff away from existing well area

TABLE 11-1 FACILITY DRAINAGE CHARACTERISTICS (continued)

FACILITY SITE	MILEPOST	Q (cfs)			DRAINAGE BY RESOURCE	POTENTIAL MITIGATION
		10 yr	25 yr	100 yr		
East Greenwich PS	169.80	0.16	0.18	0.22	Sole Source Aquifer	Maximize distance to adjacent wells, direct runoff away from existing well area
Warwick SS	176.91	2.46	2.81	3.35	No resource but urban environment	Install subsurface drainage system in order to adequately handle runoff
Elmwood PS	181.70	0.16	0.18	0.22	None	
Providence PS	187.55	0.16	0.18	0.22	None	
Attleboro PS	193.40	0.16	0.18	0.22	None	
Norton SwS	198.99	0.31	0.36	0.44	Water Resource	
East Foxboro PS	205.70	0.16	0.18	0.22	None	
Canton PS	212.40	0.16	0.18	0.22	None	
Readville PS	219.10	0.16	0.18	0.22	None	
Roxbury Crossing SS	226.02	2.37	2.70	3.22	No resource, but urban environment	Drain proposed system to existing roadway drainage system

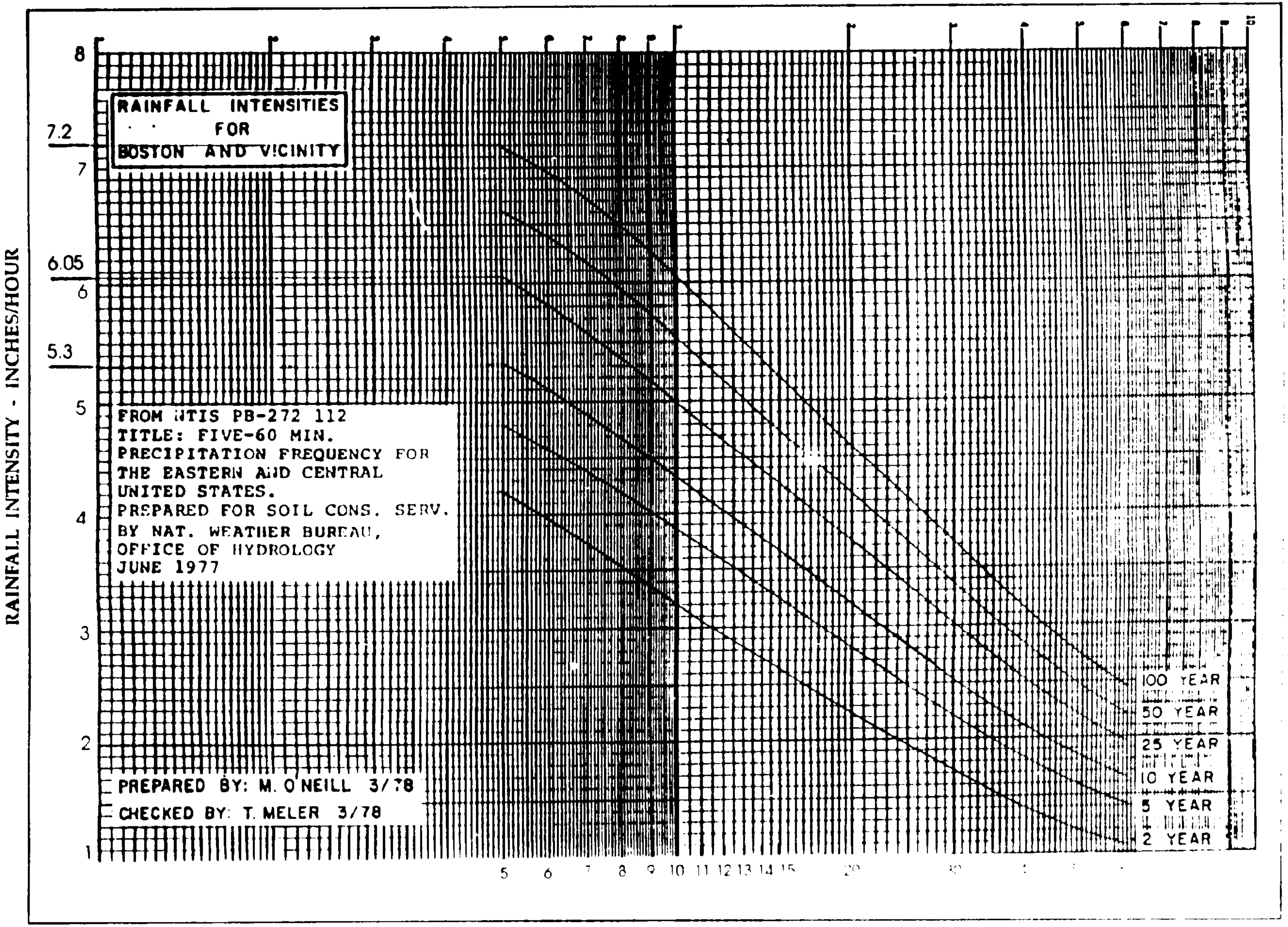


FIGURE 11-1. STORM EVENT INTENSITY CURVES

TABLE 11-2 COMMON RUNOFF COEFFICIENTS

TYPE OF DRAINAGE AREA	RUNOFF COEFFICIENT C
BUSINESS	
Downtown areas	0.70-0.95
Neighborhood areas	0.50-0.70
RESIDENTIAL	
Single-family areas	0.30-0.50
Multi-units, detached	0.40-0.60
Multi-units, attached	0.60-0.75
Suburban	0.25-0.40
Apartment dwelling areas	0.50-0.70
INDUSTRIAL	
Light areas	0.50-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad-yard areas	0.20-0.40
Unimproved areas	0.10-0.30
STREETS	
Asphaltic	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.95
LAWNS	
Sandy Soil, flat, 2%	0.05-0.10
Sandy soil, avg, 2-7%	0.10-0.15
Sandy soil, steep, 7%	0.15-0.20
Heavy soil, flat, 2%	0.13-0.17
Heavy Soil, avg, 2-7%	0.18-0.22
Heavy soil, steep, 7%	0.25-0.35

Source: Standard Handbook for Civil Engineers

11.3.9.2 Mitigative Measures for Drainage

The majority of proposed facility sites are less than quarter of an acre in size and for this reason, the anticipated run-off quantities and associated impacts are expected to be minor. For those sites located in areas within the 100 year flood plain or a sole source aquifer, thereby run-off quantities may have adverse effects, special corrective measures should be taken as noted in Table 11-1.

11.4 EVALUATION OF NATURAL RESOURCES AT THE PROJECT SITES

This section includes a description of existing natural resource conditions at each project site, anticipated impacts to those resources from the proposed project and recommended mitigation measures. The natural resources discussed include wetlands, critical wildlife habitat, endangered species, floodplains, coastal resources and water quality. The discussion of the resources in the vicinity of the electrical facilities and the bridges only includes those municipalities in which such facilities are located and is organized by municipality from west to east in Section 11.4.1 (Branford, CT) through 11.4.25 (Boston, MA). Under Amtrak's proposal, no substations and utility corridors, switching stations, or parallelling stations would be sited and no bridges would be raised in the following communities: New Haven, East Haven, Clinton, East Lyme and the City of Groton, CT; East Greenwich and Central Falls, RI; and Mansfield, Canton, Westwood and Dedham, MA. Because the moveable bridges, all located in Connecticut, generally lie between municipalities, the discussion of the resources in the vicinity of these project sites can be found in section 11.4.26.

Summaries of the resources present at each of the project sites can be found in Tables 4 through 8 in Appendix A for the substations, switching stations, paralleling stations, bridges to be raised and moveable bridges, respectively. Summaries of the impacts to those resources present at each project site can be found in Tables 6 through 10 in Appendix A.

11.4.1 Branford, CT

11.4.1.1 Branford Substation and Utility Corridor.

Wetlands. There are no wetlands associated with the Branford substation site or the 100-foot area around it. The utility corridor associated with the aerial feeder line to the north does not impact any wetlands. The proposed underground feeder line from the substation to the rail line on the south side of I-95 ends adjacent to a series of small drainage areas which lie between the railroad bed and the highway. Proper erosion and sedimentation control measures and stormwater management practices should be utilized to avoid impacts to these areas.

Wildlife. Site characteristics of the substation location include a paved road and mowed grass site with interspersed planted shrubs such as autumn olive (*Elaeagnus umbellata*), black cherry (*Prunus serotina*), and black oak (*Quercus velutina*). A five foot chain link fence currently restricts access to portions of the site. The New Haven County Soil Survey describes site soils as Urban Land. Due to the lack of access and the adjacent highway, this site would be limited to small game such as groundhog (*Marmota monax*) which could utilize grass species and burrowing opportunities. Songbirds would also utilize the site and available shrub species.

The utility corridor for the aerial feeder to the north is located within a forested area with a dense layer of shrubs and vines including species such as multiflora rose (*Rosa multiflora*), American bittersweet (*Celastrus scandens*), greenbriar (*Smilax spp.*) and Japanese honeysuckle (*Lonicera japonica*). The dense shrub/vine layer, as well as varied adjacent habitats, would provide wildlife habitat for a number of species of wildlife, including gray squirrel (*Sciurus carolinensis*), great-crested flycatcher (*Myiarchus crinitus*), and other songbirds.

Wildlife impacts associated with the Branford substation and utility corridor could be expected to be primarily short-term impacts including direct mortality to fossorial animals and the loss of nesting sites for songbirds. Long-term impacts would be expected to be limited since similar habitats are available to the north and west.

The mitigation effort at the Branford Substation should include transplantings or new plantings to replace lost shrub species on the highway side of the site. Recommended plants include shrub species valuable to wildlife such as russian olive (*Elaeagnus angustifolia*), American cranberry bush (*Viburnum trilobum*), or tartarian honeysuckle (Lonicera tartarice). The new utility corridor would be expected to provide ample shrub species for nesting opportunities.

Endangered Species. The Connecticut Natural Diversity Database Search indicated no Federal or State Endangered, Threatened or Special Concern Species.

Floodplains. The substation site and proposed feeder lines do not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Branford, Connecticut, Community Panel 090073-0001D. No 100-year flood zones occur north of the rail line, on the west side of Hosley Avenue.

Coastal Resources. The Connecticut Coastal Resources map (Branford Quadrangle, 1979) indicate the proposed substation site and utility corridors are outside of the Coastal Boundary.

Water Resources. There are several private water supply wells in the area around this substation site. According to the East Shore District Health Department file of applications for water wells in Branford, there are 3 private wells on the north side of the substation; two houses along Hosley Road have existing wells and a new house northeast of the substation has an existing well in proximity to the utility corridor for the aerial feed to the north. No record of municipal wells exists in the area of the project according to the town Planning Department (personal communication, 1992).

Lake Saltonstall, a water supply reservoir, is located approximately 1700 feet to the west of the substation site and will not be affected by the project.

No direct impacts to any wells or water supplies would be expected as a result of the development of the substation site or utility corridor. Potential impacts to the private wells adjacent to the utility corridor could result from on-site storage or maintenance of construction vehicles. Off-site storage and maintenance of any vehicles would mitigate these affects.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.2 Guilford, CT

11.4.2.1 Leetes Island Paralleling Station.

Wetlands. No wetlands occur on the site of the proposed Leetes Island paralleling station, although three wetlands under tidal influence occur within 100 feet of the site. Field investigation indicates a small wetland within 50 feet of the site. This wetland is located on the west side of the site and appears to be a pocket of freshwater marsh; however the Connecticut Department of Environmental Protection (Conn DEP) Tidal Wetlands Map #35-1-2 indicates a connection to the tidal marsh on the south side of the railroad tracks. The marsh to the north is situated on the opposite side of Stony Creek Road (Route 146).
No direct impacts to wetlands or degradation of adjacent wetland characteristics or functions are expected.
Proper erosion and sedimentation control measures and stormwater management practices should be utilized to minimize impacts to adjacent wetlands, including slope stabilization.

Wildlife. Characteristics of the paralleling station site include an overstory of black cherry and red cedar (*Juniperus virginiana*). The understory includes shrub species such as multiflora rose, smooth sumac (*Rhus glabra*), and bayberry (*Myrica pensylvanica*). An existing dirt road goes through the center of the site. The adjacent Stony Creek Road and a steep railroad embankment on the south side limit the amount of habitat available. The New Haven County Soil Survey identifies the site soils as Cheshire-Holyoke complex, well drained upland soils.

Wildlife impacts associated with the Leetes Island paralleling station would be primarily the loss of feeding and nesting sites for songbirds. The majority of the site is situated on an old gravel access road limiting its suitability for fossorial species. Although the surrounding marsh and upland edge would provide wildlife habitat values, the paralleling station site is too small and isolated to provide adverse values.

Mitigation of any potential wildlife impacts would best be compensated for by incorporating wildlife plantings in the landscaping undertake at the site. Species could include red cedar and bayberry.

Endangered Species. The Connecticut Natural Diversity Database search indicated no Federal or State Endangered, Threatened or Special Concern Species.

Floodplains. The proposed Leetes Island paralleling station is located within the 100-year floodplain. The area is noted as Zone A6, which has a base flood elevation determined to be

12 feet, according to the FEMA Flood Insurance Rate Map for Guilford, Connecticut, Community Panel 090077-0016B.

The most recent site plans indicate the existing elevation of the paralleling station ranges from approximately 6 feet to 14 feet. The base flood elevation has been determined to be at 12 feet, according to the FEMA/FIRM map indicating an impact to the 100-year floodplain would be expected. The potential for impacts to the floodplain will require following the eight step process outlined in Executive Order 11988. Site specific steps which can be taken to address the impact include minimization of slopes and the project footprint as well as shifting the site upslope to the maximum extent practicable. Additional steps required under Executive Order 11988 include evaluation of alternatives to locating in the floodplain, providing public review, and restoration of any natural and beneficial floodplain values.

Coastal Resources. The Connecticut Coastal Resources Map (Guilford Quadrangle, 1979) indicates the proposed paralleling station site lies within the Coastal Boundary. The site is in a Coastal Flood Hazard Area, within the 100-year floodplain identified in the FEMA maps.

As noted in the floodplains sections, impacts to the coastal flood hazard area or 100-year floodplain would be expected. Mitigation measures are noted in that section, above.

Water Resources. The Planning Office in Guilford indicated there are no municipal wells in the area of the paralleling station site, and there are no groundwater protection districts associated with the site (personal communication, 1993)..

Surface waters associated with the site include three wetlands under tidal influence within 100 feet of the site described in the wetlands section.

Summary of Impacts. No adverse impacts are anticipated to wetlands, wildlife, endangered species, or water resources. Adverse impacts are expected to occur to floodplains and coastal resources.

11.4.3 Madison, CT

11.4.3.1 Madison Paralleling Station.

Wetlands. There are no wetlands occurring on the site of the proposed Madison paralleling station. A large forested wetland occurs to the north of the site, approaching to within 25 feet of the site on the northwest side. No direct impacts to wetlands or degradation of adjacent wetland characteristics are expected. Mitigation effort should focus on utilizing proper erosion and sedimentation control measures to minimize impacts to adjacent wetlands.

Wildlife. Site characteristics of the switching station location include a hardwood forested community with an overstory that includes: big-toothed aspen (*Populus grandidentata*), black cherry and red maple (*Acer rubrum*). The dense understory consists of vines including bittersweet, greenbriar, and Japanese honeysuckle. Adjacent habitat includes an old house site which is now overgrown. The New Haven County Soil Su.vey describes the site soils as well-drained Hinckley gravelly sandy loam. Overall, the site does provide wildlife habitat due to the presence of the adjacent wetland and the limited access; however, the limited diversity and shrub layer would probably restrict use of the area to birds, such as hairy woodpeckers (*Picoides villosus*), and gray squirrels.

With similar habitats located adjacent to the site, long-term impacts to surrounding wildlife habitat values would be limited. The mitigation effort at the Madison paralleling station should include transplantings to replace lost shrub species. Recommended plants include russian olive and tartarian honeysuckle for wildlife food, cover and nesting opportunities. Cover would be improved with plantings of evergreen species such as white pine (*Pinus strobus*).

Endangered Species. The Connecticut Natural Diversity Database Search indicated no Federal or State Endangered, Threatened or Special Concern Species.

Floodplains. The switching station site does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Madison, Connecticut, Community Panel 090079-0011C.

Coastal Resources. The Connecticut Coastal Resources Map (Clinton Quadrangle, 1979) indicates the proposed switching station site is outside the Coastal Boundary.

Water Resources. No record of municipal wells exists in the area of the proposed switching station, according to the town water resources map and Planning Department (personal communications, 1993). No water resource protection area is associated with the site.

A small stream is located approximately 125 feet north of the switching station site, with palustrine forested wetlands within approximately 25 feet. The mitigation effort at the Madison paralleling station should focus on minimizing slopes and utilizing proper erosion and sedimentation control measures and stormwater management practices to minimize impacts to the stream.

Summary of Impacts. No impacts are anticipated to any of the resource categories.

11.4.4 Westbrook, CT

11.4.4.1 Grove Beach Paralleling Station.

Wetlands. No wetlands occur on the site of the proposed Grove Beach paralleling station, although the site is within 50 feet of freshwater wetlands. A palustrine scrub-shrub swamp occurs within 20 feet of the site on the south side, while a forested wetland occurs across the tracks approximately 50 feet to the north. No direct impacts to the adjacent wetland are expected. The close proximity of the scrub-shrub swamp on the south side indicates potential for water quality impacts through erosion and sedimentation.

The mitigation effort at the Grove Beach paralleling station site should focus on utilizing proper erosion and sedimentation control measures as well as stormwater management practices.

Wildlife. Characteristics of the proposed paralleling station site include a sparse overstory and understory. The site is currently used as a storage area for an adjacent trailer park and contains piles of wood chips, rock, and dirt. Vegetation includes species such as goldenrod (*Solidago spp.*), little bluestem (*Schizachyrium scoparium*), and ragweed (*Ambrosia artemisiifolia*). Soils on the site consist of a gravel-based fill material.

Due to the limited cover and vegetative diversity of the paralleling station site, the area has very limited wildlife habitat value. The adjacent wetland contains numerous highbush blueberry (*Vaccinium corymbosum*) shrubs and evidence of extensive use by raccoon (*Procyon lotor*) and songbirds such as black-capped chickadees (*Parus atricapillus*) and mockingbirds (*Mimus polyglottus*). Despite the presence of numerous wildlife species in the vicinity, all wildlife activity was focused in the wetlands with the actual paralleling station site providing mainly a wildlife corridor to the surrounding habitats.

With the adjacent wetlands providing the wildlife values of the surrounding area and the site itself containing limited cover and a fill substrate, the proposed paralleling station would not be expected to impact wildlife habitat values in the area.

Endangered Species. The Connecticut Natural Diversity Database search indicated no Federal or State Endangered, Threatened or Special Concern Species.

Floodplains. The proposed site of the Grove Beach paralleling station does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Westbrook, Connecticut, Community Panel 090070-0005D.

Coastal Resources. The Connecticut Coastal Resources Map (Essex Quadrangle, 1979) indicates the proposed paralleling station site lies within the Coastal Boundary. The site is listed as Shorelands (an upland area). The adjacent wetlands are listed as Freshwater Wetlands. No direct impacts to the adjacent wetlands are expected. All potential adverse impacts to coastal resources will be minimized as defined in C.G.S. section 22a-93(15).

Water Resources. The town planner of Westbrook indicated there were no municipal wells in the vicinity of the paralleling station site. The adjacent trailer park is supplied by the regional water company. There is no water protection district located in the vicinity of the paralleling station site (personal communication, 1993).

Surface waters associated with the Grove Beach site include a scrub-shrub wetland approximately 20 feet to the south and a forested wetland approximately 50 feet to the north, across the tracks; these are addressed in the wetlands section.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.5 Old Saybrook, CT

11.4.5.1 Westbrook Switching Station.

Wetlands. There are no wetlands on the proposed site of the Westbrook switching station site in Old Saybrook. Wetlands in the vicinity are limited to a large forested wetland on the west side of school street. Drainage areas not considered to be wetlands occur to the west and across the tracks to the north. No direct impacts to wetlands or degradation of adjacent wetland characteristics are expected. Since direct wetland impacts have been avoided, the mitigation effort should focus on utilizing proper erosion and sedimentation control measures.

Wildlife. Characteristics of the proposed switching station area includes a large industrial warehouse/office complex immediately adjacent to the south and scattered housing to the north. The switching site is currently dominated by a mowed lawn, other vegetation includes red cedar and evening primrose (*Penothera biennis*). The Middlesex County Soil Survey indicates the site is Paxton and Montauk fine sandy loams. The proposed site of the switching station is located in an area of mixed development with varied vegetation off-site including apple (*Malus spp.*) trees. The surrounding wetlands and diverse habitats in the area add to the diversity of wildlife habitat values, however the limited cover associated with the switching station site restrict wildlife habitat values. Any wildlife values associated with the proposed Westbrook switching station site are more closely associated with the diverse surroundings. The lack of cover and industrial land use adjacent limit wildlife values at the site.

Endangered Species. The Connecticut Natural Diversity Database search indicated no Federal or State Endangered, Threatened or Special Concern Species.

Floodplains. The proposed site of the Westbrook switching station site in Old Saybrook does not impact any floodplains; according to the FEMA Flood Insurance Rate Map for Old Saybrook, Connecticut, Community Panel 090069-0004D.

Coastal Resources. The Connecticut Coastal Resources Map (Essex Quadrangle, 1979) indicates the proposed switching station site is outside the Coastal Boundary.

Water Resources. The Health Department for the Town of Old Saybrook indicated no municipal wells exist in the area of the project. No groundwater protection districts are located in the vicinity of the switching station site. A non-operating industrial processing well is located within 40 feet of the site. The facilities manager for the R.R. Donelley & Sons Co. indicated the well had not been used for a number of years (personal communication, 1993).

Surface waters associated with the Westbrook switching station site include a large forested wetland on the west side of School House Road. No wetlands are expected to be filled or dredged for the proposed switching station. Direct impacts to water resources are not expected at this site. No wetlands are expected to be impacted and the adjacent water well is assumed not to be in operation. Mitigation measures are as described above for wetlands.

Summary of Impacts. No impacts are anticipated to any of the resource categories.

11.4.6 Old Lyme, CT

11.4.6.1 Old Lyme Paralleling Station.

Wetlands. No wetlands occur on the site of the proposed Old Lyme paralleling station. A palustrine forested/scrub-shrub wetland occurs approximately 75 feet to the north across the railroad tracks. An isolated palustrine forested wetland occurs to the southeast, approximately 75 feet from the site. This wetland is dominated by red maple and highbush blueberry; no inlet or outlet was noted. A small pond is located over 100 feet to the south.

This site's soils are identified on the town wetland maps as being poorly drained, and the Connecticut Coastal Soil Maps indicate the area included very poorly drained Adrian and Palm Muck soils and well drained Enfield silt loam soils, which would be considered wetlands in Connecticut. Site investigation indicates the actual paralleling station site is located on an area of fill which may be associated with an old road. Because the site is designated as poorly drained soil, Amtrak will have to request a change in designation which would require that a petition be filed with the state. The petition would require supporting documentation and must be prepared by a qualified soil scientist. Based on the reclassification of the site as non-wetland, no direct impacts to wetlands or degradation of adjacent wetland characteristics are expected.

To avoid impacts to adjacent wetlands proper erosion and sedimentation control measures and stormwater management practices should be used.

Wildlife. The site characteristics of the proposed paralleling station includes scattered residential dwellings. The overstory of the site is predominately open, with hardwoods consisting primarily of big-toothed aspen and white oak (*Quercus alba*). The understory consists of disturbed field species such as goldenrod, little bluestem, and mullein (*Verbascum thapsus*) with patches of hair-cap moss (*Polytrichum commune*). The shrub layer includes gray birch (*Betula populifolia*), white pine, and black and white oak. Although the New London County Soil Survey indicates the site is Scarboro mucky fine sandy loam, site conditions would indicate this soil type is more likely to occur across the tracks since the site is primarily a sandy gravel.

The proposed site of the paralleling station is located at the edge of a forested community with a large scrub-shrub wetland across the tracks and an isolated wetland southeast of the site which may provide vernal pool habitat. The variety of habitats in the vicinity, as well as the vegetative diversity of the surroundings, would provide wildlife habitat values. The presence of recent deer browse on shrubs in the area is evidence of wildlife use.

Impacts to wildlife habitat would primarily be associated with impacts to the adjacent wetlands. Direct impacts to fossorial species would be expected. The presence of similar habitats in adjacent areas should limit the long-term impacts to small game and/or the deer currently making use of the site.

The mitigation effort at the Old Lyme site should focus on maximizing the distance to any wetlands as well as minimizing slopes associated with site development. Plantings of shrub species should be incorporated in any landscaping of the site and could include species as tartarian honeysuckle and highbush blueberry.
Endangered Species. The Connecticut Natural Diversity Database search indicated no Federal or State Endangered, Threatened, or Special Concern Species.

Floodplains. The proposed site of the Old Lyme paralleling station does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Old Lyme, Connecticut, Community Panel 090103-0016D.

Coastal Resources. The Connecticut Coastal Resources Map (Old Lyme Quadrangle, 1979) indicates the proposed paralleling station site lies within the Coastal Boundary. The site is listed as Freshwater Wetlands, which includes any soil mapped as "poorly drained, very poorly drained, alluvial and floodplain" (Inland Wetlands and Watercourses Act). Field investigation indicates the site is actually a fill area, possibly from an old road-bed.

Once the site has been reclassified as an upland as described in the wetland section, it is assumed the site location would be considered Shorelands or upland within the Coastal Boundary. As such, development of this site would be expected to be consistent with the policies set forth in C.G.S. Section 22a-92.

Water Resources. According to the City Engineer's office, no municipal wells are located in the area of the proposed paralleling station. Small private water companies supply the coastal villages, however no wells are located in the vicinity of the site (personal communication, 1993).

Surface waters associated with the Old Lyme paralleling station site include a palustrine forested/scrub-shrub wetland approximately 75 feet across the tracks. Other wetlands include an isolated forested wetland on the southeast side, approximately 75 feet from the site. These are addressed in the wetlands section.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.6.2 Johnnycake Hill Road Bridge.
Wetlands. There are no wetlands associated with the Johnnycake Hill Road bridge or the 100-foot area around it the bridge site.

Wildlife. Site characteristics include a hardwood overstory dominated by tree-of-heaven (*Alianthus altissima*), with a dense layer of bittersweet vines. One hundred feet north of the site is Old Lyme Country Club. Due to the presence of the golf course, the forested nature of the area around the bridge adds diversity and edge habitat. Reconstruction of the bridge should have little impact on habitat values in the area, since the area of disturbance will be limited and adjacent values will remain.

__Endangered Species__. The Connecticut Natural Diversity Database Search indicated no Federal or State Endangered, Threatened or Special Concern Species.

__Floodplains__. The bridge site is not located in any floodplain, as noted on the FEMA Flood Insurance Rate Map, Con .nunity Panel 0901303-0016D.

__Coastal Resources__. The Connecticut Coastal Resources map (Old Lyme Quadrangle, 1979) indicates the Johnnycake Hill Road bridge is located outside the Coastal Boundary.

__Water Resources__. No municipal wells or water protection districts are associated with the bridge site, according to the City Engineer's Office (personal communication, 1993). There are no surface waters associated with the site areas. No impact to water resources would be expected to occur due to the bridge reconstruction.

__Summary of Impacts__. No impacts are anticipated to any of the resource categories.

11.4.7 Waterford, CT

11.4.7.1 Millstone Paralleling Station.

__Wetlands__. There are no wetlands occurring on the site of the proposed Millstone paralleling station. A narrow drainage channel does occur across the railroad tracks within 50 feet of the site, eventually emptying into a tidal marsh approximately 500 feet away. No direct impacts to wetlands or degradation of adjacent wetland characteristics are expected.

__Wildlife__. Situated within a managed vegetative community associated with powerlines, site characteristics of the paralleling station location include an open field/shrub community with no overstory species. The Millstone Station power lines are directly overhead. Vegetation is dominated by American bittersweet, multiflora rose, and hawthorne (*Crataegus spp.*). Herbaceous species include goldenrod and little bluestem. Adjacent habitats include mixed hardwood forest and estuarine marsh. The New London County Soil Survey describes the site soils as Chatfield-Hollis fine sandy loam.

As part of a vegetative community which provides forest openings as well as edge habitat, the paralleling station site would provide wildlife habitat values to many species, especially songbirds which can utilize the shrubs (such as mockingbirds, rodents, and aerial predators such as the red-tailed hawk, (*Buteo jamaicensis*)). Overall, however, the proposed paralleling station would have little impact on the availability of this type of habitat, with the powerline corridor and similar habitat types continuing to the north.

With limited wildlife impacts expected, the mitigation effort will focus on incorporating wildlife plantings in any landscaping effort. The existing open field habitat can be enhanced with the addition of shrub species such as tartarian honeysuckle, and russian olive, as well as evergreen species to provide cover.

Endangered Species. The Connecticut Natural Diversity Database Search indicated no Federal or State Endangered, Threatened or Special Concern Species.

Floodplains. The Millstone paralleling station site does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Waterford, Connecticut, Community Panel 090107-0015E.

Coastal Resources. The Connecticut Coastal Resources Map (Niantic Quadrangle, 1979) indicates the proposed switching station site would be considered Shorelands within the Coastal Boundary. As such, this site would be subject to provisions of the Connecticut Coastal Management Act.

As Shorelands, which are described as upland communities not subject to dynamic coastal processes, the development of this site would be expected to be consistent with the policies set forth in C.G.S. section sa-92.

Water Resources. The Town Planning Department indicates no municipal wells are located in the vicinity of the proposed paralleling station site. Although a stratified drift aquifer is situated to the east of the site, no groundwater protection districts or formal restrictions are in place. The Millstone Station power plant has water wells in the "general area" of the proposed site; however, these wells are industrial process wells and not drinking water wells according to Don Diondi of Northeast Utilities (personal communication, 1993).

Surface waters associated with the site include a narrow drainage ditch on the north side of the tracks, as described in the wetlands section.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.7.1 Millstone Point Road Bridge.

Wetlands. No wetlands occur immediately adjacent to the bridge, although two drainage ditches do occur approximately 50 feet to the south of the bridge. Another drainage ditch is located on the north side of the bridge. Since the existing road cross-section will be maintained, no direct impacts to wetlands or degradation of adjacent wetland characteristics are expected. The mitigation effort should focus on avoiding any drainage ditches or adjacent wetlands.

Wildlife. Site characteristics include a hardwood overstory with patches of dense bittersweet and red cedar. There is only limited residential development around the site, however the limited vegetative diversity and limited interspersion of habitats restrict wildlife habitat values. Since the existing road cross-section will be maintained and the area of disturbance will be minimal, the reconstruction of the bridge would not be expected to impact, degrade or destroy essential wildlife habitat.

Endangered Species. The Connecticut Natural Diversity Database Search indicated no Federal or State Endangered, Threatened, or Special Concern Species.

Floodplains. The bridge site is not located in any floodplain, as noted on the FEMA Flood Insurance Rate map for Waterford, Connecticut, Community Panel 090107-0005D.

Coastal Resources. The Connecticut Coastal Resources map (Niantic Quadrangle, 1979) indicates the Millstone Point bridge is located inside the Coastal Boundary. The site is identified as Shorelands, an upland area. As an upgrade of an existing facility, reconstruction of the Millstone Point Road bridge would be consistent with all policies set forth in C.G.S. section 22a-92.

Water Quality. No municipal wells or water protection districts are associated with the bridge site, according to the Town Planning Department (personal communication, 1993).

Surface waters associated with the bridge site include a large palustrine forested wetland on the east side of Millstone Point Road, north of the bridge as described in the wetlands section.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.8 New London, CT

11.4.8.1 New London Substation and Utility Corridor.

Wetlands. No wetlands occur on the site of the proposed substation in New London or the aerial and underground feeder line to the existing Connecticut Light and Power substation at Williams Street, approximately 4700 feet to the northwest. The proposed route of the utility corridor to Williams Street continues along the Central Vermont rail line for approximately 2300 feet. This route parallels the Thames River and approaches to within 100 feet of the river at several points. The underground feeder line continues across Riverside Park to McGrath Street and Crystal Avenue to connect with the Williams Street substation to the southwest. No wetlands are associated with this portion of the site. No direct wetland impacts are associated with the substation or the feeder line to the northwest. The underground feeder line does not directly impact the Thames River and remains isolated from it by the Central Vermont rail line.

Wildlife. Site characteristics of the substation location included a limited amount of vegetative cover, since the area is located within an active rail yard. Vegetation is limited to scattered grasses, which would provide limited cover or food for wildlife. Soils on the site are described in the SCS Soil Survey for New London County as Urban Land. Other factors influencing habitat values are the presence of two active rail lines immediately adjacent and the Interstate 95 bridges across the Thames River, which dominate the aerial landscape. Due to the highly developed nature of the site and the high level of activity around it, the substation site would provide very limited, if any wildlife values. The utility corridor connecting the site to the Williams Street substation will be buried underground along the majority of its route.

Neither the New London substation site nor the utility corridor north to Adelaide Avenue would impact directly wildlife habitats due to the open and highly developed nature of the area. The utility corridor through Riverside Park to Williams Street crosses hardwood forested/parkland habitats and residential areas, however the power line will be buried underground and would not be expected to disturb existing vegetation or communities. The mitigation effort should provide for replanting any lost vegetation, especially in the Riverside Park area.

Endangered Species. The Connecticut Natural Diversity Database Search indicated no Federal or State Endangered, Threatened or Special Concern Species are associated with the substation site.

Floodplains. The proposed site of the New London substation is located within the 100-year floodplain, according to the FEMA Flood Insurance Rate Map for New London, Connecticut, Community Panel 090100-0001C. The rail yard represents the upper limit of the floodplain. The utility corridor is located within a 500-year floodplain up to Adelaide Avenue, at which point it leaves any floodplain. Site location and available topographic plans would indicate the substation site is at least partially located in the 100-year floodplain. The base flood elevation in this vicinity has been determined to be 10 feet. The elevations noted on site plans range from approximately 7 feet to over 10 feet. Beyond the substation location, the utility corridor will not impact 100-year floodplain. The potential for impacts to the floodplain will require following the eight step process outlined in Executive Order 11988. Site specific steps which can be taken include minimization of the project footprint and any associated slopes, as well as shifting the site to the highest elevation practicable. Compensation for any lost floodplain values will likely be required, especially loss of storage.

Coastal Resources. The Connecticut Coastal Resources Map (New London Quadrangle 1979) indicates the proposed substation site lies within the Coastal Boundary. The area is listed as a Developed Shorefront, which describes areas which have been highly developed to the point of functional impairment or substantial alteration of their natural features. The portion of the utility corridor located in Riverside Park is considered to be Shorelands, an upland area.

As noted in the floodplain section, impacts to the coastal flood hazard area or 100-year flood plain would be expected. All potential adverse impacts to coastal flood hazard areas or other coastal resources will be minimized as defined in C.G.S. section 22a-93(15). Degradation of coastal resources along the utility corridor as well as the coastal resources associated with the Shorelands portion of the site would not be expected to be impacted by the temporary disturbance associated with construction activities.

The mitigation effort at the site are described above for floodplains.

Water Resources. The City Engineer's office indicated there was no record of municipal or private water wells in the vicinity of the substation site (personal communication, 1993). No wells were noted in the field Surface waters associated with the substation site are restricted to the Thames River, approximately 400 feet to the northeast of the substation site and adjacent to the utility corridor.
Mitigation of water quality impacts should focus on maximizing the distance to the river and utilizing proper erosion and sedimentation control measures and stormwater management practices.

Summary of Impacts. No adverse impacts are anticipated to wetlands, wildlife, endangered species, or water resources. Adverse impacts are expected to occur to floodplains.

11.4.9 Town of Groton, CT

11.4.9.1 Noank Paralleling Station.
Wetlands. No wetlands occur on the site of the proposed Noank paralleling station. A narrow, steep-sided stream flows between the proposed site and the railroad tracks to the north. This stream connects with Palmer Cove to the west and a tidal marsh on the east side of Long Point Road. The channel, which is under tidal influence, also picks up road drainage from a culvert on the south end. The proposed paralleling station site lies within approximately 25 feet of the stream cited above on the east side. No direct impacts to wetlands or degradation of adjacent wetland characteristics are expected since the channel is isolated from the paralleling station by a berm. Due to the proximity of the adjacent stream, the mitigation effort should focus on utilizing proper erosion and sedimentation control measures and stormwater management practices.

Wildlife. Site characteristics for the proposed Noank paralleling station include a large paved parking lot and a steep banked stream channel under tidal influence with a narrow band of scrub-shrub habitat between the parking lot and railroad to the north. Vegetation along this zone includes an overstory of black cherry with a dense understory of bittersweet, multiflora rose, and staghorn sumac (*Rhus typhina*). The New London County Soil Survey indicates the site contains Udorthents-Urban Land Complex, well drained to excessively well drained soils in a disturbed setting.

Located in a developed area adjacent to Palmer Cove, the surrounding site provides wildlife habitat values in the form of vegetative diversity, as well as food and cover opportunities. The species most likely to utilize the available habitat would be songbirds such as black-capped chickadee, mockingbird and blue jays (*Cyanocitta cristata*). Direct impact associated with the paralleling station would be limited due to its location in a paved parking lot. Construction of the proposed paralleling station would not be expected to impact the wildlife values in the area.

Endangered Species. The Connecticut Natural Diversity Database search indicated no Federal or State Endangered, Threatened, or Special Concern Species.

Floodplains. The proposed site of the Noank paralleling station is located within the 100-year floodplain. The area is noted as Zone A 7, which has a base flood elevation determined to be 10 feet, according to the FEMA Flood Insurance Rate Map for Groton, Connecticut Panel 090129-0002B.

Site location and available topographical plans seem to confirm that the paralleling station site is located in the 100-year floodplain. The elevations noted on site plans range from approximately 8 feet to 9 feet, while the FEMA/FIRM map indicates the base flood elevation for the area is at 10 feet.

The potential impacts to the floodplain will require following the eight step process outlined in Executive Order 11988. Site specific steps which can be taken include minimization of the project footprint and any associated slopes. If the structure remains in this parking lot it will require floodproofing and elevating the structure as well as providing compensatory storage to mitigate for any expected losses.

Coastal Resources. The Connecticut Coastal Resources Map (New London, 1979) indicates the proposed paralleling station site lies within the Coastal Boundary. The site is listed as a Coastal Flood Hazard Area within the 100-year floodplain identified in the FEMA maps noted above, and impacts and mitigation measures are discussed in the previous section.

Water Resources. The Planning Department in Groton indicates no municipal water wells or water protection districts are associated with the proposed paralleling station site.

Surface waters associated with this site include a narrow channel which connects Palmer Cove approximately 500 feet to the west with a tidal wetland across Long Point Road as described in the wetlands section, along with mitigation measures.

Summary of Impacts. No adverse impacts are anticipated to wetlands, wildlife, endangered species, or water resources. Adverse impacts are expected to occur to floodplains and coastal resources.

11.4.10 Stonington, CT

11.4.10.1 Stonington Paralleling Station.

Wetlands. There are no wetlands occurring on the site of the proposed Stonington paralleling station site. Wetlands to the north and east are located over 100 feet from the site. No direct impacts to wetlands or degradation of adjacent wetland characteristics are expected.

Wildlife. Site characteristics of the paralleling station location include a predominately open area with a large ledge outcropping and a dense growth of greenbriar dominating the western half of the site. Additional vegetation noted included sweet pepperbush (*Clethra alnifolia*) and little bluestem. The surrounding habitat is primarily oak-hardwood forest, with marsh and forested wetlands in the vicinity. The New London County Soil Survey describes the site soils as

Ninigret fine sandy loam, a moderately well drained soil. Located in an oak forest with a variety of habitats available in the surrounding area and development around the site limited, this site would be expected to provide wildlife habitat in the form of nesting and cover for small mammals and birds.

Impacts to wildlife habitat at the Stonington paralleling station site will include the loss of a small area of forested cover as well as shrub species. Since the area of the station has been identified as open, with trees and shrubs located to the south, north and west, the major impact to wildlife will be the loss of diversity in the surrounding area. The presence of ledge outcroppings would limit the value of the area to fossorial species and therefore limit any impacts to these species.

The mitigation effort at the Stonington site should focus on maximizing the distance to any wetlands, as well as minimizing the footprint of the site, limiting the extent on site disturbance. Once the site has been developed, plantings of shrub species should be incorporated in any landscaping effort and include species which would provide food, cover and nesting opportunities for birds and small mammals. Species should include red cedar, northern bayberry and tartarian honeysuckle. Erosion and sedimentation control measures would be necessary during and after development to assure impacts to adjacent wetland habitats are minimized.

Endangered Species. The Connecticut Natural Diversity Database Search indicated no known populations of Federal or State Endangered, Threatened or Special Concern species occur at the switching station site. Records indicate a state endangered species, the American bittern (*Botaurus lentiginosus*) has been recorded within close proximity of the project area. Coordination with the Natural Diversity Database and Connecticut Wildlife Division is requested to identify whether this species nests in the area.

Direct impacts to state endangered species are not expected to occur. Indirect impacts, however, may arise as a result of activity associated with the site including disturbance during the nesting season if bittern are found nearby.

Mitigation of potential impacts to state endangered species at the Stonington site will include coordination of a site review by Natural Diversity Database personnel and/or the Connecticut Valley Wildlife Division during the appropriate season. If the American bittern is found to occur close by or nest in the vicinity, steps will have to be taken to avoid disruption of their normal behavior and may include scheduling any construction activities to a period other than the breeding season. Other steps may be required by the state agencies.

Floodplains. The proposed Stonington paralleling station site is located within the 100-year Coastal Flood Zone. A base flood elevation of 14 feet is identified on the Flood Insurance Rate Maps for Stonington, Connecticut, Community Panel 090106-0018E.

Site location and available topographical plans confirm that the paralleling station is located in the 100-year floodplain. The elevations noted on site plans range from approximately 7 feet to 9 feet, while the FEMA/FIRM map indicates the base flood elevation for the area is at 10 feet.

The mitigation of potential impacts to the floodplain will require following the eight step process outlined in Executive Order 11988. Site specific steps which can be taken include minimization of the project footprint and any associated slopes. If the structure remains at this location it will require floodproofing and elevating the structure as well as providing compensatory storage to mitigate for any expected losses.

Coastal Resources. The Connecticut Coastal Resources Map (Mystic Quadrangle, 1979) indicates the proposed switching station site would be considered Shorelands within the Coastal Boundary and a portion is within the Coastal Flood Hazard Area.

As Shorelands within the Coastal Boundary, most of this site would be considered uplands not subject to dynamic coastal processes. The development of this site would be expected to be consistent with the policies set forth in C.G.S. section 22a-92. All potential adverse impacts on coastal resources defined in C.G.S. section 22a-93(15), such as degrading visual quality, wildlife habitat or water quality will be minimized. Impacts to the coastal flood hazard area would be expected as noted in the floodplain section above.

The mitigation effort at the site will include following through on floodplain mitigation and the eight-step process outlined in Executive Order 11988. Any unavoidable losses to the floodplain will require compensation. Other potential impacts to be minimized include degradation of visual qualities through screening and landscaping efforts. Degradation of adjacent wetlands by water quality impacts will be minimized through stabilization of any slopes and the utilization of proper erosion and sedimentation control measures.

Water Resources. According to the Town Planning Department (personal communication, 1993), no municipal wells are located in the vicinity of the proposed paralleling station site. Water is supplied by surface water reservoirs to the north. No groundwater or watershed protection district is associated with the site.

Surface waters associated with the site include tidal wetlands within 150 feet on the east side and a freshwater forested wetland located over 100 feet to the north across the tracks. No direct impacts to the water resources in the vicinity of the site are expected.

Summary of Impacts. No adverse impacts are anticipated to wetlands, wildlife, coastal resources, or water resources. Adverse impacts are expected to occur to endangered species and floodplains.

11.4.10.2 State Line Parallelling Station.

Wetlands. No wetlands occur on the site of the proposed State Line paralleling station in Stonington, CT. The site is, however, identified as a regulated wetland on the Town of

Stonington map referred to as Location Identification Aid for Inland Wetlands and Watercourses (1975). Available soils data provide conflicting information, identifying the area as hydric and non hydric soils.

The Coastal Soil Survey for the site area indicates the soils are Rumney fine sandy loams, a poorly drained soil generally associated with level floodplains. The New London County Soil Survey indicates the site is a Merrimac sandy loam on a 3 to 8% slope, which is described as a somewhat excessively drained outwash soil. The paralleling station site appears to be a sandy loam more closely resembling a Merrimac soil, especially since it is found on a slope rather than a level floodplain. Because the site is designated as poorly drained soil, Amtrak would have to petition the state for a change to the designation with documentation to support the change. No other wetlands are located within 100 feet of this site. Assuming a reclassification of the area as non-wetland, no direct impacts to wetlands or degradation of adjacent wetland characteristics are expected.

<u>Wildlife</u>. Site characteristics of the proposed paralleling station include a mixed land-use area with a commercial/residential base. Immediately adjacent to the area are a heating oil company and boat dealer/storage shop. The vegetative community on the site includes an overstory of black cherry and white ash (*Fraxinus americana*), with bittersweet and blackberry (*Rubus spp.*) dominating the understory. The New London County Soil Survey identifies the soils as Merrimac sandy loam, a somewhat excessively drained soil. Overall, the wildlife values of the site are dictated by the developed surroundings and dense understory of vines which would limit habitat use to small mammals such as the eastern chipmunk (*Tamiasciurus striatus*) and songbirds such as the black-capped chickadee.

Any wildlife impacts associated with the site are closely tied to the loss of the dense understory and its associated nesting and cover values. The overall abundance of similar habitat in the remainder of the lot and the surrounding area indicate that construction of the paralleling station would have little effect on the overall abundance of wildlife habitat in the area.

<u>Endangered Species</u>. The Connecticut Natural Diversity Database search indicated no Federal or State Endangered or Threatened Species or Species of Special Concern.

<u>Floodplains</u>. The proposed site of the State Line paralleling station does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Stonington, Connecticut, Community Panel 090106-0017E.

<u>Coastal Resources</u>. The Connecticut Coastal Resources Map (Watch Hill Quadrangle, 1979) indicates the proposed paralleling station site lies within the Coastal Boundary. The site is listed as Freshwater Wetlands, which includes any soil mapped as "poorly drained, very poorly drained, alluvial and floodplain" (Inland Wetlands and Watercourses Act). Field investigation indicates the site is a sandy loam soil with a vegetative community dominated by upland species. Documentation will have to be provided by a soil scientist to petition a change to this classification.

Assuming the state concurs with the site reclassification as an upland, it is assumed the site location would be considered Shorelands within the Coastal Boundary. Shorelands are described as typical upland features which are not subject to dynamic coastal processes; as such development of this site would be expected to be consistent with the policies set forth in C.G.S. section 22a-92.

__Water Resources__. The Town of Westerly provides water to the Village of Pawcatuck. According to the Groundwater Reservoirs/Public Wellfield Locations Map for the Westerly Comprehensive Plan (1990), no public wells are located in the vicinity of the proposed State Line paralleling station site, nor are any groundwater reservoirs located in the site vicinity. The watershed of the Wood and Pawcatuck Rivers, which includes the location of this station, has been designated a Sole Source Aquifer Area by the U. S. EPA.

Surface waters associated with this site include a culverted stream approximately 300 feet northwest of the site. The Pawcatuck River is located approximately 500 feet to the east. Pending a designation of the area as a non-wetland, the site is well beyond the 100 feet from any wetland. No wetlands are expected to be filled or dredged for the proposed paralleling station.

Direct impacts to the water resources are not expected at this site, since no public wells or groundwater reservoirs are located in the vicinity. Any potential impacts to the adjacent culverted stream or Pawcatuck River will be minimized. The location of the site within a Sole Source Aquifer will trigger a review of impacts by the U.S. EPA, however, the location and facilities associated with the site generally would not pose a threat to water quality. Runoff from the proposed paralleling station is not expected to contain adverse amounts of contaminants, so there is not expected to be impact on the ground water.

The mitigation effort at the State Line paralleling stations site should focus on minimizing and stabilizing slopes and utilizing proper erosion and sedimentation control measures and stormwater management practices. Potential short term impacts to the water quality can be minimized by staging construction equipment and performing and vehicle maintenance off-site.

__Summary of Impacts__. No adverse impacts are anticipated to any of the resource categories.

11.4.11 Westerly, RI

11.4.11.1 Bradford Paralleling Station.
__Wetlands__. No wetlands appear to occur on the proposed site of the Bradford paralleling station, although palustrine forested and scrub-shrub wetlands appear to occur within the 50 foot buffer zone regulated by the State of Rhode Island. South and west of the proposed paralleling station site is a forested/scrub-shrub wetland dominated by red maple, speckled alder (*Alnus rugosa*) and sweet pepperbush. Immediately behind the site is a narrow band of wetland associated with a groundwater discharge area located to the north.

No direct impact to the adjacent wetlands are expected. No alteration of the wetlands ability to moderate flooding, provide wildlife habitat or recreation would be expected. The town of Westerly Groundwater Reservoir map (1990) identifies the area as groundwater recharge areas indicating a potential impact to that function.

The mitigation effort at this site should include minimization of the slopes associated with the paralleling station to maximize the distance to the adjacent wetlands. Once the site location is established proper sedimentation and erosion control measures should be in place before construction begins. Interception of ground or surface water should be minimized by reducing impervious surfaces and providing proper stormwater management practices.

Wildlife. Site characteristics of the proposed paralleling station include an undeveloped area with a mixed hardwood overstory of red maple, red oak (*Quercus rubra*) and white oak. Understory species include shrubs such as gray birch, highbush blueberry, beaked hazelnut (*Corylus cornuta*) and cinnamon fern (*Osmunda cinnamomea*).

A large portion of the proposed site includes an open area with trash and old appliances, including washing machines and car parts. Adjacent habitat includes a large palustrine forested wetland to the southwest with a groundwater seep behind the site.

Wildlife habitat values are related to the close proximity of snag trees with cavities, as well as the presence of the large wetland to the north and west. Overall the proposed paralleling station site contributes somewhat to the value of the surrounding habitat, however due to its disturbed nature the site's habitat values are limited. Impacts to the wildlife habitat associated with the Bradford paralleling station site would be more closely related to the loss of habitat at the edge of the site, loss of snag trees or disturbance to the wetland border. Since the majority of the site is currently open and disturbed, the overall impact is limited.

The mitigation effort at the paralleling station site should include maximizing the distance to the adjacent wetlands and avoiding impacts to the standing dead trees or snags which occur close by. Minimization of the project footprint and associated slopes as well as plantings of shrubs should be incorporated to enhance the existing conditions. Shrub species such as honeysuckles, russian olive or red-osier dogwood would provide food and nesting opportunities for the surrounding songbird community.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the paralleling station site.

Floodplains. The proposed site of the Bradford paralleling station does not include any 100-year floodplains, according to the FEMA Flood Insurance Rate Map for Bradford, Rhode Island, Community Panel 445410-0010C. The site is identified as Zone C, an area of minimal flooding.

Coastal Resources. The Bradford paralleling station site lies outside the area of coastal influence and the jurisdiction of the Coastal Resources Management Program.

Water Resources. The Westerly Town Engineer, as well as the Ground Water Reservoirs/Public Wellfield Locations Map in the Westerly Comprehensive Plan (1990), indicate public wells are located east and south of the Bradford site, approximately 1500 feet and 3000 feet away, respectively. The site lies within an area identified on the Ground Water Reservoir Map as the "critical portion of the recharge areas to the groundwater reservoirs as delineated by the R.I. Department of Environmental Management." The watershed of the Wood and Pawcatuck Rivers, which includes the location of this station, has been designated a Sole Source Aquifer area by the U.S. EPA.

Surface waters associated with the site include forested wetlands immediately to the southwest of the paralleling station site, as well as across the railroad tracks. These wetlands are part of a large wetland system which continues to the southwest. No wetlands are expected to be filled or dredged for the paralleling station site, however the site will most likely be within the 50-foot wetland buffer zone regulated by the Rhode Island DEM.

No direct impacts to water resources are expected at this site. Potential impacts do exist with the wetlands adjacent and the site located within the critical recharge area to the groundwater reservoir. The site's location in a Sole Source Aquifer requires a review by U.S. EPA to determine if siting the project at this location could contaminate the aquifer or cause a public health hazard. Although, this site is located within the groundwater recharge area, the closest well is located approximately 1500 feet away. Any runoff from the proposed paralleling station is not expected to have adverse amounts of any contaminants, while the transformers and electrical equipment associated with the operation do not contain PCB's and generally do not pose a threat to water quality.

The mitigation effort at this site will include maximizing the distance to the adjacent wetlands, minimizing the footprint of the project, stabilization of any slopes or disturbed areas and incorporation of proper erosion and sedimentation control measures to minimize any detrimental modifications of the natural capabilities of the adjacent wetlands, including groundwater discharge and recharge. Short term impacts to water quality associated with site development can also be minimized by staging construction equipment and performing any vehicle maintenance off-site, and generally following Best Management Practices for working in Aquifer Protection Areas.

Summary of Impacts. No adverse impacts are anticipated to wetlands, wildlife, endangered species, floodplains, coastal or resources. Adverse impacts are expected to occur to water resources.

11.4.12 Charlestown, RI

11.4.12.1 Burdickville Road Bridge.

Wetlands. No wetlands occur within 100 feet of the Burdickville Road bridge. Wetlands are associated with the approach road on the west side of the bridge. In the current road design work will occur within the 50 foot buffer zone regulated by the State of Rhode Island.

Pending a final road design which would encroach on the wetlands along the northern approach road, no direct wetland or buffer zone impacts are expected. Reconstruction of the bridge would not be expected to alter the adjacent wetland's ability to moderate flooding, provide wildlife habitat, recreational opportunity or groundwater recharge/discharge.

The mitigation effort at this site will include maximizing the distance to any wetlands and stabilizing slopes associated with it. If impacts are expected once the road design is available, modifications should be made to avoid any wetlands.

Wildlife. Site characteristics include an oak-hardwood forest in an undeveloped area. The shrub layer includes oaks as well as mountain-laurel (*Kalmia latifolia*) and patches of greenbriar. With the adjacent wetlands and diversity of habitats surrounding the site, this area provides wildlife habitat values, however bridge reconstruction should not adversely impact the available habitat. Impacts to the surrounding wildlife habitats is expected to be limited and as such, reconstruction of the bridge would be expected to impact, degrade or destroy wildlife, finfish, or shellfish habitat.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the bridge site, although The Charlestown Comprehensive Plan (1991) indicates endangered species habitat is located west of the site.

Floodplains. The bridge site is not located in any floodplain, as noted on the FEMA Flood Insurance Rate Map for Charlestown, Rhode Island, Community Panel 445395-0015C.

Coastal Resources. The Burdickville Road bridge is not located in an area of coastal influence or within the jurisdiction of the Coastal Resources Management Program.

Water Resources. No municipal wells or water protection district (aquifer or recharge area) are associated with the bridge site, as noted in the Charlestown Comprehensive Plan (1991). However, the site is within the Pawcatuck River watershed and therefore a Sole Source Aquifer Area designated by the U.S. EPA.

Surface waters associated with this bridge include a large forested wetland approximately 250 feet to the west as described in the wetlands section. No impacts to water resources are expected with the reconstruction of the Burdickville Road bridge and although located in a Sole Source Aquifer, the extent of work is expected to be limited in nature and should not impact these resources.

The mitigation effort at this site should focus on stabilizing any slopes or disturbed areas and utilization of proper erosion and sedimentation controls.

Summary of Impacts. No adverse impacts are anticipated to wildlife, endangered species, floodplains, coastal resources or water resources. Adverse impacts are expected to occur to wetlands.

11.4.13 Richmond, RI

11.4.13.1 Richmond Switching Station.

Wetlands. No wetlands occur on the site of the proposed Richmond switching station. The station site does appear to be within the 200-foot buffer zone of the Pawcatuck River. Additional floodplain wetlands associated with the river are located on the south side of the tracks and to the north. No direct impact to the adjacent wetlands or river is expected. No alteration of the resource's ability to moderate flooding, provide wildlife habitat or recreation would be expected since the proposed site of the station is the railroad right of way or adjacent bank.

The mitigation effort at this site will include maximizing the distance to the river and wetlands, as well as minimizing the footprint of the project and any slopes. Once the site is established proper sedimentation and erosion control measures will be in place before construction begins. Interception of ground and surface waters will be minimized by reducing impervious surfaces and providing proper stormwater management practices.

Wildlife. Site characteristics of the proposed switching station include a 70 foot wide railbed with vegetation limited to the bankings or adjacent floodplains. Vegetation includes gray birch, white oak and little bluestem with red maple and meadowsweet adjacent. The adjacent area includes an old factory complex immediately to the northwest. Wildlife habitat values of the area are related to the close proximity of the river. Overall, the proposed switching site provides little wildlife value with its disturbed soils, fenced surroundings and limited vegetation. Impacts to wildlife habitat associated with the Richmond switching station would be more closely related to loss of habitat at the edge of the site. With a fenced boundary and disturbed habitat prevalent the overall impact is limited.

The mitigation effort at the switching station site should focus on minimizing impacts to the surrounding area and the river as described in the wetlands section.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the switching station site.

Floodplains. The proposed Richmond switching station appears to be within a 100-year floodplain, according to the FEMA Flood Insurance Rate Map for Richmond, Rhode Island, Community Panel 440031-14B. No base flood elevations were available to determine the exact involvement of the switching station in the floodplain, however the FIRM map indicates the floodplain associated with the Pawcatuck River extends approximately 150 feet from the centerline of the river, which would include the current location of the project. The potential impacts to the floodplain will require following the eight step process outlined in Executive Order 11988. Site specific steps will need to be taken as part of the mitigation effort, including avoidance of the floodplain through shifting the location and minimization of the project footprint or any associated slopes. If the structure remains in the current location it will require floodproofing the structure and providing compensatory storage to mitigate for any expected for any expected losses.

Coastal Resources. The Richmond switching station site lies outside the area of coastal influence and the jurisdiction of the Coastal Resources Management Program.

Water Resources. According to the Richmond Town Clerk and Building Inspector (personal communication, 1993) no municipal wells or water protection districts occur on the site of the switching station. The watershed of the Wood and Pawcatuck Rivers, which includes the location of this station, has been designated a Sole Source Aquifer area by the U.S. EPA. According to the Charlestown Comprehensive Plan (1991) the site is located within a high yield aquifer and recharge area Surface waters associated with the site include the Pawcatuck River approximately 90 feet east of the western edge of the station. Forested wetlands occur approximately 70 feet south of the station.

No direct impacts to water resources are expected at this site. Potential impacts do exist with the river and wetlands adjacent. The site's location in a Sole Source Aquifer requires a review by U.S. EPA to determine if siting the project at this location could contaminate the aquifer or cause a public health hazard. Although located within the aquifer, no municipal wells are located in the vicinity. Any runoff from the proposed switching station is not expected to have adverse amounts of any contaminants, while the transformers and electrical equipment associated with the operation do not contain PCB's and generally do not pose a threat to water quality.

The mitigation effort at this site will include maximizing the distance to the river and adjacent wetlands, minimizing the footprint of the project, stabilization of the slopes and incorporation of proper erosion and sedimentation control measures to minimize any detrimental modifications of the natural capabilities of the adjacent wetlands including groundwater recharge/discharge, flood control or recreation. Short term impacts to water quality associated with site development can also be minimized by staging construction equipment and performing any vehicle maintenance off-site, and generally following Best Management Practices for working in aquifer protection areas.

Summary of Impacts. No adverse impacts are anticipated to wetlands, wildlife, endangered species, or coastal resources. Adverse impacts are expected to occur to floodplains and water resources.

11.4.13.2 Kenyon School/Beaver River Road Bridge.

Wetlands. There are no wetlands associated with the Beaver River Road bridge. The Pawcatuck River is located over 200 feet to the south. The buffer zone, regulated by the State, is 200 feet.

No impact to the adjacent river is expected to occur. Reconstruction of the bridge would not alter the river's ability to moderate flooding, provide wildlife habitat, or provide recreational opportunities. With the river located downslope of the bridge, potential impacts to groundwater or surface waters may occur during construction.

Wildlife. The site is within a heavily developed residential/industrial area. Overstory vegetation is limited to white ash, with species such as bittersweet and Japanese knotweed in the understory. Due to the limited vegetative cover and developed surroundings, this site provides limited wildlife values.

Since wildlife habitat is limited in the surrounding area and the existing cross-section will be maintained, reconstruction of the bridge would not be expected to impact, degrade or destroy essential wildlife habitat.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the bridge site.

Floodplains. The bridge site is not located in any floodplain, as noted on the FEMA Flood Insurance Rate Map for Richmond, Rhode Island, Community Panel 444031-0020B.

Coastal Resources. The Beaver River Road bridge site is not located in an area of coastal influence or within the jurisdiction of the Coastal Resources Management Program.

Water Resources. No municipal wells or water protection districts are associated with the bridge site, according to the Town Building Inspector (personal communication, 1993). The site is within the Pawcatuck Basin Sole Source Aquifer Area, as designated by the U.S. EPA.

Surface waters associated with this site include the Pawcatuck River which flows closest to the bridge on the south side over 200 feet away. A large bend in the river approaches to within approximately 500 feet on the west side. No wetland impacts are expected for the bridge reconstruction, since the extent of work is expected to be limited.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.14 South Kingstown, RI

11.4.14.1 Kingston Paralleling Station.
Wetlands. No wetlands occur on the site of the proposed Kingston paralleling station. A palustrine forested wetland occurs across the railroad tracks, over 75 feet from the paralleling station site.

Since no direct impacts to wetlands or buffer zones are expected, the mitigation effort should focus on utilizing proper erosion and sedimentation control measures and stormwater management practices.

Wildlife. The proposed paralleling station is in a sparsely developed area on a lot adjacent to the Rhode Island DEM Division of Fish and Game Regional Office. The overstory includes white oak, red oak and red maple with greenbriar and goldenrod in the understory. One very large (over 48" diameter) white oak with numerous cavities is located at the back side of the site. The Rhode Island Soil Survey identifies the soils on the site as Canton and Charlton very stony fine sandy loam, a well drained soil.

Habitats available in the area include the wetland across the tracks from the site, as well as numerous openings and forested areas, which provide for vegetative diversity and interspersion. Numerous deer tracks and songbirds were noted in the proposed site, confirming the area's habitat value.

Impacts to wildlife habitat at the site of the Kingston paralleling station would be minimal due to the presence of similar habitats around the site including the Great Swamp Wildlife Reservation immediately to the south and west. The most important feature for wildlife on the site is the large white oak with its numerous cavities located just to the south. With its numerous cavities and spreading branches, this tree provides ample opportunity for cavity nesting as well as roosting for bird species and denning or nesting for arboreal mammals.

Mitigation of impacts to wildlife habitat on this site should focus on avoidance of the large oak tree, including shifting the site away from the area; if impacts are unavoidable, the tree should be retained and trimming kept to the minimum extent practicable.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the paralleling station site.

Floodplains. The proposed site of the Kingston paralleling station does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for South Kingstown, Rhode Island, Community Panel 445407-0015D.

Coastal Resources. The Kingston paralleling station site lies outside the area of coastal influence and the jurisdiction of the Coastal Resources Management Program.

Water Resources. The Town Planning Office indicates no municipal wells are located in the vicinity of the proposed paralleling station site (personal communication, 1993). The Map of Critical and Environmentally Sensitive Areas in the Comprehensive Plan for South Kingstown (1991) indicates the paralleling station site lies outside the Groundwater Protection Overlay District. The watershed of the Wood and Pawcatuck Rivers, which includes the location of this station, has been designated a Sole Source Aquifer Area by the U.S. EPA.

Surface waters associated with this site including a forested wetland located across the tracks, approximately 75 feet away. This wetland is part of the much larger wetland system referred to as The Great Swamp. No wetlands are expected to be filled or dredged for the proposed paralleling station site. The site is located outside the 50-foot wetland buffer regulated by the state.

No direct impacts to water resources are expected at this site. Potential impacts do exist with wetlands located across the tracks. The site's location within a Sole Source Aquifer requires a review by U.S. EPA to determine if siting the project at this location could contaminate the aquifer or cause a public health hazard, although no town wells are located in the vicinity of the project. Any runoff from the proposed paralleling station is not expected to have adverse amounts of any contaminants, while the transformers and electrical equipment associated with the operation do not contain PCB's and generally do not pose a threat to water quality.

The mitigation effort at the Kingston paralleling station will include minimizing the footprint of the project, stabilizing slopes and incorporation of proper erosion and sedimentation control measures to minimize any detrimental modifications of the natural capabilities of the adjacent wetlands including groundwater discharge/recharge. Short term impacts to water quality associated with site development can also be minimized by staging construction equipment and performing vehicle maintenance off-site.

Summary of Impacts. No adverse impacts are anticipated to wetlands, wildlife, endangered species, floodplains, or coastal resources. Adverse impacts are expected to occur to water resources.

11.4.14.2 Rhode Island Route 138 Bridge.

Wetlands. There are no wetlands associated with the Main Street bridge or within 100 feet of the site.

Wildlife. Site characteristics include a developed area with residential/commercial land use on the south side. The north side includes a large agricultural field. The overstory is a hardwood forest with white ash and black cherry. The understory includes little bluestem, bittersweet and red cedar. Located adjacent to an agricultural field, the vegetated slopes associated with the bridge provide some edge and cover habitat. The reconstructed bridge is not expected to be widened, so impacts to slopes and wildlife habitat should be limited.

Since the existing cross-section will be maintained and disturbance to the surrounding habitats will be minimal, reconstruction of the bridge would not be expected to impact, degrade or destroy essential habitat.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the bridge site.

Floodplains. The bridge site is not located in any floodplains, as noted on the FEMA Flood Insurance Rate Map for South Kingstown, Rhode Island, Community Panel 445407-0015D.

Coastal Resources. The Main Street bridge is not located in an area of coastal influence or within the jurisdiction of the Coastal Resources Management Program.

Water Resources. No municipal wells are in proximity to the bridge site, however the site lies within a Groundwater Protection Overlay District, according to the Town Planning Department and Comprehensive Plan for South Kingstown (1991). The watershed of the Wood and

Pawcatuck Rivers, which includes the location of this bridge, has been designated a Sole Source Aquifer Area by the U.S. EPA.

There are no surface waters associated with this site and no wetlands or buffer zones are expected to be impacted by bridge reconstruction.

No impacts to water resources are expected with the reconstruction of the Main Street bridge and although located within a Sole Source Aquifer and a Groundwater Protection Overlay District for South Kingston, the extent of work is expected to be limited in nature and should not impact these resources.

The mitigation effort at this site should focus on stabilizing any slopes or disturbed areas and utilization of erosion and sedimentation control measures.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.15 Exeter, RI

11.4.15.1 Exeter Paralleling Station.
Wetlands. There are no wetlands occurring on the site of the proposed Exeter paralleling station. A scrub-shrub wetland on the edge of Yawgoo Mill Pond is located over 60 feet to the west across the railroad tracks. The state-regulated buffer zone for ponds and wetlands is 50 feet in Rhode Island.

Since no impacts to wetlands or buffer zones are expected, the mitigation effort should focus on utilizing proper erosion and sedimentation control measures and stormwater management practices.

Wildlife. Site characteristics for the Exeter switching site include an oak-hardwood overstory dominated by black oak, while the understory includes species such as little bluestem, black oak, and blackberry. Adjacent habitat includes a large agricultural field used for growing turf, less than 100 feet to the east. Yawgoo Mill Pond is located on the west side of the tracks, and provides a large area of open water. The Rhode Island Soil Survey describes the site soils as a well-drained Enfield silt loam. The area surrounding the switching station site does provide a variety of habitats as well as the vegetative diversity and interspersion of habitat types to provide wildlife values.

Impacts to wildlife habitats associated with the Exeter paralleling station would be limited since the site's primary values are related to the diversity of vegetative types and the interspersion of the various habitats around the site. These factors would remain in place.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the switching station.

Floodplains. The Exeter switching station site does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Exeter, Rhode Island, Community Panel 440032-0027A.

Coastal Resources. The Exeter switching station site lies outside the area of coastal influence and outside the jurisdiction of the Coastal Resources Management Program.

Water Resources. The town clerk in Exeter cited no town wells in the vicinity of the switching station site (personal communication, 1993). The town has a groundwater overlay district and water-related Sensitive Areas Map; however, these regulated areas are not in the vicinity of the site. The Rhode Island Department of Environment Management, Wellhead Protection Areas Map (1993) indicates a community water system well is located approximately two-thirds of a mile to the southwest with the wellhead protection area slightly less than one-half mile away. The watershed of the Wood and Pawcatuck Rivers, which includes the location of this station, has been designated a Sole Source Aquifer Area by the U.S. EPA.

Surface waters adjacent to the site include Yawgoo Mill Pond over 60 feet to the west, across the railroad tracks. Another pond is located approximately 160 feet to the south. No wetlands are expected to be filled or dredged for the Exeter paralleling station site. The adjacent ponds are located beyond the 50-foot regulated buffer zone.

No direct impacts to water resources are expected at this site. Potential impacts do exist with Yawgoo Mill Pond and another pond located close by. The site's location in a Sole Source Aquifer requires a review by U.S. EPA to determine if siting the project at this location could contaminate the aquifer or cause a public health hazard. Although located within a Sole Source Aquifer, no municipal wells are located in the vicinity. Short term impacts may arise because of construction activity but once established, any runoff associated with the paralleling station is not expected to contain adverse amounts of any contaminants. The transformers and electrical equipment associated with the operation do not contain PCB's and generally do not pose a threat to water quality.

The mitigation effort at this site should include maximizing the distance to the adjacent ponds and wetland edge, minimizing the footprint of the project, stabilizing slopes and incorporating proper erosion and sedimentation control measures to minimize any detrimental modifications of the natural capabilities of the adjacent wetlands including groundwater recharge/discharge, flood control or recreation. Short term impacts to water quality associated with site development can also be minimized by staging construction equipment and performing any vehicle maintenance off-site.

Summary of Impacts. No adverse impacts are anticipated to wetlands, wildlife, endangered species, floodplains, or coastal resources. Adverse impacts are expected to occur to water resources.

11.4.16 North Kingstown, RI

11.4.16.1 East Greenwich Paralleling Station.

Wetlands. No wetlands occur on the site of the proposed East Greenwich paralleling station in North Kingstown and no wetlands occur within the 100-foot area around the site.

Wildlife. Site characteristics of the area include a narrow band of vegetation along the railroad tracks, in an area which contains very limited topography or cover. No overstory exists on the site. Shrub species include pitch pine (*Pinus rigida*), gray birch, and black oak. Ground cover consists of little bluestem and goldenrod. Adjacent habitat on the north side is similar, except the overstory includes more saplings and trees. The Rhode Island Soil Survey identifies the site as having gravel pit soils. The area to the south has now been leveled and developed as a golf driving range. Due to the lack of cover and vegetative diversity this site provides limited wildlife values, except perhaps nesting cover for birds along the vegetated edge. As an area of limited cover the proposed paralleling station location would create very little impact to wildlife habitat in the area.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the paralleling station site.

Floodplains. The proposed site of the East Greenwich paralleling station does not impact any 100-year floodplains, according to the FEMA Flood Insurance Rate Map for North Kingstown, Rhode Island, Community Panel 445404-0001B.

Coastal Resources. The East Greenwich paralleling station site lies outside the area of coastal influence and the jurisdiction of the Coastal Resources Management Program.

Water Resources. The North Kingstown Town Planning Department indicates the proposed paralleling station site is located within a wellhead protection area, as well as a groundwater recharge overlay district (personal communication, 1993). The site is also located within the Hunt-Annaquatucket-Pettaquamscott Sole Source Aquifer, as designated by the U.S. EPA.

Surface waters associated with the site are limited to the Hunt River, which lies over 800 feet to the northwest and approximately 1500 feet to the northeast. No wetlands are expected to be filled or dredged for the proposed paralleling station site. No wetlands occur within the 50-foot buffer regulated by the Rhode Island DEM.

No direct impacts to water resources are expected at this site. Potential impacts do exist with the site located in a wellhead protection area as well as a groundwater recharge overlay district. The site's location in a Sole Source Aquifer requires a review by the U.S. EPA to determine if siting the project at this location could contaminate the aquifer or cause a public health hazard. The site would appear to be located in close proximity to several wells for North Kingstown, Kent County Water Authority and the Rhode Island Port Authority. Short term impacts may arise because of construction activity, but once established, any runoff associated with the paralleling station is not expected to contain adverse amounts of any contaminants. The transformers or electrical equipment associated with the operation do not contain PCB's and generally do not pose a threat to water quality.

The mitigation effort at the East Greenwich site will include maximizing the distance to the adjacent wells minimizing the footprint of the project, stabilizing any slopes and incorporating proper erosion and sedimentation control measures to minimize any detrimental modifications to the surrounding wellhead protection area. Short term impacts to water quality associated with site development can also be minimized by staging construction equipment and performing any vehicle maintenance off-site, and generally following Best Management Practices for working in aquifer protection areas.

Summary of Impacts. No adverse impacts are anticipated to wetlands, wildlife, endangered species, floodplains, or coastal resources. Adverse impacts are expected to occur to water resources.

11.4.17 Warwick, RI

11.4.17.1 Warwick Substation.

Wetlands. There are no wetlands occurring on the site of the proposed Warwick substation site and no wetlands occur within the 100 foot area around the site. The site is currently a paved parking lot with a lumber supply warehouse adjacent. The utility corridor associated with the underground feeder crosses under Jefferson Boulevard in an industrial area. This corridor would not impact wetlands.

Wildlife. Site characteristics of the substation location include a paved parking lot in a lumber yard. There is very limited vegetation around the site. Adjacent habitats include hardwoods along the rail line and residential/industrial land use. The utility corridor connecting the site to the power line approximately 600 feet to the west will be buried underground across Jefferson Boulevard to the powerline. Since it is primarily an industrial area with only scattered tree cover, the site provides limited habitat values. Any disturbance associated with the project would be expected to occur only during construction activities. As an industrial area, neither the substation or underground utility corridor would be expected to impact the limited wildlife habitat values of the area.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the substation site.

Floodplains. The proposed site of the Warwick substation is not located within any floodplain, according to the FEMA Flood Insurance Rate Map for Warwick, Rhode Island, Community Panel 445409-0002D. The utility corridor is also outside any floodplain.

Coastal Resources. The Warwick substation site and the utility corridors are located outside the area of coastal influence and the jurisdiction of the Coastal Resources Management Program.

Water Resources. The Planning Department indicated no municipal wells exist in the vicinity of the substation site or the utility corridor to the east. No wells were noted in the field. No watershed or groundwater protection districts are associated with tne site. No surface waters are associated with the site. The Three Ponds area is located over 1700 feet to the west. No wetlands are expected to be filled or dredged for the proposed Warwick substation site. No impacts to water resources are expected at the Warwick substation site or its utility corridor, due to the lack of wells and water resources in the project vicinity.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.17.2 Pettaconsett Avenue Bridge.

Wetlands. There are no wetlands associated with the Pettaconsett Avenue bridge. A drainageway alongside the tracks and adjacent to the bridge site would not be considered a jurisdictional wetland.

Wildlife. Site characteristics include a residential area to the east and an industrial/commercial area to the west. Vegetation is limited around the site, with a hardwood overstory of black oak and green ash. The understory is limited to low species such as little bluestem and mullein. Reconstruction of the bridge should not impact the already limited habitat value of the site. Due to the limited habitat in the area, reconstruction of the bridge would not be expected to impact, degrade, or destroy essential wildlife, finfish, or shellfish habitat.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the bridge site.

Floodplains. The bridge site is not located in any floodplain, as noted in the FEMA Flood Insurance Rate Map for Warwick, Rhode Island, Community Panel 445409-0003E.

Coastal Resources. The Pettaconsett Avenue bridge is not located in an area of coastal influence or within the jurisdiction of the Coastal Resources Management Program.

Water Resources. No municipal wells or water protection districts are located near the bridge site, according to the City Planning Department (personal communication, 1993). There are no surface waters associated with this site and no wetlands or buffer zones are expected to be impacted by the bridge reconstruction. No impacts to water resources are expected with the reconstruction of Pettaconsett Avenue bridge. The lack of resources in the area and limited extent of work should not impact these resources.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.18 Cranston, RI

11.4.18.1 Park Avenue Bridge.

Wetlands. There are no wetlands associated with the Park Avenue bridge site or within 100 feet of the site.

Wildlife. Site characteristics of the bridge site include a heavily developed residential/industrial area, containing oak-hardwood species for cover. Overall the site provides limited habitat values. Since the Park Avenue bridge is located in a developed industrial area, reconstruction would not be expected to impact, degrade or destroy essential wildlife, finfish, or shellfish habitat.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the bridge site.

Floodplains. The bridge is not located in any floodplain, as noted in the FEMA Flood Insurance Rate Map for Cranston, Rhode Island, Community Panel 445396-0006B.

Coastal Resources. The Park Avenue bridge is not located in an area of coastal influence or within the jurisdiction of the Coastal Resources Management Program.

Water Resources. No municipal wells or water protection districts are located near the bridge site, according to the City Planning Department (personal communication, 1993). There are no surface waters located within 1000 feet of the site and no wetlands or buffers zones are expected to be impacted by the bridge reconstruction. No impacts to water resources are expected with the reconstruction of Park Avenue bridge. The lack of resources in the area and limited extent of work associated with the bridge reconstruction should not result in impacts to the area's water resources.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.19 Providence, RI

11.4.19.1 Elmwood Paralleling Station.

Wetlands. No wetlands occur on the site of the proposed Elmwood paralleling station. Mashapoag Pond is located over 200 feet north of the site, beyond the buffer zone regulated by the Rhode Island DEM.

Wildlife. The proposed paralleling station site is on the edge of an old parking lot associated with an abandoned factory. Site characteristics of the proposed Elmwood paralleling station include a cracked asphalt surface with little bluestem dominating the understory. Scattered shrub and sapling species include gray birch, black oak, and tree of heaven. Surrounding habitat is primarily industrial/commercial with limited vegetative diversity or cover available to fossorial or ground nesting species. With limited vegetation in a heavily developed area, the Elmwood paralleling station site provides very limited wildlife habitat values. With the limited wildlife values associated with the site, impacts associated with its development are not expected to degrade or destroy essential wildlife habitat.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the paralleling station site.

Floodplains. The proposed site of the Elmwood paralleling station does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Providence, Rhode Island, Community Panel 445406-0007E.

Coastal Resources. The Elmwood paralleling station site lies outside the area of coastal influence and the jurisdiction of the Coastal Resources Management Program.

Water Resources. No municipal water wells or water protection districts are located in the vicinity of the proposed paralleling station site, according to the City Planning Department (personal communication, 1993). Surface waters adjacent to the site include Mashapoag Pond, which is located approximately 200 feet to the north. No wetlands are expected to be filled or dredged for the proposed paralleling station site. No wetlands occur within the 50-foot buffer regulated by the Rhode Island DEM. Direct impacts to water resources are not expected at the Elmwood site due to the lack of wells in the vicinity and the distance to Mashapoag pond.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.20 Pawtucket, RI

11.4.20.1 Providence Paralleling Station.
Wetlands. There are no wetlands occurring on the site of the proposed Providence paralleling station site, or within 100 feet of the area.

Wildlife. Site characteristics for the Pawtucket paralleling station site include a lack of overstory species, while the herbaceous layer is primarily composed of little bluestem, with some milkweed (*Asclepias syriaca*) and mullein (*Verbascum thapsus*). Adjacent habitat includes scattered hardwoods, such as black oak and catalpa (*Catalpa spp.*). The Rhode Island Soil Survey describes the site soils as Udorthents - Urban Land Complex. Availability of habitat to wildlife is limited due to the limited access to the site with I-95 and a chain link fence on the west side and industrial land use predominant around the rest of the site. Overall, the site has limited cover or vegetative diversity to provide wildlife habitat values, and as such construction of the paralleling station would create limited impact to habitats.

Endangered Species. The Rhode Island Natural Heritage Program indicates no rare species occurrences in the vicinity of the paralleling station.

Floodplains. The Providence paralleling station in Pawtucket does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Pawtucket, Rhode Island, Community Panel 440022-0002D.

Coastal Resources. The Pawtucket paralleling station site lies outside the area of coastal influence and outside the jurisdiction of the Coastal Resources Management Program.

Water Resources. The Pawtucket Planning Office indicates no municipal wells exist in the vicinity of the paralleling station site (personal communication, 1993).

Surface water associated with the site is limited to the Moshassuck River, located approximately 400 feet to the east across the interstate highway. The Moshassuck River also crosses under the railroad approximately 1200 feet to the north. No wetlands or buffer zones are expected to be impacted by the Pawtucket paralleling station site.

Direct impacts to water resources are not expected at this site, since no public wells or groundwater reservoirs are located within the vicinity. Any potential impacts to the Moshassuck River will be minimized. Runoff from the paralleling station would not be expected to have adverse amounts of any contaminants, and likewise the facilities associated with the site do not contain PCB's or materials which would be expected to impact groundwater or water resources.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.21 Attleboro, MA

11.4.21.2 Attleboro Paralleling Station.

Wetlands. No wetlands occur on the site of the proposed Attleboro Paralleling Station. The station lies outside the 100-foot buffer of the Ten Mile River, a resource regulated by the State of Massachusetts and the City of Attleboro under the Massachusetts Wetlands Protection Act (M.G.L. c. 131 s.40).

Wildlife. Characteristics of the Attleboro site include a mixed plant community of scattered saplings and an open field habitat. Dominant species include black cherry, glossy buckthorn, and greenbriar with meadowsweet and silky dogwood (*Cornus amomum*) common throughout. Adjacent habitats include hardwood forest, the Ten Mile River and its adjacent canal, as well as commercial development and residential areas. Available wildlife habitat in the area of the proposed paralleling station site is provided by shrub species and field habitats which provide food and cover to small game and numerous bird species such as the eastern cottontail (*Sylvilagus floridanus*) and the dark-eyed junco (*Junco hyemalis*), as evidenced by the numerous tracks. Due to the developed surroundings, the area would provide little other value to wildlife. Impacts to wildlife habitat around the site would be limited since similar habitats are located in the surrounding area.

Endangered Species. A Massachusetts Natural Heritage Database search indicated no rare species or adverse natural communities near this site.

Floodplains. The proposed site of the Attleboro paralleling station site does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Attleboro, Massachusetts, Community Panel 250049-0010C.

Coastal Resources. The Attleboro paralleling station site is located outside the area of coastal influence and the Coastal Zone Boundary.

Water Resources. The Town Planning Office and Water Department Director indicate no municipal wells occur in the vicinity of the site (personal communication, 1993). The Town Resource Map indicates the paralleling station site is outside the limits of any water resource protection district.

The town of Seekonk has an aquifer protection district located south of the paralleling station site. The Ten Mile River, located over 100 feet east of the site, continues on to the south and flows very close to a town water well in Seekonk. Water quality impacts to the river could reach the well supply through induced infiltration.

Surface waters associated with the site include the Ten Mile River. A canal associated with the Ten Mile River is located approximately 250 feet to the east. No wetlands are expected to be filled or dredged for the proposed paralleling station site.

No direct impacts to water resources are expected at this site. Potential impacts do exist with the river adjacent and aquifer protection district located downstream, however there are no municipal wells in the vicinity of the project. Any runoff from the proposed paralleling station is not expected to have adverse amounts of any contaminants, while any transfo ıers or electrical equipment associated with the operation do not contain PCB's and gener ·y do not pose a threat to water quality.

The mitigation effort at this site will include maximizing the distance to the river, minimizing the footprint of the project, stabilization of the slopes and incorporation of proper erosion and sedimentation control measures to minimize any detrimental modifications to the natural capabilities of the adjacent wetland and the resources protected under the Wetland Protection Act. Short term impacts to water quality can be minimized by staging construction equipment and performing any vehicle maintenance off-site.

Summary of Impacts. No adverse impacts are anticipated to wetlands, wildlife, endangered species, floodplains, or coastal resources. Adverse impacts are expected occur to water resources.

11.4.21.2 Norton Switching Station.

Wetlands. There are no wetlands associated with the Norton switching site, although the site occurs within the 100-foot buffer of a large forested wetland located to the north.

No direct impact to the adjacent wetland is expected to occur. Construction of the switching station would not alter the adjacent wetland's ability to perform the functions or interests identified in the Massachusetts Wetlands Protection Act (M.G.L. c131, s.40), including public or private water supplies, groundwater supplies, flood control, storm damage prevention, prevention of pollution, protection of land containing shellfish, protection of fisheries, and protection of wildlife habitat. Potential impacts arising during construction include erosion and surface water degradation.

The mitigation effort at this site should include maximizing the distance to the adjacent wetland, and minimizing the footprint of the project and any slopes associated with it. Proper erosion and sedimentation control measures and stormwater management practices should be in place prior to construction to reduce the potential runoff from the site.

Wildlife. Site characteristics of the switching station location include an open meadow with an existing house immediately adjacent. Planted shrub species are located in the vicinity of the house with smooth sumac and blackberry located adjacent to the rail corridor. Due to the open character of the site, in an area that includes extensive forested acreage, the switching station area could be expected to provide diversity and edge habitat to a variety of wildlife species including white-tailed deer (*Odocoileus virginiana*), eastern cottontails, and field sparrows (*Spiizella pusilla*).

Wildlife impacts associated with development of the switching station site would include disturbance of fossorial species and species which commonly inhabit meadow or grassy areas such as meadow voles (*Microtus pennsylvanicus*). The existing edge habitat will not be altered by the switching station.

The mitigation effort at the Norton switching station site should focus on re-establishing the sumac shrubs which will most likely be eliminated during construction. Since the principal value of the site is its open character the only new plantings which would be proposed would be grasses to stabilize slopes.

Endangered Species. A Massachusetts Natural Heritage Database search indicated no rare species or adverse natural communities near the site.

Floodplains. The switching station site does not impact any 100-year floodplains according to the FEMA Flood Rate Insurance map for Attleboro, Community Panel 250049-005C.

Coastal Resources. The Norton switching station site is located outside the area of coastal influence and the Coastal Boundary.

Water Resources. The City of Attleboro Engineer's Office and Resource Map noted no municipal wells in the vicinity of the switching station site (personal communication, 1992). No record of private wells is available, nor were any noted in the field. According to a plan entitled "Water Resources Protection Districts, City of Attleboro, Massachusetts, 1991" the site lies within the Bungay River Water Resource Protection District. The associated regulations prohibit the outdoor storage of hazardous substances which are susceptible to being carried into the surface or groundwaters of the protection district.

Surface waters associated with this site include the large forested wetland located approximately 70 feet to the north. A small stream crossing under the railroad tracks is located approximately 160 feet to the north. No wetlands or buffer zone are expected to be filled or dredged by the Norton switching station, however the site does lie within the 100-foot buffer zone regulated by the City of Attleboro and the Commonwealth of Massachusetts.

No direct impacts to water resources are expected at this site. Potential impacts do exist with the wetlands adjacent and the site located within the Bungay River Water Resource Protection District. Although located in the protection district, no municipal wells are located in the area of the switching station. Any runoff from the site is not expected to have adverse amounts of contaminants, while any transformers and electrical equipment associated with the operation do not contain PCB's and generally do not pose a threat to water quality.

The mitigation effort at this site are described in the wetlands section.

Summary of Impacts. No adverse impacts are anticipated to wetlands, wildlife, endangered species, floodplains, or coastal resources. Adverse impacts are expected occur to water resources.

11.4.22 Foxborough, MA

11.4.22.1 East Foxborough Paralleling Station.

Wetlands. No wetlands occur on the site of the proposed East Foxborough paralleling station. No wetlands occur within the 100-foot buffer regulated by the State of Massachusetts and the City of Foxborough.

Wildlife. The proposed site is mostly forested with an open area adjacent to residential development. The overstory is a mixed hardwood/softwood community of white pine, trembling aspen (*Populus tremula*), and black cherry. The understory consists of species such as little bluestem, beaked hazelnut, sweet fern (*Comptonia peregrina*) and Queen Anne's lace (*Daucus carota*). The Norfolk County Soil Survey indicates the site contains Merrimac fine sandy loam, a somewhat excessively drained soil.

The presence of numerous songbirds was noted, including: the cardinal (*Cardinalis cardinalis*), black capped chickadee and mockingbird. In addition, animal sign in the form of rabbit tracks, gray squirrel tracks, and deer tracks indicates the area contains at least some of the factors which provide wildlife habitat, including vegetative diversity and the interspersion of vegetative communities in the surrounding area.

Impacts to wildlife habitat associated with the Foxboro paralleling station site would be due primarily to the loss of vegetable diversity in the immediate area. Similar habitats of forest opening/white pine stand are found in the surrounding area, however development of the site would clearly impact songbird habitat and the small mammals currently utilizing the area.

The mitigation effort at the Foxboro site should focus on minimizing the footprint of the project and limiting the extent of site disturbance. Once the site has been developed, plantings of shrub species should be incorporated in any landscaping effort and include species which would provide food, cover and nesting opportunities for birds and small mammals. Species could include tartarian honeysuckle and Russian olive. Erosion and sedimentation control measures should be undertaken to limit the extent of off-site impacts.

Endangered Species. A Massachusetts Natural Heritage Database search indicated no rare species or adverse natural communities near this site.

Floodplains. The proposed site of the East Foxborough paralleling station does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Foxborough, Massachusetts, Community Panel 250239-0003B.

Coastal Resources. The Foxborough paralleling station site is located outside the area of coastal influence and the Coastal Zone Boundary.

Water Resources. The Town Conservation Administrator for Foxborough indicated no municipal wells are located in the East Foxborough area (personal communication, 1993). The site is also outside the location of the proposed aquifer protection district. Surface water associated with this site is limited to a small stream approximately 500 feet west of the site, across the railroad tracks. No wetlands are expected to be filled or dredged or buffer zones impacted for the proposed paralleling station site. No impacts to water resources are expected at this site with no wetlands, municipal wells or water protection districts associated with the project area. The mitigation effort at this site should include stabilization of any slopes and incorporation of proper erosion and sedimentation control measures to minimize potential impacts to adjacent areas.

Areas of Critical Environmental Concern. The proposed Foxborough paralleling station is located just east of the western boundary of the Canoe River Area Aquifer of Critical Environmental Concern. This situation will require a review by the Commonwealth of Massachusetts, Department of Environmental Management, Inland ACEC Program under 301 CMR 12.00 of the Massachusetts Code of Regulations.

Resource impacts associated with the Foxboro paralleling station are limited with no wetlands or buffer zones located in the vicinity. Other resources identified by the ACEC office director as important in the Canoe River Aquifer ACEC include aquifers. The Town of Foxboro Conservation Commission Administrator indicated the site lies outside any existing or proposed aquifer protection districts (personal communication, 1993). The mitigation effort at this site should focus on utilizing proper erosion and sedimentation control measures and stormwater management practices.

Summary of Impacts. No adverse impacts are anticipated to wetlands, endangered species, floodplains, coastal resources, water resources, or ACECs. Adverse impacts are expected to occur to wildlife.

11.4.23 Sharon, MA

11.4.23.1 Canton Paralleling Station.

Wetlands. There are no wetlands occurring on the site of the proposed Canton paralleling station. A large forested and emergent wetland exists over one-quarter mile to the south.

Wildlife. Site characteristics of the paralleling station location include a limited overstory due to the presence of an overhead power line. Shrub/sapling species include black oak, gray birch, and smooth sumac. The herbaceous layer is dominated by meadowsweet, little bluestem, and a large patch of blackberry on the east side of the opening. Adjacent habitat includes forested areas of mixed hardwood/white pine. The Norfolk County Soil Survey describes the site soils as well drained Canton fine sandy loams. Overall, the proposed paralleling station site would provide limited cover and nesting opportunities restricted to birds and small mammals due to the lack of overstory. The surrounding area provides the majority of wildlife values to the site with a variety of habitats in close proximity.

Impacts to wildlife habitat would be expected to be limited in nature since the site provides limited cover and nesting opportunities and most of the wildlife values would be associated with the surrounding area. Direct impacts to fossorial species would be expected.

The mitigation effort at the Canton paralleling station site should focus on stabilizing any slopes and disturbed soils created during site development. Plantings of shrub species should be incorporated in any landscaping of the site and could include species such as red cedar, Russian olive and tartarian honeysuckle.

Endangered Species. A Massachusetts Natural Heritage Database search indicated no rare species or adverse natural communities near the site.

Floodplains. The paralleling station site does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Sharon, Massachusetts (Community Panel 440032-0029A) which includes the proposed site.

Coastal Resources. The Canton paralleling station site is located outside the area of coastal influence and the Coastal Zone Boundary.

Water Resources. The paralleling station site is located outside the area of any wells, surface water protection district, or groundwater protection district for the Town of Sharon according to the Town of Sharon Zoning Map (1989). No impacts to water resources or wetlands are expected at the Canton paralleling station site since no municipal wells or aquifer protection districts are associated with the site.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.23.2 Depot Street Bridge.
Wetlands. Beaver Brook and its bordering wetlands are associated with the westerly approach road. Pending final plans it appears that the 100 foot buffer may be impacted.

No direct impact to the adjacent wetlands are expected to occur. Reconstruction of the bridge would not alter the adjacent wetland's ability to serve the interests identified in the Massachusetts Wetland Protection Act, including flood control, storm damage prevention, prevention of pollution, and the protection of wildlife habitat. Functions which may be impacted by the reconstruction include groundwater and public water supplies, and protection of fisheries, due to the adjacent town groundwater protection district and the potential for contamination of Beaver Brook across Norwood Street approximately 300 feet to the northwest. The existing site plans would indicate the bridge reconstruction should not encroach on 100-year floodplains associated with Beaver Brook.

Coastal Resources. The Depot Street bridge is located outside the area of coastal influence and the Coastal Zone Boundary.

Water Resources. The Depot Street bridge is located adjacent to Town Well No. 4. Other wells are located over 2000 feet to the north and south, according to the Town of Sharon Zoning Map (1989). The bridge is also located in a groundwater protection district, which is regulated by the Town Zoning Board.
Surface waters associated with the bridge site include Beaver Brook, which crosses under the northerly approach road approximately 450 feet to the north. The brook is associated with an emergent wetland on the northwest side of the bridge and scrub-shrub wetlands to the northeast. Wetland impacts are pending a final road design. Buffer zone impacts may occur requiring application through the town Conservation Commission.

Pending final plans, no direct impacts to water resources are expected at this site, although potential for impact to the adjacent Town Well No. 4 and groundwater protection district as well as Beaver Brook ar located nearby. The primary concern would be short term impacts associated with the construction activities. Once completed, the bridge and road would not be expected to increase the amount of contaminants entering on-site.

The mitigation effort at this site will focus on stabilizing any slopes and utilization of proper erosion and sedimentation control measures. Potential short term impacts to water quality can also be minimized by staging construction equipment and performing vehicle maintenance off-site.

Summary of Impacts. No adverse impacts are anticipated to wildlife, endangered species, floodplains, or coastal resources. Adverse impacts are expected to occur to wetlands and water resources.

11.4.23.3 Maskwonicut Street Bridge.

Wetlands. Beaver Brook and its bordering wetlands are closely associated with the Maskwonicut Street bridge site. The buffer zone and wetlands will most likely be impacted.

At the Maskwonicut Street crossing Beaver Brook is confined to a culvert. Reconstruction of this portion of the bridge would not be expected to alter the adjacent wetland's ability to perform most of the functions or interests identified in the Massachusetts Wetland Protection Act, including storm damage prevention, flood control, prevention of pollution, protection of wildlife habitat. Functions which may be impacted by the reconstruction include groundwater supplies and public water supplies and protection of fisheries, due to the adjacent town groundwater protection district, and the potential for contamination of Beaver Brook through erosion and sedimentation.

The mitigation effort at this site will include maximizing the distance to the adjacent wetlands and stabilizing any slopes associated with it. Proper erosion and sedimentation control measures and stormwater management practices should be in place prior to construction to reduce the potential for runoff entering the adjacent wetland.

Wildlife. Site characteristics include a hardwood forest in a residential district. Species in the overstory include green ash, black cherry, and red maple, while the understory includes bittersweet, silky dogwood, and speckled alder. Adjacent habitat is similar, with scattered snag trees available. Beaver Brook flows under Maskwonicut Street and there is a ponded portion on the south side of the road. The brook is stocked with trout by the Massachusetts Fish and Game Department.

No final plans are available detailing the extent of work associated with the bridge reconstruction, however the current proposal calls for the road to be upgraded and widened which may result in impacts to Beaver Brook. Although the bridge site has a variety of wildlife habitats in the immediate area, the narrowness of the wetland zone and the availability of habitat in surrounding sites limits the impact of the bridge reconstruction on the wetland wildlife community. The potential for fisheries impacts does exist, primarily in the form of water quality degradation through sedimentation and erosion.

The mitigation planning process would require examining the possibility of avoidance of the wetlands and brook crossing altogether. perhaps by maintaining the existing road width while raising the bridge superstructure. The next step would require minimizing impacts through increasing slopes to 1:1 or reducing the road shoulders at the brook crossing. Although compensation for impacts is generally an alternative, it would be difficult to compensate for water quality impacts, leaving the best alternative as some form of design changes to reduce the potential for impacts.

Endangered Species. A Massachusetts Natural Heritage Database search indicated no rare species or adverse natural communities near the site.

Floodplains. The bridge site is located in a 100-year floodplain, according to Community Panel 250252-0005B. Beaver Brook crosses under Maskwonicut Street approximately 50 feet to the northwest of the bridge. [Impacts to the floodplain are dependent on the final road design.] No base flood elevations were available to determine the exact involvement of the bridge reconstruction in the floodplain, however the FIRM map indicates the floodplain in the Maskwonicut Street area is closely associated with the street channel. Once the final bridge design is completed, potential impacts to the floodplain will require following the eight step process outlined in Executive Order 11988. Steps will need to be taken to minimize involvement in the floodplain, if impacts remain compensatory storage will be required for any expected losses.

Coastal Resources. The Maskwonicut Street bridge is not located in an area of coastal influence or within the Coastal Zone Boundary.

Water Resources. The Maskwonicut Street bridge is located 1000 feet north of a town well which is adjacent to Beaver Brook. Additional town wells are located at least 3000 feet to the south. According to the Town of Sharon Zoning Map (1989), the bridge site is also located in a groundwater protection district, which is regulated by the local Zoning Board.

Surface waters associated with the bridge site include Beaver Brook, which flows under Maskwonicut Street on the north side of the bridge. Bordering wetlands are associated with the bridge site on the north and south sides. Buffer zone impacts are unavoidable, requiring application through the local Conservation Commission. Encroachment into Beaver Brook crossing area is dependent on the final road design.

Pending final plans for the bridge reconstruction, potential impacts to the Beaver Brook crossing and bordering wetlands may occur due to its proximity and the proposed road widening. The bridge site is also located in a groundwater protection district, however the closest town well is found 1000 feet to the north. Due to the limited extent of work associated with the bridge reconstruction, direct impacts to these resources would not be expected. The primary concern of the project would be short term impacts to the brook and those associated with the construction activities. Once completed, the bridge and road would not be expected to increase the amount of contaminants entering the brook, wetlands or groundwater.

The mitigation planning process is described in the wetlands section.

Summary of Impacts. No adverse impacts are expected to endangered species and coastal resources. Adverse impacts are expected to occur to wetlands, wildlife, floodplains, and water resources.

11.4.24 Boston, MA

11.4.24.1 Readville Paralleling Station.

Wetlands. No wetlands occur on the site of the proposed Readville paralleling station site. No wetlands occur within the 100-foot buffer zone regulated by the State of Massachusetts and the City of Boston.

Wildlife. Site characteristics of the proposed paralleling station location include a sparse overstory of cottonwood (*Populus deltoides*). The site understory is predominately little bluestem, with some multiflora rose and mullein. Surrounding land use includes a major train yard and passenger station, and industrial/residential development. The Suffolk County Soil Survey indicates the area soils are Udorthents, described as a loamy fill material. Wildlife use of the area is limited by the lack of vegetative diversity and available cover. Located in a heavily developed area with a large rail yard adjacent, development of this paralleling station would not be expected to impact upon the limited wildlife habitat values of the area. The mitigation effort at the Readville paralleling station should focus on stabilizing any slopes and disturbed areas, while compensation for any losses to bird cover and nesting habitat could include plantings of shrubs such as tartarian honeysuckle and Russian olive.

Endangered Species. A Massachusetts Natural Heritage Database search indicated no rare species or adverse natural communities near the site.

Floodplains. The proposed site of the Readville paralleling station does not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Boston, Massachusetts, Community Panel 250286-0028C.

Coastal Resources. The Readville paralleling station site is located outside the area of coastal influence and the Coastal Zone Boundary as noted in 30 CMR 20.99 of the Massachusetts Code of Regulations.

Water Resources. No municipal water wells or water protection districts are located in the vicinity of the proposed Readville paralleling station site according to the Boston Conservation Commission and the Massachusetts Department of Environmental Protection. (personal communication, 1993). There are no surface waters associated with this site. No wetlands are expected to be filled or dredged for the proposed paralleling station site and no wetlands ar e located within the 100-foot buffer zone regulated by the Commonwealth of Massachusetts and the City of Boston. No impacts to water resources are expected at this site with no wetlands, municipal wells or water protection districts associated with the project area.

Areas of Critical Environmental Concern. The proposed Readville paralleling station lies approximately 300 feet inside the northern boundary of the Fowl Meadow Area of Critical Environmental Concern. A review will be required by the Commonwealth of Massachusetts, Department of Environmental Management, Inland ACEC Program under 301 CMR 12.00 of the Massachusetts Code of Regulations.

Resource impacts associated with the Readville paralleling station are limited since the project area is heavily developed and the presence of resources is limited. No wetlands or buffer zones are located in the vicinity of the project and the Massachusetts Natural Heritage Database search indicated no rare species or adverse natural communities near the site. Other resources indicated by the ACEC office director as important in the Fowl Meadow ACEC include wildlife and groundwater protection. Neither of these resources were found to be a consideration on this site, as noted in the sections above.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.24.2 Roxbury Crossing Substation.
Wetlands. There are no wetlands associated with the Roxbury crossing substation site, utility corridor or the 100 foot buffer around it.

Wildlife. Site characteristics of the substation location and adjacent utility corridor include an urban environment with a train station and numerous businesses and homes in the immediate area. The proposed site of the substation is an empty lot with a 6-8 foot chain link fence surrounding it and very limited vegetation. The site represents an area of minimal value to wildlife due to a lack of food, cover, and access. Located in a heavily developed area, neither the substation nor utility connector would be expected to impact upon the limited wildlife habitat values of the area.

Endangered Species. A Massachusetts Natural Heritage Database Search indicated no rare species or adverse natural communities near this site.

Floodplains. The substation site and adjacent feeder lines do not impact any floodplains, according to the FEMA Flood Insurance Rate Map for Boston, Community Panel 250286-0010C.

Coastal Resources. The Roxbury Crossing substation site and feeder line are located outside the area of Coastal Influence and the Coastal Boundary as noted in 301CMR 20.99 of the Massachusetts Code of Regulations.

Water Resources. No record of municipal or private water wells could be found through Boston according to the Conservation Commission and the Massachusetts Department of Environmental Protection (personal communication, 1993). There are no surface waters associated with this site. No wetlands or buffer zones are expected to be filled or dredged by the Roxbury Crossing substation site. No water resource impacts are expected at the Roxbury Crossing substation, due to the lack of wells and water resources in the project vicinity.

Summary of Impacts. No adverse impacts are anticipated to any of the resource categories.

11.4.25 Moveable Bridges with Underwater Cable Crossings.

Five moveable bridges located in Connecticut will require submarine cables to maintain continuous electrical service. These cables will enter and exit the water from the bridge supports closest to the moveable section of the bridge.

11.4.25.1 Wetlands. All five bridges are located in Navigable Waters of the United States; as such permits are required for certain activities pursuant to Section 10 of the Rivers and Harbors Act along with Section 404 of the Clean Water Act. No activities are proposed to take place along the shore or in adjacent wetlands. The cable will be buried under the river bed for a distance corresponding to the expanse between the bridge supports closest to the moveable sections. Any disturbance associated with these sites will be temporary. Although the final determination is dependent on the final plans plus methods no impacts are expected with the river crossings. In order to bury the cable, Army Corps of Engineers personnel noted a section 404 permit would be required. The burying of the cables would be considered dredge activities even though it is only a temporary disturbance. A permit is also required under Section 10 of the Rivers and Harbors Act, due to its location within a navigable waterway.

11.4.25.2 Wildlife. All five bridges are located in areas of estuarine habitat. Wildlife and fisheries impacts associated with the cable crossings are generally dependent on final design plans as well as the timing of the project. Issues identified by Connecticut DEP-Marine Fisheries personnel indicate the preliminary concerns for all five crossings involve the temporary impacts of turbidity on marine estuarine and anadromous fish, meaning those species which travel from the sea to freshwater for breeding purposes. Winter flounder (*Pseudopleuronectes americanus*) was also identified as susceptible to impacts associated with turbidity. Table 4 in Appendix E provides a list of fish species which occur in these rivers.

The long term impact of electromagnetic fields (EMFs) generated by the cable on existing fisheries was also identified by DEP personnel as a concern. Identification of impacts to fisheries resources are dependent on final plans and especially the seasonal timing of the project and methods of burying cables. Impacts arising from EMFs noted by Fisheries Division personnel include references which indicated a number of fish species are sensitive to low frequency EMFs. Technical Study Five of this report looks into potential impacts associated with EMFs and as reported earlier found that field levels associated with the cables decrease to minimal amounts in short distance. This information in combination with the limited disturbance of any buried cable should result in limited impacts related to EMFs.

The mitigation effort is dependent on final plans and a final determination of impacts. However, it would be expected to include restricting work on a seasonal basis to minimize impacts on spawning and migrating finfish.

11.4.25.3 Endangered Species. The U.S. Fish & Wildlife Service and National Marine Fisheries Service identified the federally endangered short-nosed sturgeon as occurring in the Connecticut River on a seasonal basis. A determination of impacts associated with the cable crossing of the Connecticut River will be made by NMFS when more complete plans are available and the seasonal timing of the work is known. No other federally listed species were identified for the cable crossings of the Niantic River, Shaw's Cove, Thames River and Mystic River.

The Connecticut Natural Diversity Database search for state listed Endangered, Threatened or Special Concern Species has been requested, but has not been received.

11.4.25.4 Floodplains. All five bridge sites are located in coastal flood hazard areas, as identified on the FEMA Flood Insurance Rate Maps for the appropriate communities. Placement of the cables in the water should not result in any alteration of shoreline configurations or increase the coastal flood hazard.

11.3.25.5 Coastal Resources. All five of the moveable bridges are located within the Coastal Boundary as indicated in the State of Connecticut Coastal Resources Maps and all five lie within the Coastal Flood Hazard Area. The Connecticut, Thames, and Mystic Rivers are identified as Estuarine Embayments. The southern shore of the Niantic River is identified as Beaches and Dunes. The shorelines of Shaw's Cove, as well as the Thames and Mystic Rivers, are identified as Developed Shorefront.

Under Section 307 (c) of the Coastal Zone Management Act, the state must certify that an activity is consistent with the standards and policies of the Connecticut Coastal Management Statutes. Amtrak must also demonstrate that activities are consistent with coastal resource and use policies set forth in C.G.S. Section 22a-92; and that all adverse impacts on coastal resources as defined in C.G.S. Section 22a-93 (15) have been minimized. It is not anticipated that the proposed activities at the movable bridges will be in conflict with the standards and policies.

11.4.25.6 Water Resources. The four major waterways which these cables cross are not associated with any water supply wells, surface water supplies or any water supply protection districts. No wells are located on the immediate shore areas, according to the planning offices in the affected communities.

The trenching or burying of the cable beneath the river bottom will result in disturbance of sediments and a temporary turbidity increase requiring a Section 404 permit from the Army Corps of Engineers (personal communication, 1993). The Section 401 Water Quality Certification requirements direct applicants to the State of Connecticut Water Quality Statutes C.G.S. Section 22a-426. Since this activity lies within the Connecticut coastal boundary, the Coastal Zone Management Act also applies. The Act outlines the policies which must be complied with and impacts, such as degradation of water quality through the introduction of any contaminants or changes in circulation patterns by altering channel contours, which must be minimized. As all activities associated with this project are temporary, it is anticipated that measures to mitigate these impacts can be identified upon the availability of more complete construction plans.

APPENDIX A
Natural Resource and Impact Tables

TABLE 1. OCCURRENCE OF NATURAL RESOURCES ON SUBSTATION SITES AND POWER LINE CORRIDORS[1]

SUBSTATION & UTILITY CORRIDOR	MILE POST	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Branford Branford, CT	79.26	near substation-to-rail feeder	limited	none	none	none	private wells
New London New London, CT	123.55	none	very limited	none	substation	substation: developed shorefront	none
Warwick Warwick, RI	176.91	none	limited	none	none	none	none
Roxbury Crossing Boston, MA	226.02	none	minimal	none	none	none	none

[1] NOTES:

Wetlands indicates whether the site is in wetlands or the buffer zone. Buffer zone in Connecticut is 100 feet unless otherwise specified in text. Buffer zone in Rhode Island is 50 feet unless otherwise specified in text. Buffer zone in Massachusetts is 100 feet.

Wildlife indicates the value of the site as wildlife habitat and considers the presence and appropriateness of the plant community for providing food and cover and the diversity of the habitat (e.g. open fields, wetlands, forest).

Endangered Species indicates the presence of threatened or endangered species, as defined in the Endangered Species Act, using information provided by the states' Natural Heritage Inventories.

Floodplains indicate whether a site falls within the boundaries of the 100-year flood zone.

Coastal Resources indicates whether the site falls within the coastal zone, as delineated by each states coastal zone management agency. In Connecticut, coastal resources are categorized and the category shoreland describes uplands.

Water Resources indicates whether the site is on or near ground or surface drinking water supplies, other surface waters, or water resource protection areas.

TABLE 2. OCCURRENCE OF NATURAL RESOURCES ON SWITCHING STATION SITES[1]

SWITCHING STATION & LOCATION	MILE POST	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Westbrook Old Saybrook, CT	103.53	buffer	limited	none	none	none	none
Richmond Richmond, RI	150.35	buffer[2]	limited	none	yes	none	sole source aquifer (EPA)
Norton Attleboro, MA	198.99	buffer	diverse edge habitat	none	none	none	Bungay River Water Resource Protection District

[1] See notes following Table 1 for descriptions of resource categories.
[2] Buffer of rivers greater than 10 feet wide is 200 feet. This site lies approximately 90 feet from the Pawtucket River.

TABLE 3. OCCURRENCE OF NATURAL RESOURCES ON PARALLELING STATION SITES[1]

PARALLELING STATION & LOCATION	MILE POST	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Leetes Island Guilford, CT	85.99	none	limited	none	yes	coastal flood hazard area	none
Madison Madison, CT	92.41	none	limited	none	none	none	none
Grove Beach Westbrook, CT	99.11	buffer	limited	none	none	shorelands	none
Old Lyme Old Lyme, CT	109.50	none[2]	moderate	none	none	shoreland[2]	none
Millstone Waterford, CT	117.56	buffer	moderate: many species	none	none	shoreland	buffer
Noank Groton, CT	129.46	buffer of stream	limited	none	yes	coastal flood hazard area	buffer of stream
Stonington Stonington, CT	134.65	none	moderate	state endangered species	yes	shoreland	none
State Line Stonington, CT	139.93	none[2]	limited	none	none	shoreland[2]	sole source aquifer (EPA)

(continued on next page)

[1] See notes following Table 1 for descriptions of resource categories.

[2] These sites are listed on town wetlands maps as poorly drained soils. which are considered wetlands by the towns and Long Island Sound (coastal zone) Program. Field investigations, however, determined that these are filled areas with no wetlands characteristics. Amtrak should apply for reclassification of these sites. Upon reclassification, they will be classified as shorelands - the coastal zone designation for uplands.

TABLE 3. CONTINUED. OCCURRENCE OF NATURAL RESOURCES ON PARALLELING STATION SITES

PARALLELING STATION & LOCATION	MILE POST	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Bradford Westerly, RI	145.19	onsite or in buffer - pending	limited	none	none	none	critical recharge area& sole source aquifer (EPA)
Kingston So. Kingstown, RI	157.11	none	high	none	none	none	sole source aquifer (EPA)
Exeter Exeter, RI	161.78	none	moderate	none	none	none	sole source aquifer (EPA)
East Greenwich No. Kingstown, RI	169.80	none	limited	none	none	none	wellhead protection area; groundwater recharge district
Elmwood Providence, RI	181.70	none	limited	none	none	none	none
Providence Pawtucket, RI	187.55	none	limited	none	none	none	none
Attleboro Attleboro, MA	193.40	buffer	limited	none	none	none	Ten Mile River buffer
East Foxboro Foxboro, MA	205.70	none	moderate	none	none	none	Adjacent to Canoe River ACEC
Canton Sharon, MA	212.40	none	limited	none	none	none	none
Readville Boston, MA	219.10	none	limited	none	none	none	300 ft from Fowl Meadow ACEC

TABLE 4. OCCURRENCE OF NATURAL RESOURCES AT BRIDGES TO BE MODIFIED

BRIDGE NAME	MILE POST	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Johnnycake Hill Road Old Lyme, CT	108.51	none	edge habitat	none	none	none	none
Millstone Point Road Waterford, CT	117.31	buffer/pending	limited	none	none	shoreland	none
Burdickville Road Charlestown, RI	148.41	westerly approach road/pending	moderate	none	none	none	sole source aquifer (EPA)
Kenyon School/ Beaver River Road Richmond, RI	154.04	none	limited	none	none	none	sole source aquifer (EPA)
RI Route 138/Main St. So. Kingstown, RI	158.32	none	edge habitat	none	none	none	groundwater protection overlay district; sole source aquifer (EPA)
Pettaconsett Avenue Warwick, RI	178.48	none	limited	none	none	none	none
Park Avenue Cranston, RI	180.29	none	limited	none	none	none	pending
Depot Street Sharon, MA	211.04	buffer	limited	none	none	none	groundwater protection district, adjacent town well
Maskwonicut Street Sharon, MA	211.62	wetlands & buffer - pending[2]	moderate	none	yes	none	groundwater protection district, Beaver Brook

[1] See notes following Table 1 for descriptions of resource categories.
[2] Buffer of 200 feet from rivers greater than 10 feet wide may apply.

TABLE 5. OCCURRENCE OF NATURAL RESOURCES AT MOVEABLE BRIDGE CABLE CROSSINGS

MOVEABLE BRIDGE & LOCATION	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Connecticut River Old Saybrook/Old Lyme, CT	in river	moderate	federal - short nosed sturgeon	yes	coastal flood hazard area; estuarine embayment	Connecticut River
Niantic River East Lyme/ Waterford, CT	in river	moderate	none - pending NMFS	yes	coastal flood hazard area; beaches & dunes	Niantic River
Shaw's Cove New London, CT	in river	moderate	none - pending NMFS	yes	coastal flood hazard area; developed shorefront	Shaw's Cove
Thames River New London/ Groton, CT	in river	moderate	none - pending NMFS	yes	coastal flood hazard area; estuarine embayment; developed shorefront	Thames River
Mystic River Groton/ Stonington, CT	in river	moderate	none - pending NMFS	yes	coastal flood hazard area; estuarine embayment; developed shorefront	Mystic River

TABLE 6. ADVERSE IMPACTS TO NATURAL RESOURCES ON SUBSTATION SITES AND UTILITY CORRIDORS[1]

SUBSTATION & UTILITY CORRIDOR	MILE POST	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Branford Branford, CT	79.26	no	no	N/A	N/A	N/A	yes
New London New London, CT	123.55	N/A	no	N/A	yes	no	N/A
Warwick Warwick, RI	176.91	N/A	no	N/A	N/A	N/A	N/A
Roxbury Crossing Boston, MA	226.02	N/A	no	N/A	N/A	N/A	N/A

[1] NOTES:

Wetlands Any bridge modification or facility site located in a wetland as defined by Federal or the appropriate state regulations is considered to have a adverse impact.

Wildlife Any degradation of wildlife habitat considered to be of high value will be considered a adverse impact, including the construction of facilities within the high value habitat is considered adverse.

Endangered Species Any degradation of the designated habitat for a Federal or state designated species is considered a adverse impact.

Floodplains Any facility sited in the 100 year floodplain is considered adverse.

Coastal Resources Any facility sited in coastal flood hazard as defined by Federal and appropriate state regulations is considered to have a adverse impact.

Water Resources Any action that requires state water quality certification or is in a Federal, state or local aquifer protection district.

N/A no resource present

TABLE 7. ADVERSE IMPACTS TO NATURAL RESOURCES ON SWITCHING STATION SITES[1]

SWITCHING STATION & LOCATION	MILE POST	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Westbrook Old Saybrook, CT	103.53	no	no	N/A	N/A	N/A	N/A
Richmond Richmond, RI	150.35	no	no	N/A	yes	N/A	yes
Norton Attleboro, MA	198.99	no	no	N/A	N/A	N/A	yes

TABLE 8. ADVERSE IMPACTS TO NATURAL RESOURCES ON PARALLELING STATION SITES[1]

PARALLELING STATION & LOCATION	MILE POST	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Leetes Island Guilford, CT	85.99	N/A	no	N/A	yes	no	N/A
Madison Madison, CT	92.41	N/A	no	N/A	N/A	N/A	N/A
Grove Beach Westbrook, CT	99.11	no	no	N/A	N/A	no	N/A
Old Lyme Old Lyme, CT	109.50	N/A	no	N/A	N/A	no	N/A
Millstone Waterford, CT	117.56	no	no	N/A	N/A	no	no
Noank Groton, CT	129.46	no	no	N/A	yes	no	no
Stonington Stonington, CT	134.65	N/A	no	yes	yes	no	N/A
State Line Stonington, CT	139.93	N/A	no	N/A	N/A	no	yes

continued on next page

TABLE 8. CONTINUED. ADVERSE IMPACTS TO NATURAL RESOURCES ON PARALLELING STATION SITES

PARALLELING STATION & LOCATION	MILE POST	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Bradford Westerly, RI	145.19	no	no	N/A	N/A	N/A	yes
Kingston So. Kingstown, RI	157.11	N/A	yes	N/A	N/A	N/A	yes
Exeter Exeter, RI	161.78	N/A	no	N/A	N/A	N/A	yes
East Greenwich No. Kingstown, RI	169.80	N/A	no	N/A	N/A	N/A	yes
Elmwood Providence, RI	181.70	N/A	no	N/A	N/A	N/A	N/A
Providence Pawtucket, RI	187.55	N/A	no	N/A	N/A	N/A	N/A
Attleboro Attleboro, MA	193.40	no	no	N/A	N/A	N/A	yes
East Foxboro Foxboro, MA	205.70	N/A	no	N/A	N/A	N/A	no
Canton Sharon, MA	212.40	N/A	no	N/A	N/A	N/A	N/A
Readville Boston, MA	219.10	N/A	no	N/A	N/A	N/A	no

TABLE 9. ADVERSE IMPACTS TO NATURAL RESOURCES AT BRIDGES TO BE MODIFIED

BRIDGE NAME	MILE POST	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Johnnycake Hill Road Old Lyme, CT	108.51	N/A	no	N/A	N/A	N/A	N/A
Millstone Point Road Waterford, CT	117.31	no	no	N/A	N/A	no	N/A
Burdickville Road Charlestown, RI	148.41	no	no	N/A	N/A	N/A	no
Kenyon School/ Beaver River Road Richmond, RI	154.04	N/A	no	N/A	N/A	N/A	no
RI Route 138/Main St. So. Kingstown, RI	158.32	N/A	no	N/A	N/A	N/A	no
Pettaconsett Avenue Warwick, RI	178.46	N/A	no	N/A	N/A	N/A	N/A
Park Avenue Cranston, RI	180.29	N/A	no	N/A	N/A	N/A	no
Depot Street Sharon, MA	211.04	no	no	N/A	N/A	N/A	yes
Maskwonicut Street Sharon, MA	211.62	no	no	N/A	no	N/A	yes

TABLE 10. MOVEABLE BRIDGE CABLE CROSSINGS

MOVEABLE BRIDGE & LOCATION	MILE POST	WETLANDS	WILDLIFE VALUE	ENDANGERED SPECIES	FLOOD PLAINS	COASTAL RESOURCES	WATER RESOURCES
Connecticut River Old Saybrook/Old Lyme, CT	106.89	no	yes	yes	no	yes	yes
Niantic River East Lyme/ Waterford, CT	116.74	no	no	no	no	yes	yes
Shaw's Cove New London, CT	122.65	no	no	no	no	yes	yes
Thames River New London/ Groton, CT	124.09	no	no	no	no	yes	yes
Mystic River Groton/ Stonington, CT	132.16	no	no	no	no	yes	yes

APPENDIX B
Sample Functional Assessment Sheet

WETLAND FUNCTIONAL ASSESSMENT

Wetland ID: Prepared by: Date:

1. Groundwater Recharge/Discharge

1. Wetland has an inlet and no outlet (recharge).
2. Wetland has an outlet and no inlet (discharge).
3. There is an obvious discharge differential between inlet and outlet (neg. = recharge, pos. = discharge).
4. There are signs of discharge (seeps, unfrozen areas, etc.).
5. Water table wetland.
6. Perched wetland.
7. Wetland is associated with stratified drift aquifer, or an aquifer is not far downstream, or public wells are downstream.

Occurrence of function: Recharge Discharge Unknown
Principal valuable? Y N
Comments:

2. Flood Storage and Desynchronization

A. Opportunity for the wetland to receive high runoff or flood flows

1. The wetland's watershed is large relative to the size of the wetland.
2. There are relatively few wetlands upstream in the wetland's watershed.
3. The wetland's watershed is highly developed or has sources of runoff.

B. Ability of the wetland to store, delay, or desynchronize flood flows

4. There is no outlet, or the outlet is constricted.
5. There is a relatively large flood storage area or volume.
6. Flow through the wetland is diffused or sinuous.
7. Vegetation is woody or dense, or there is high vegetation/water interspersion.
8. The wetland is not a fringe, island, or hillside wetland.
9. The water regime is seasonally flooded or drier.
10. The wetland is large (relative to others in the study area).
11. The wetland is in the upper half of the watershed of the flood-prone lands.
12. There are developed flood-prone lands downstream.

Occurrence of function: Y N
Principal valuable? Y N
Comments:

3. Sediment and Shoreline Stabilization

A. Potential for erosion within the wetland

1. There is some flow present or a shoreline present.
2. The flow is high velocity or there is substantial unsheltered open water or wave action.
3. There are steep slopes or sediment sources upstream or evidence of sedimentation within the wetland.

B. Ability of the wetland to reduce erosional potential or stabilize shorelines

4. There is confined or impounded water within the wetland.
5. The vegetation is woody or dense emergent (within the area of flow or along shore).
6. In potential erosional areas, the vegetation is wide or well interspersed with open water.

Occurrence of function: Y N
Principal valuable? Y N
Comments:

4. Sediment/Toxicant Retention

A. Potential for inputs of sediments or toxicants

1. There are sources of sediments or toxicants upstream, or steep slopes upstream.
2. The wetland is low in the watershed (of downstream receiving waters that would be affected by pollutants).

B. Ability of the wetland to retain sediment or toxicant inputs

3. There is no outlet or a constricted outlet.
4. There has been damming or impoundment within the wetland , or the wetland has known flood storage value.
5. Flow is diffused or very low velocity, with weak or no channel development.
6. There is no erosion evident and little unsheltered open water.
7. Vegetation, especially in the area of flow, is mostly woody or dense emergent, with little open water.
8. There is high vegetation/water interspersion or wide vegetation within the area of flow.

Occurrence of function: Y N
Principal valuable? Y N
Comments:

5. Nutrient Retention/Transformation

A. Potential for nutrient inputs

1. There are sources of nutrients upstream (lawns, fish hatcheries, treatment plants, etc.).

B. Ability of the wetland to retain nutrient inputs

2. Flow is diffused or very low velocity, with weak or no channel development.
3. Flow is dammed or impounded or ponded, or the wetland has known flood storage value.
4. Vegetation within the area of flow is dense or wide.
5. Vegetation within the area of flow is woody or emergent.

6. The wetland has known sediment trapping potential.
Occurrence of function: Y N
Principal valuable? Y N
Comments:

6. Nutrient Export

A. Nutrient production within the wetland

1. The wetland is vegetated with mostly aquatic bed or emergent vegetation, or has high instream vegetation interspersion, or is densely vegetated generally.
2. The wetland appears to have high productivity (detritus, algae, etc.).
3. The wetland is not a bog.

B. Potential for export of nutrients

4. There is an outlet.
5. The wetland is low velocity.
6. The wetland is a fringe or island wetland.

Occurrence of function: Y N
Principal valuable? Y N
Comments:

7. Aquatic Diversity/Abundance and Fish and Shellfish Habitat

1. The wetland includes aquatic habitat, especially a pond, lake, or unchannelized perennial stream.
2. Water quality is high.
3. The watershed upstream is not highly developed, with no known toxin sources.
4. There are shade and cover objects for aquatic life.
5. There are fish spawning areas (submerged vegetation or gravel beds).
6. There is aquatic bed vegetation.
7. There is some diversity of vegetation types or interspersion of vegetation and water in the aquatic habitats.
8. One of the hydroperiods is intermittently exposed or wetter.

Occurrence of function: Y N
Principal valuable? Y N
Comments:

8. Wildlife Habitat

1. The wetland is large (relative to others in the study area).
2. There is little disturbance in the wetland.
3. The surrounding habitat is in good condition.
4. The wetland's watershed is not highly developed.
5. There is vegetation class diversity or vegetation/water interspersion.
6. The wetland includes marsh habitat.

7. The edge is irregular or there are upland islands.
8. The wetland is part of a river or wetland corridor.
9. There is wildlife corridor access in surroundings (>50' wide).
10. The wetland is part of a "cluster" (many similar wetlands).
11. The wetland is part of an "oasis" (the only one of its type nearby).
12. The wetland is connected by surface water to other wetlands nearby.
13. There is observed wildlife sign.

Occurrence of function: Y N
Principal valuable? Y N
Comments:

9. Endangered Species Habitat

1. The wetland is known to contain threatened or endangered species.
2. The wetland contains critical habitat for a state or federally listed threatened or endangered species.

Occurrence of function: Y N
Principal valuable? Y N
Comments:

10. Recreation (Consumptive and Nonconsumptive)

1. The wetland is part of a recreation area, park, public forest, or refuge.
2. Fishing is available within the wetland.
3. Hunting is permitted in the wetland.
4. Hiking occurs or has the potential to occur within the wetland.
5. The wetland has many wildlife habitat features.
6. Watercourses, ponds, or lakes associated with the wetland are unpolluted.
7. The wetland has many visual/aesthetic qualities.
8. There is access to water available at the potential recreation site for boating, canoeing, or fishing.
9. The watercourse associated with the wetland is wide and deep enough to accommodate canoeing and/or non-powered boating.
10. Off-road public parking is available at the potential recreation site.
11. Travel within the wetland is reasonably easy.
12. The wetland is within a short drive or walk from highly populated ares.

Occurrence of function: Y N
Principal valuable? Y N
Comments:

11. Uniqueness/Heritage

1. The upland surrounding the wetland is primarily urban.
2. More than 3 acres of shallow (<2 m deep) permanent open water, including streams,

occurs within the wetland.

3. Three or more wetland classes are present.
4. The dominant wetland class is marsh or bog.
5. There is a high degree of interspersion of vegetation classes and/or vegetation/open water occurring in the wetland.
6. Historical buildings, stone or earthen foundations, berms, dams, mill ponds, standing structures, archeological sites, etc. occur within the wetland.
7. The wetland is a national natural landmark or recognized by the NH Natural Heritage Inventory as an exemplary natural community in NH, or is hydrologically connected to a state or federally designated river.
8. The wetland has local significance because it has biological, geological, or other features which are locally rare or unique.

Occurrence of function: Y N
Principal valuable? Y N
Comments:

12. Educational/Scientific

(not listed in ACOE;s **Guide for Permit Applicants**)

1. The potential educational site contains a diversity of wetland classes which are accessible or potentially accessible.
2. The potential educational site is undisturbed and natural.
3. The wetland has many wildlife habitat features.
4. The wetland is located within a nature preserve or wildlife management area.
5. There is off-road parking suitable for school buses at the potential educational site.
6. The potential educational site is close to schools.
7. There is direct access to a stream, pond, or lake at the potential educational site.
8. The wetland is known to be a site for scientific research.
9. The wetland has many visual/aesthetic qualities.

Occurrence of function: Y N
Principal valuable? Y N
Comments:

13. Visual Quality/Aesthetics

(not listed in ACOE;s **Guide for Permit Applicants**)

1 Multiple wetland classes are visible from primary viewing location(s).
2. Emergent marsh, bog, or open water are visible from primary viewing location(s).
3. Surrounding land use visible from primary viewing locations is largely undeveloped.
4. Visible surrounding landforms contrast sharply with the wetland.
5. Wetland views are absent of trash, debris, noise, odors, and other signs of disturbance.

Occurrence of function: Y N
Principal valuable? Y N
Comments:

APPENDIX C
Sample Field Form

NATURAL RESOURCE FIELD SHEET

PROJECT NAME:______________________________ DATE:______________
____

PROJECT NUMBER:______________________________ BY:

PROJECT LOCATION:______________________________ ______________
____

WATERSHED AREA:______________________________ ______________
____

SHEET NO:______________ WETLAND NO:________ USGS QUAD:______________
____

1. Plant species in Wetland (in order of abundance; note dominants)

Trees:______________________________
____

Saplings:______________________________
____

Shrubs:______________________________
____

Herbs:______________________________
____

2. Soils

Depth (") Remarks	Horizon	Munsell Color (Wet) Matrix	Munsell Color (Wet) Mottle	USDA Texture (Wet)

___Organic Soil (>50% of top soil 32" is O.M.)

___Histic Epipedon (8-16" layer with ≥ 20% O.M.)

___Sulfidic Material

___Aquic or Periaquic Moisture Regime (saturated by groundwater)

___Reducing Conditions (colorimetric test)

___Gleying below A or <10"

___Matrix Chroma ≤2 (mottle soils) below A or <10"

___Matrix Chroma ≤1 (unmottles) below A or <10"

___On NTCHS list

IF SOILS ARE SANDY:

___High Organic Content in Surface Horizon

___Dark Vertical Streaking in Subsurface Horizons

___Wet Spodosols

Other Observations:

3. Hydrology

____Inundated

____Depth to Saturation

____Depth to Free Water

____In Major Portion of Root Zone?

Other Observations:

____Water Marks (woody vegetation)

____Drift Lines (along channels)

____Water-Bourne Sediments

____Drainage Patterns (scour, etc.)

"Unofficial" indicators:

____Oxidized Rhizoshere

____Water-Stained Leaves

____Shallow Root Systems

4. Classifications (Cowardin et al.)

____

____

____

____

Functional Assessment Checklist

1. Inlets (size, type):

Outlets (size, type):

2. Watercourses | Width | Depth | Velocity | Composition

Watercourses	Width	Depth	Velocity	Composition
________	______	______	________	__________
________	______	______	________	__________
________	______	______	________	__________
________	______	______	________	__________

3. Flow diffused ___
    meandering ___
    fairly straight ___
    channelized ___

4. Fetch (length of open water):

5. Hydroperiod:

6. Disturbance within wetland:

7. Condition of surroundings:

8. Sources of excess runoff, contaminants, or sediments within wetland's watershed (roads, farm fields, lawns, parking lots, etc.).

9. Vegetation cover: type and extent (%)
FO1___ FO4___ SS1___ SS4___ EM___ AB___ OW___ Other:______

10. Habitat interspersion (refer to WET figures)

Vegetation class interspersion:

Vegetation/open water interspersion:

Wetland/upland edge irregularity:

11. Productivity:

High? (algae, duckweed, other signs of high productivity)
Low? (nutrient poor, acidic, bog, fibric or hemic soil, leatherleaf or other low nutrient species)
Unknown

12. Aquatic habitat besides watercourses described above?
(size, depth, substrate, etc.)

13. Fish habitat cover (describe)

14. Wildlife features (sign, distinct habitats, etc.)

15. Recreation: (describe evidence)

16. Aesthetics: visual contrast, diversity, visual accessibility, eyesores, etc.

APPENDIX D
Wetland Summary Sheet

WETLAND FUNCTIONAL ASSESSMENT JSM 1/14/92 FAII

Wetland ID: ________ **Prepared by:** ____________________ Date: ________

Classifications: ____________________ **Area (ac):** ________ Shape rounded, narrow, winding, convoluted?

Principal vegetation: ____________________ Soil substrate: ____________________

Disturbance within wetland: ____________________ Surrounding land use: ____________________

Watercourses/water bodies within wetland: ____________________

Wildlife observations: ____________________

POTENTIAL IMPACTS

Type of impact	Impact area (ac)	Wetland types impacted & key characteristics

FUNCTIONS	Occurrence Y/N	Rationale (Number)	Principal Valuable?	Comments	ACOE conf. level
Groundwater recharge/ discharge					
Flood storage and desynchronization					
Sediment and shoreline stabilization					
Sediment/toxicant retention					
Nutrient retention/ transformation					
Nutrient export					
Aquatic diversity/abundance & fish & shellfish hab.					
Wildlife habitat					
Endangered species habitat					
Recreation (consumptive and non-consumptive)					
Uniqueness/heritage					
Educational/scientific					
Visual quality/aesthetics					

APPENDIX E
Animal Species List

TABLE 1
AMPHIBIANS AND REPTILES WITH RANGES OVERLAPPING THE STUDY AREA

	Species	Scientific Name
o*	Marbled Salamander	(Ambystoma opacum)
*	Jefferson Salamander	(Ambystoma jeffersonianum)
o*	Blue-Spotted Salamander	(Ambystoma laterale)
o*	Tremblay's Salamander	(Ambystoma tremulayi)
	Spotted Salamander	(Ambystoma maculatum)
	Red-Spotted Newt	(Notophthalmus v. viridescens)
	Northern Dusky Salamander	(Desmognathus f. fuscus)
	Redback Salamander	(Plethodon cinereus)
	Four-Toed Salamander	(Hemidactylium scutatum)
	Northern Two-Lined Salamander	(Eurycea b. bislineata)
o*	Eastern Spadefoot	(Scaphiopus h. holbrookii)
	Eastern American Toad	(Bufo a. americanus)
o	Fowler's Toad	(Bufo woodhousii fowleri)
	Northern Spring Peeper	(Hyla c. crucifer)
	Gray Treefrog	(Hyla versicolor)
	Bullfrog	(Rana catesbeiana)
	Green Frog	(Rana clamitans melanota)
	Wood Frog	(Rana sylvatica)
	Pickeral Frog	(Rana palustris)
*	Northern Leopard Frog	(Rana pipiens)
	Common Snapping Turtle	(Chelydra s. serpentina)
*	Stinkpot	(Sternotherus odoratus)
o*	Spotted Turtle	(Clemmys guttata)
o*	Bog Turtle	(Clemmys muhlengerbii)
	Wood Turtle	(Clemmys insculpta)
*	Eastern Box Turtle	(Terrapene c carolina)
*	Eastern Painted Turtle	(Chrysemys p. picta)
o*	Blanding's Turtle	(Emydoidea blandingii)
	Northern Water Snake	(Nerodia s. sipedon)
*	Northern Redbelly Snake	(Storeria o. occipitomaculata)
	Northern Brown Snake	(Storeria d. delkayi)
	Eastern Garter Snake	(Thamnophis s. sirtalis)
	Eastern Ribbon Snake	(Thamnophis s. sauritus)
*	Eastern Hognose Snake	(Heterodon platyrhinos)
	Northern Ringneck Snake	(Diadophis punctatus edwardsi)
	Eastern Worm Snake	(Carphophis a. amoenus)
	Northern Black Racer	(Coluber c. constrictor)
	Eastern Smooth Green Snake	(Opheodrys v. vernalis)
*	Black Rat Snake	(Elaphe o. obsoleta)

TABLE 2
BIRDS WITH RANGES OVERLAPPING THE STUDY AREA

	Species	Scientific Name
	Pied-billed Grebe	(Podilymbus podiceps)
	American Bittern	(Botaurus lentiginosus)
	Least Bittern	(Ixobrychus exilis)
	Great Blue Heron	(Ardea herodias)
	Green-Backed Heron	(Butorides striatus)
	Black-Crowned Night Heron	(Nycticorax nycticorax)
*	Yellow-Crowned Night Heron	(Nycticorax violaceus)
*	Glossy Ibis	(Plegadis falcinellus)
*	Mute Swan	(Cygnus olor)
	Canada Goose	(Branta canadensis)
	Wood Duck	(Aix sponsa)
*	Green-winged Teal	(Anas crecca)
	American Black Duck	(Anas rubripes)
	Mallard	(Anas platyrhynchos)
*	Northern Pintail	(Anas acuta)
*	Blue-winged Teal	(Anas discors)
*	Gadwall	(Anas strepera)
*	American Wigeon	(Anas americana)
*	Canvasback	(Aythya valisineria)
	Ring-necked Duck	(Aythya collaris)
*	Common Goldeneye	(Bucephala clangula)
*	Bufflehead	(Bucephala albeola)
*	Common Merganser	(Mergus merganser)
*	Red-breasted Merganser	(Mergus serrator)
*	Turkey Vulture	(Cathartes aura)
*	Osprey	(Pandion haliaetus)
o*	Bald Eagle	(Haliaeetus leucocephalus)
	Northern Harrier	(Circus cyaneus)
	Sharp-shinned Hawk	(Accipiter striatus)
	Cooper's Hawk	(Accipiter cooperii)
	Northern Goshawk	(Accipiter gentilis)
	Red-shouldered Hawk	(Buteo lineatus)
	Broad-winged Hawk	(Buteo platypterus)
	Red-tailed Hawk	(Buteo jamaicensis)
	Rough-legged Hawk	(Buteo lagopus)
	American Kestrel	(Falco sparverius
o*	Peregrine Falcon	(Falco peregrinus)
	Ring-necked Pheasant	(Phasianus colchicus)
	Ruffed Grouse	(Bonasa umbellatus)

TABLE 2, CONTINUED
BIRDS WITH RANGES OVERLAPPING THE STUDY AREA

	Species	Scientific Name
*	Wild Turkey	(Meleagris gallopavo)
	Northern Bobwhite	(Colinus virginianus)
	King Rail	(Rallus elegans)
	Virginia Rail	(Rallus limicola)
	Sora	(Porzana carolina)
o*	Common Moorhen	(Gallinula chloropus)
	Killdeer	(Charadrius vociferus)
	Spotted Sandpiper	(Actitis macularia)
*	Common Snipe	(Gallinago gallinago)
	American Woodcock	(Scolopax minor)
	Ring-Billed Gull	(Larus delawarensis)
	Herring Gull	(Larus argentatus)
	Great Black-backed Gull	(Larus marinus)
	Common Tern	(Sterna hirundo)
	Rock Dove	(Columba livia)
	Mourning Dove	(Zenaida macroura)
	Black-billed Cuckoo	(Coccyzus euthropthalmus)
	Yellow-billed Cuckoo	(Coccyzus americanus)
	Common Barn-Owl	(Tyto alba)
	Eastern Screech Owl	(Otus asio)
	Great Horned Owl	(Bubo virginianus)
	Barred Owl	(Strix varia)
	Long-eared Owl	(Asio otus)
	Short-eared Owl	(Asio flammeus)
	Northern Saw-whet Owl	(Aegolius acadicus)
	Common Nighthawk	(Chordeiles minor)
	Whip-poor-will	(Caprimulgus vociferus)
	Chimney Swift	(Chaetura pelagica)
	Ruby-throated Hummingbird	(Archilochus colubris)
	Belted Kingfisher	(Ceryle alcyon)
	Red-Headed Woodpecker	(Melanerpes erythrocephalus)
*	Red-bellied Woodpecker	(Melanerpes carolinus)
*	Yellow-bellied Sapsucker	(Sphyrapicus varius)
	Downy Woodpecker	(Picoides pubescens)
	Hairy Woodpecker	(Picoides villosus)
	Northern Flicker	(Colaptes auratus)
o*	Pileated Woodpecker	(Dryocopus pileatus)
	Eastern Wood-Pewee	(Contopus virens)
*	Acadian Flycatcher	(Empidonax virescens)

TABLE 2, CONTINUED
BIRDS WITH RANGES OVERLAPPING THE STUDY AREA

	Species	Scientific Name
	Alder Flycatcher	(Empidonax alnorum)
	Willow Flycatcher	(Empidonax traillii)
	Least Flycatcher	(Empidonax minimus)
	Eastern Phoebe	(Sayornis phoebe)
	Great Crested Flycatcher	(Myiarchus crinitus)
	Eastern Kingbird	(Tyrannus tyrannus)
	Horned Lark	(Eremophila alpestris)
	Purple Martin	(Progne subis)
	Tree Swallow	(Tachycineta bicolor)
	Northern Rough-winged Swallow	(Stelgidopteryx serripennis)
	Bank Swallow	(Riparia riparia)
o*	Cliff Swallow	(Hirundo pyrrhonota)
	Barn Swallow	(Hirundo rustica)
	Blue Jay	(Cyanocitta cristata)
	American Crow	(Corvus brachyrhynchos)
o*	Fish Crow	(Corvus ossifragus)
	Black-capped Chickadee	(Parus atricapillus)
	Tufted Titmouse	(Parus bicolor)
	Red-breasted Nuthatch	(Sitta canadensis)
	White-breasted Nuthatch	(Sitta carolinensis)
	Brown Creeper	(Certhia americana)
o*	Carolina Wren	(Thryothorus ludovicianus)
	House Wren	(Troglodtyes aedon)
	Winter Wren	(Troglodytes troglodytes)
	Sedge Wren	(Cistothorus platensis)
	Marsh Wren	(Cistothorus palustris)
	Golden-crowned Kinglet	(Regulus satrapa)
*	Ruby-crowned Kinglet	(Regulus calendula)
	Blue-gray Gnatcatcher	(Polioptila caerulea)
	Eastern Bluebird	(Sialia sialis)
	Veery	(Catharus fuscescens)
	Hermit Thrush	(Catharus guttatus)
	Wood Thrush	(Hylocichla mustelina)
	American Robin	(Turdus migratorius)
	Gray Catbird	(Dumetella carolinensis)
	Northern Mockingbird	(Mimus polyglottos)
	Brown Thrasher	(Toxostoma rufum)

TABLE 2, CONTINUED
BIRDS WITH RANGES OVERLAPPING THE STUDY AREA

	Species	Scientific Name
	Cedar Waxwing	(Bombycilla cedrorum)
	Northern Shrike	(Lanius excubitor)
	European Starling	(Sturnus vulgaris)
*	White-eyed Vireo	(Vireo griseus)
o*	Yellow-throated Vireo	(Vireo flavifrons)
	Warbling Vireo	(Vireo gilvus)
	Red-eyed Vireo	(Vireo olivaceus)
	Blue-winged warbler	(Vermivora pinus)
o*	Golden-winged Warbler	(Vermivora chrysoptera)
	Nashville Warbler	(Vermivora ruficapilla)
	Yellow Warbler	(Dendroica petechia)
	Chestnut-sided Warbler	(Dendroica pensylvanica)
*	Black-throated Blue Warbler	(Dendroica caerulescens)
	Yellow-rumped Warbler	(Dendroica coronata)
	Black-throated Green Warbler	(Dendroica virens)
	Pine Warbler	(Dendroica pinus)
	Prairie Warbler	(Dendroica discolor)
	Black-and-White Warbler	(Mniotilta varia)
	American Redstart	(Setophaga ruticilla)
	Worm-eating Warbler	(Helmitheros vermivorus)
	Ovenbird	(Seiurus aurocapillus)
*	Northern Waterthrush	(Seiurus noveboracensis)
o*	Louisiana Waterthrush	(Seiurus motacilla)
	Common Yellowthroat	(Geothlypis trichas)
*	Hooded Warbler	(Wilsonia citrina)
	Canada Warbler	(Wilsonia canadensis)
	Yellow-breasted Chat	(Icteria virens)
	Scarlet Tanager	(Piranga olivacea)
	Northern Cardinal	(Cardinalis cardinalis)
	Rose-breasted Grosbeak	(Pheucticus ludovicianus)
	Indigo Bunting	(Passerina cyanea)
	Rufous-sided Towhee	(Pipilo erythrophthalmus)
	American Tree Sparrow	(Spizella arborea)
	Chipping Sparrow	(Spizella passerina)
	Field Sparrow	(Spizela pusilla)
	Vesper Sparrow	(Pooecetes gramineus)
	Savannah Sparrow	(Passerculus sandwichensis)
	Grasshopper Sparrow	(Ammodramus savannarum)
*	Fox Sparrow	(Passerella iliaca)

TABLE 2, CONTINUED
BIRDS WITH RANGES OVERLAPPING THE STUDY AREA

	Species	Scientific Name
	Song Sparrow	(Melospiza melodia)
	Swamp Sparrow	(Melospiza georgiana)
	Whited-throated Sparrow	(Zonotrichia albicollis)
	Dark-eyed Junco	(Junco hyemalis)
	Lapland Longspur	(Calcarius lapponicus)
	Snow Bunting	(Plectrophenas nivalis)
	Bobolink	(Dolichonyx oryzivorus)
	Red-winged Blackbird	(Agelaius phoeniceus)
	Eastern Meadowlark	(Sturnella magna)
*	Rusty Blackbird	(Euphagus carolinus)
	Common Grackle	(Quiscalus quiscula)
	Brown-headed Cowbird	(Molothrus ater)
	Orchard Oriole	(Icterus spurius)
	Northern Oriole	(Icterus galbula)
	Pine Grosbeak	(Pinicola enucleator)
	Purple Finch	(Carpodacus purpureus)
	House Finch	(Carpodacus mexicanus)
	Common Redpoll	(Carduelis flammea)
	Hoary Redpoll	(Carduelis hornemanni)
	Pine Siskin	(Carduelis pinus)
	American Goldfinch	(Cardelis tristis)
*	Evening Grosbeak	(Coccothraustes vespertinus)
	House Sparrow	(Passer domesticus)

* Species at the limit of their range.
o Uncommon or rare within their range.

TABLE 3
MAMMALS WITH RANGES OVERLAPPING THE STUDY AREA

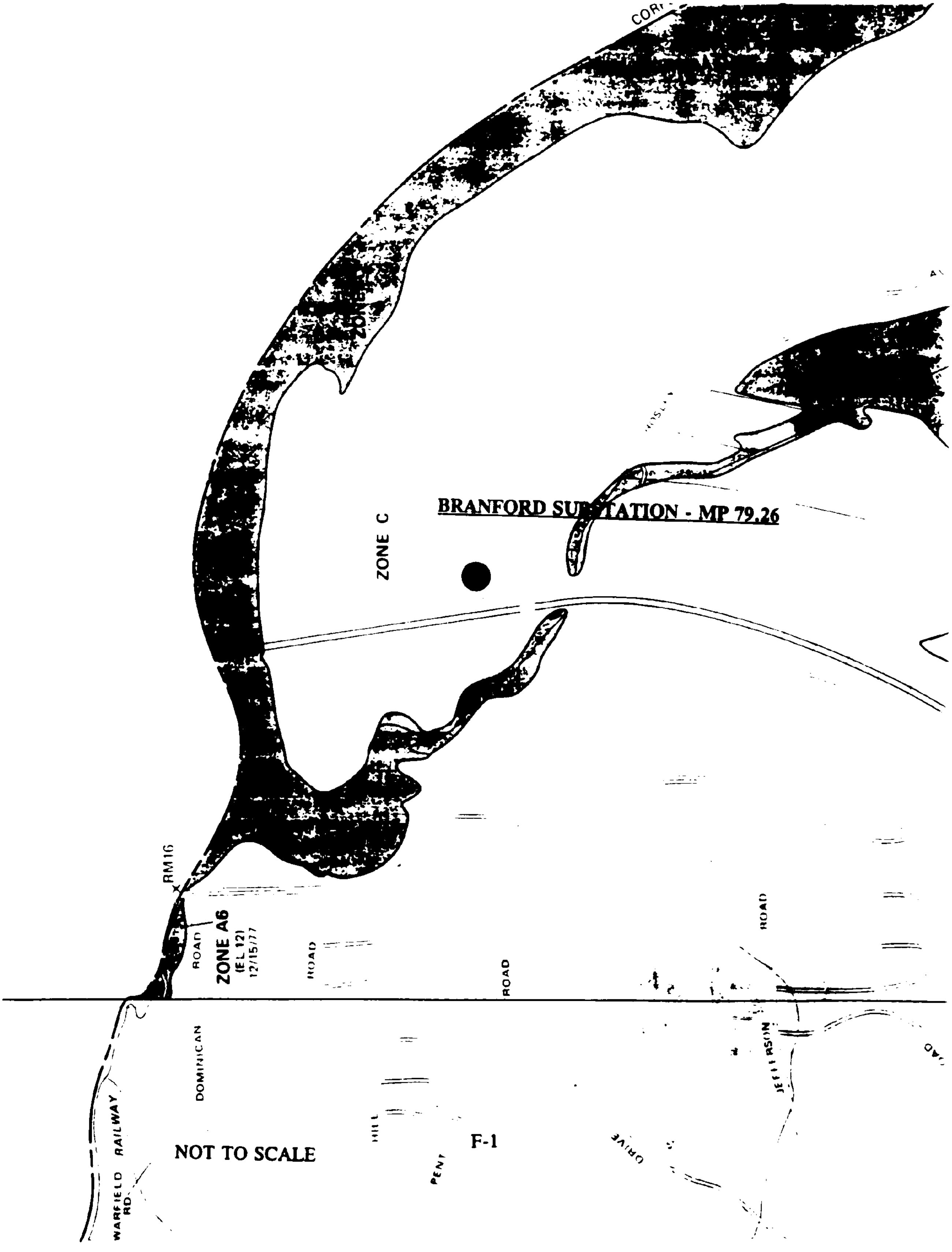
	Species	Scientific Name
	Virginia Opossum	(Didelphis virginiana)
	Masked Shrew	(Sorex cinereus)
o*	Water Shrew	(Sorex palustris)
	Northern Short-tailed Shrew	(Blarina brevicauda)
*	Hairy-tailed Mole	(Parascalops breweri)
*	Eastern Mole	(Scalopus aquaticus)
	Star-nosed Mole	(Condylura cristata)
	Little Brown Myotis	(Myotis lucifugus)
	Keen's Myotis	(Myotis keenii)
o	Silver-haired Bat	(Lasionycteris noctivagans)
o	Eastern Pipistrelle	(Pipistrellus subflavus)
	Big Brown Bat	(Eptesicus fuscus)
o	Red Bat	(Lasiurus borealis)
o	Hoary Bat	(Lasiurus cinereus)
	Eastern Cottontail	(Sylvilagus floridanus)
o*	New England Cottontail	(Sylvilagus transitionalis)
	Snowshoe Hare	(Lepus americanus)
o	European Hare	(Lepus capensis)
	Eastern Chipmunk	(Tamias striatus)
	Woodchuck	(Marmota monax)
	Gray Squirrel	(Sciurus carolinensis)
	Red Squirrel	(Tamiasciurus hudsonicus)
	Southern Flying Squirrel	(Glaucomys volans)
*	Northern Flying Squirrel	(Glaucomys sabrinus)
	Beaver	(Castor canadensis)
	White-footed Mouse	(Peromyscus leucopus)
*	Southern Red-backed Vole	(Clethrionomys gapperi)
	Meadow Vole	(Microtus pennsylvanicus)
	Woodland Vole	(Microtus pinetorum)
	Muskrat	(Ondatra zibethicus)
o	Southern Bog Lemming	(Synaptomys cooperi)
	Meadow Jumping Mouse	(Zapus hudsonius)
	Norway Rat	(Rattus norvegicus)
	House Mouse	(Mus musculus)
o*	Coyote	(Canislatrans)
	Red Fox	(Vulpes vulpes)
	Gray Fox	(Urocyon cinereoargenteus)
	Raccoon	(Procyon lotor)

TABLE 3, CONTINUED
MAMMALS WITH RANGES OVERLAPPING THE STUDY AREA

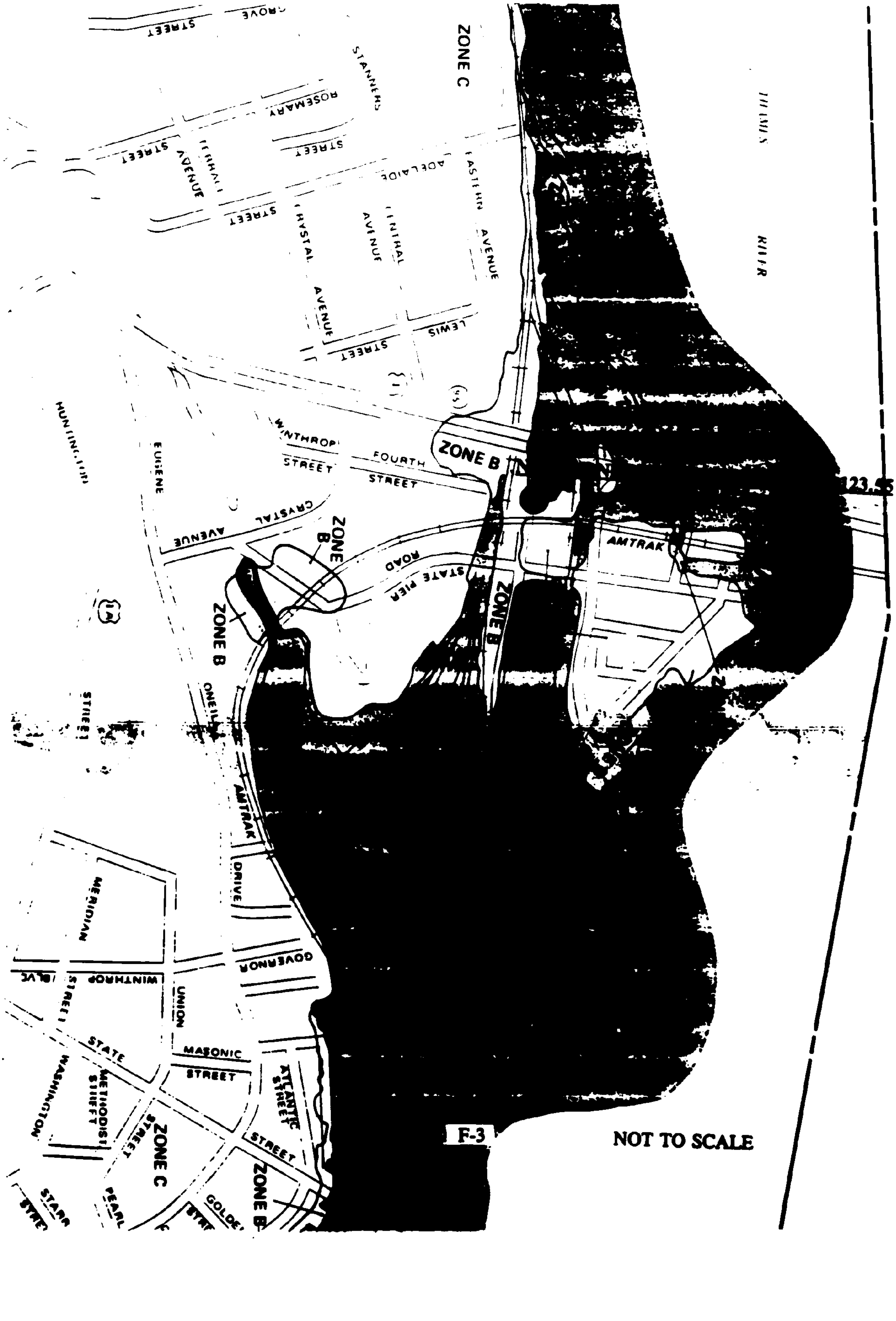
	Species	Scientific Name
	Ermine	(Mustela erminea)
	Long-Tailed Weasel	(Mustela frenata)
	Mink	(Mustela vison)
	Striped Skunk	(Mephitis mephitis)
o	River Otter	(Lutra canadensis)
	Bobcat	(Felis rufus)
	White-Tailed Deer	(Odocoileus virginianus)

* Species at the limit of their range.
o Uncommon or rare within their range.

APPENDIX F
Floodplain Maps

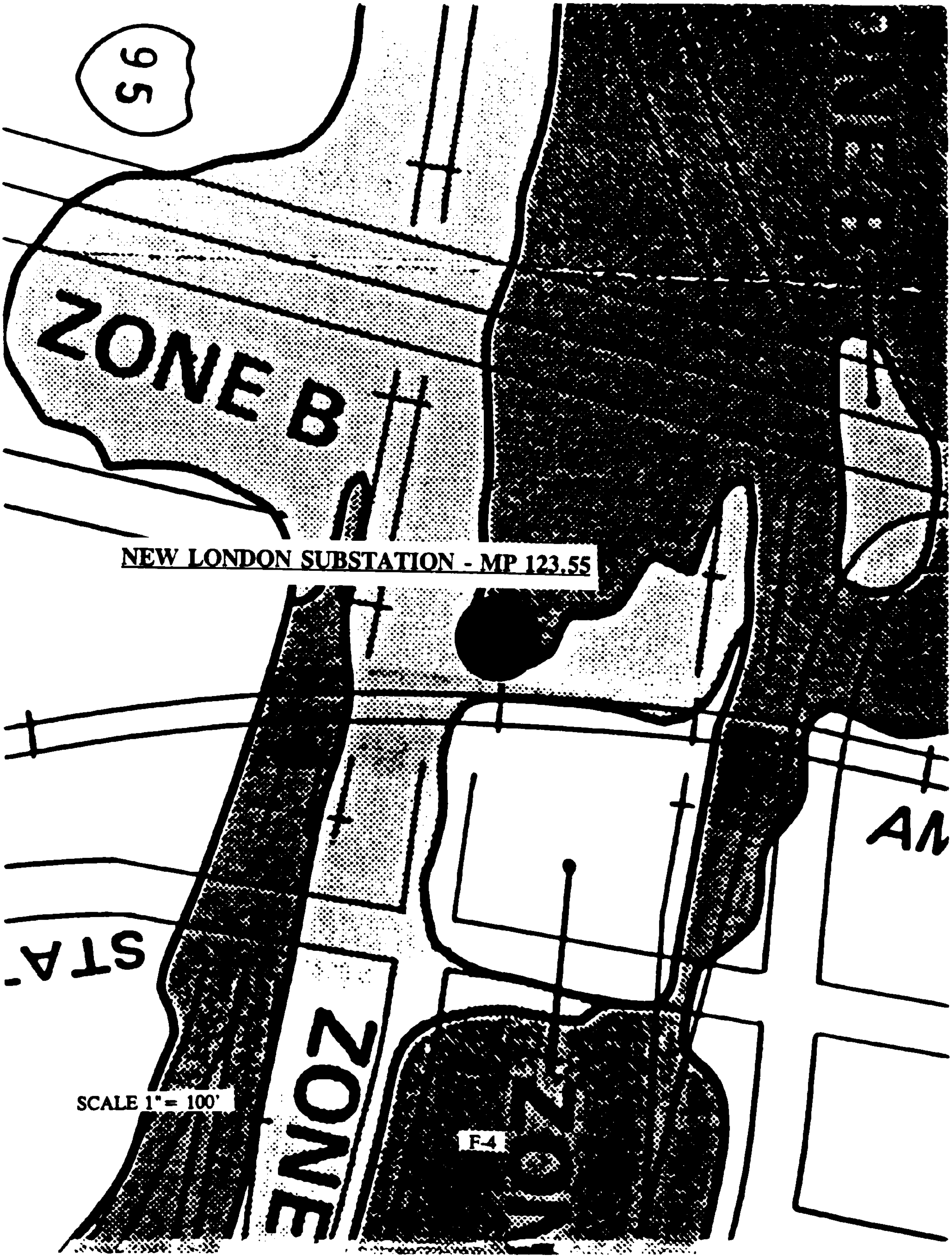

BRANFORD SUBSTATION - MP 79.26
ZONE C
ZONE A6
(EL 12)
12/15/77
RM16
ROAD
ROAD
ROAD
ROAD
DOMINICAN
JEFFERSON
DRIVE
HILL
PENT
RAILWAY
WARFIELD RD
NOT TO SCALE

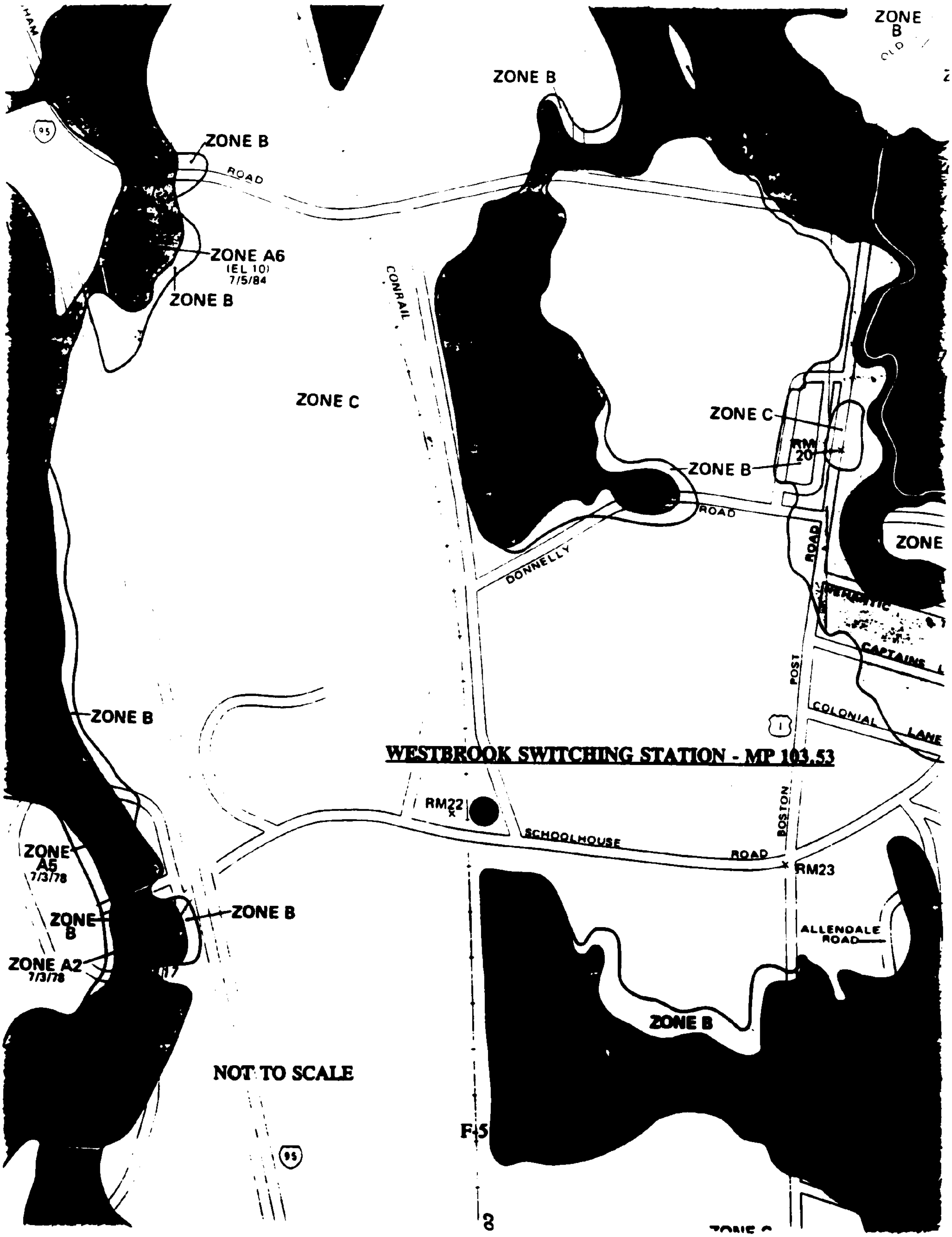
F-1

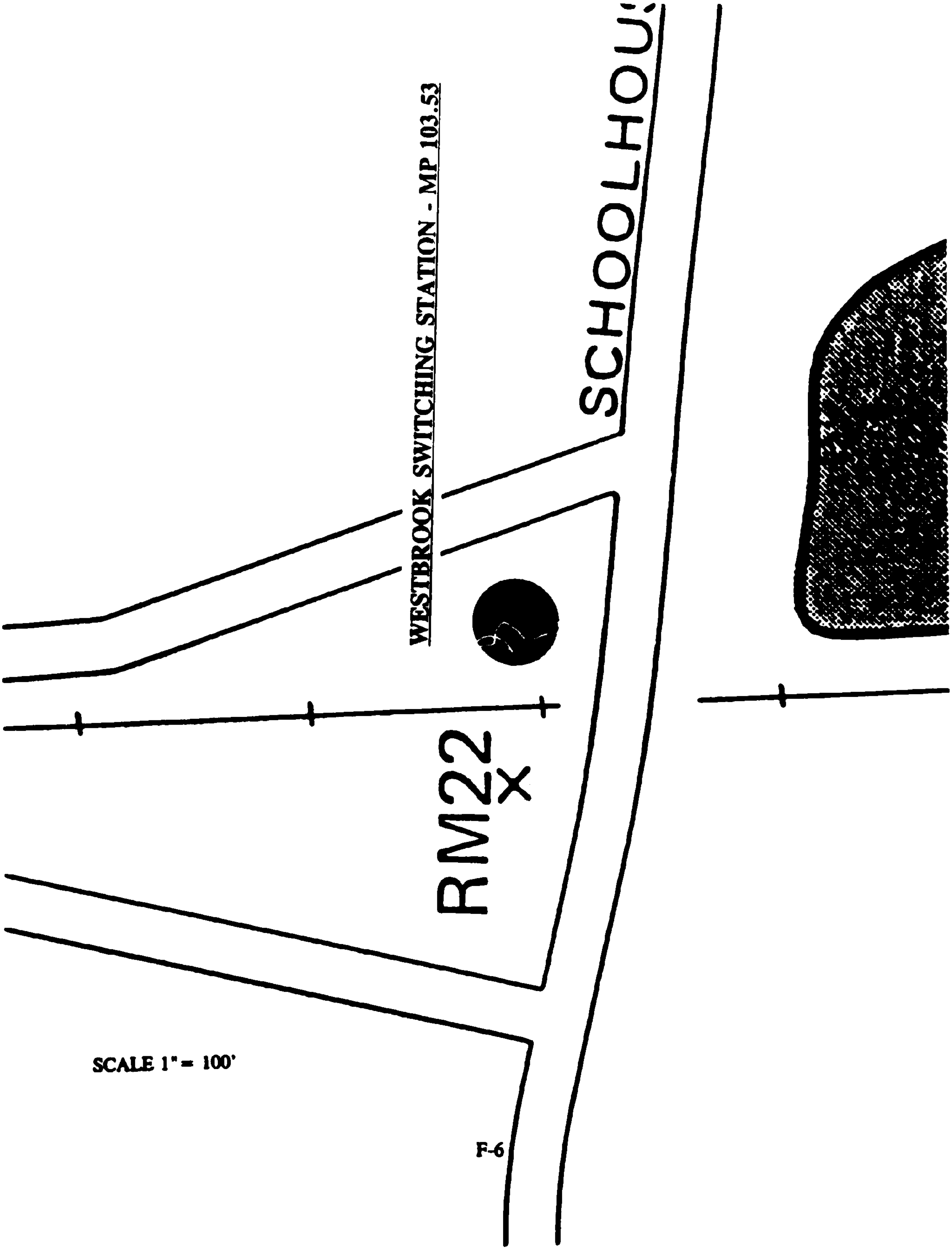


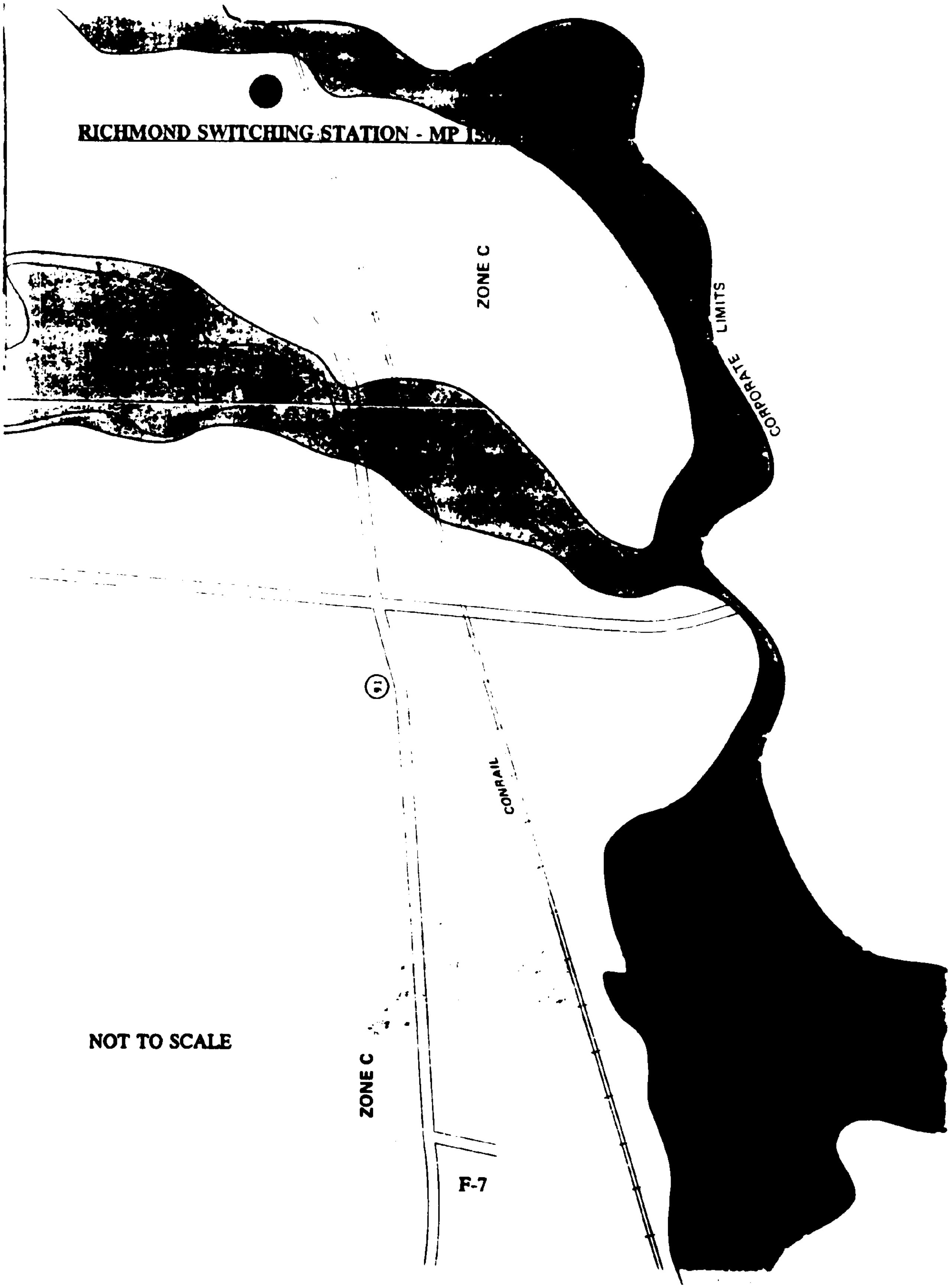
F-3

NOT TO SCALE

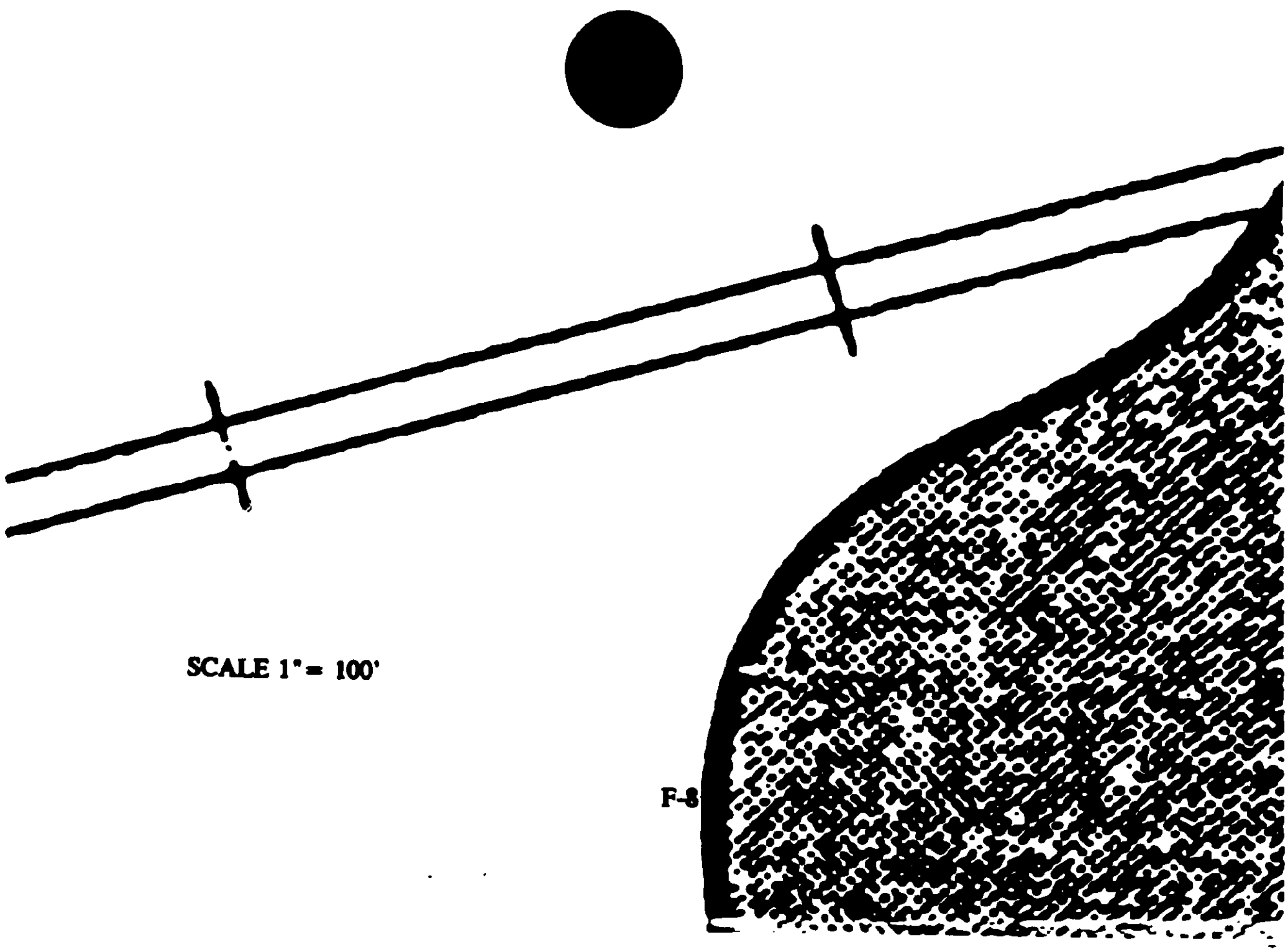

95
ZONE B
NEW LONDON SUBSTATION - MP 123.55
ZONE
SCALE 1" = 100'
F-4


ZONE B
ZONE B
ZONE B
ROAD
ZONE A6
(EL 10)
7/5/84
ZONE B
CONRAIL
ZONE C
ZONE C
RM 20
ZONE B
ROAD
ZONE
DONNELLY
ROAD
CAPTAINS
POST
COLONIAL
LANE
ZONE B
WESTBROOK SWITCHING STATION - MP 103.53
BOSTON
RM22
SCHOOLHOUSE
ROAD
RM23
ZONE A5
7/3/78
ZONE B
ZONE B
ZONE A2
7/3/78
ALLENDALE ROAD
ZONE B
NOT TO SCALE
F-5
95
95

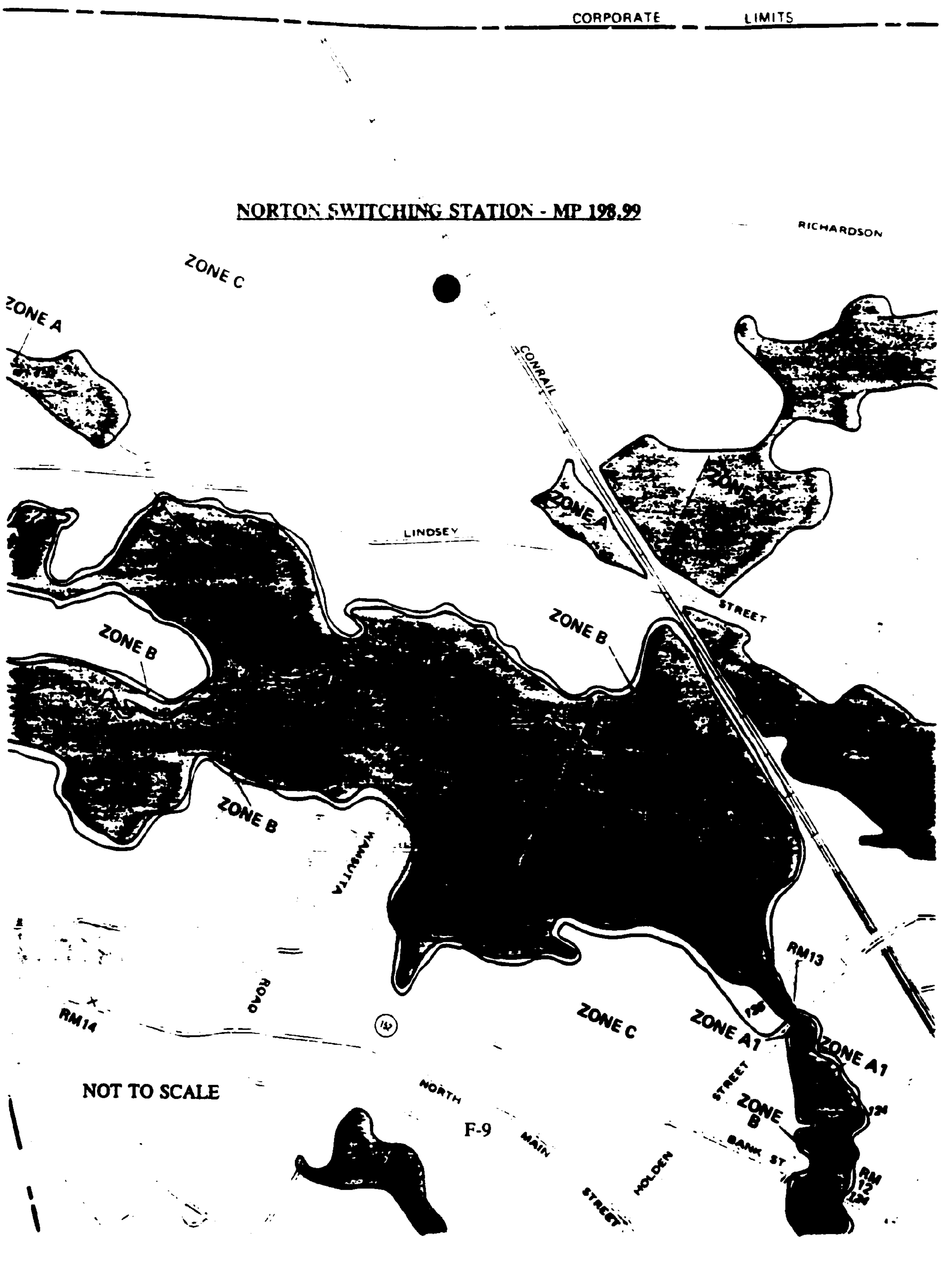

WESTBROOK SWITCHING STATION - MP 103.53
SCHOOLHOU
RM22
SCALE 1" = 100'


RICHMOND SWITCHING STATION - MP 15
ZONE C
CORPORATE LIMITS
CONRAIL
91
ZONE C
NOT TO SCALE

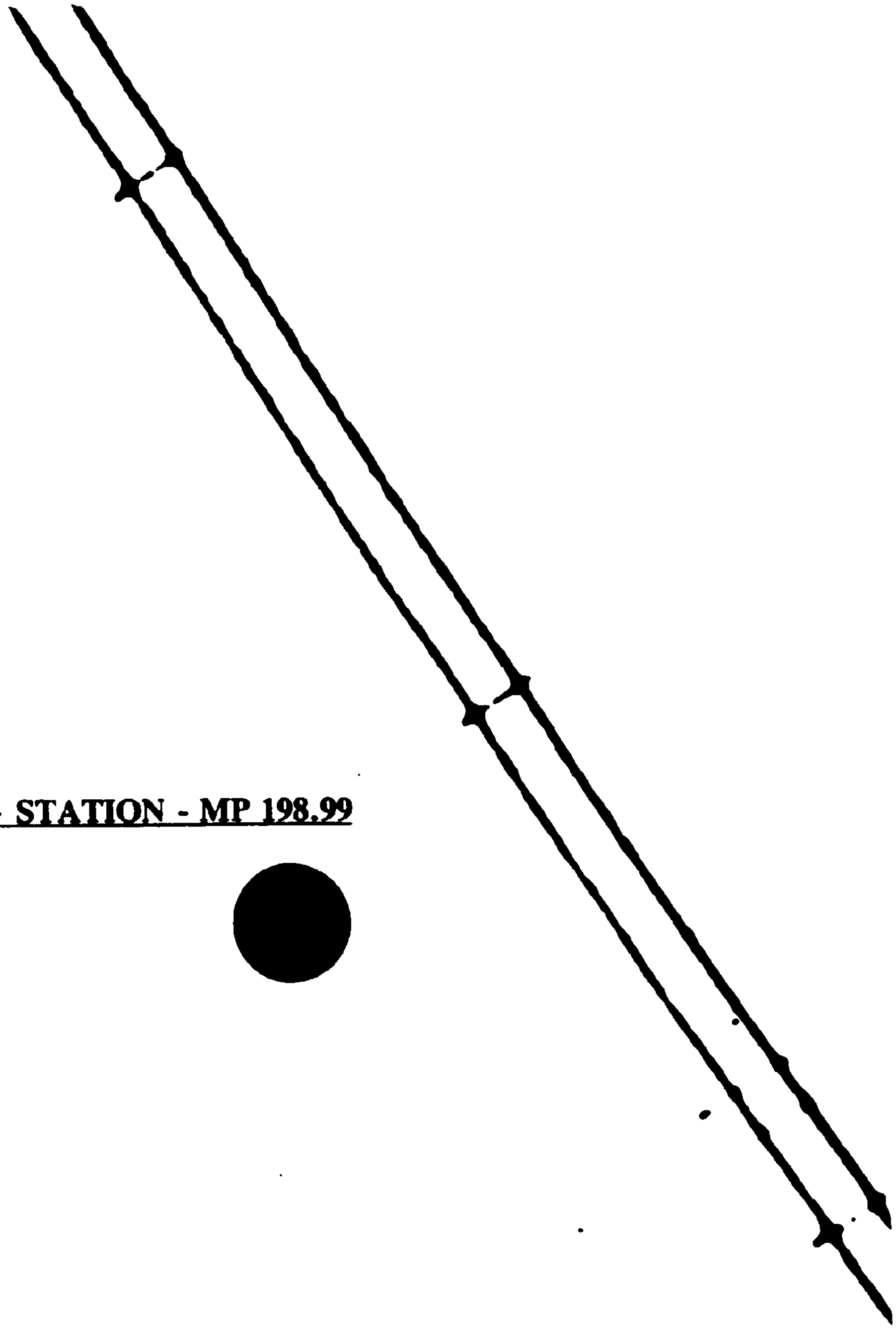
RICHMOND SWITCHING STATION - MP 150.35



NORTON SWITCHING STATION - MP 198.99



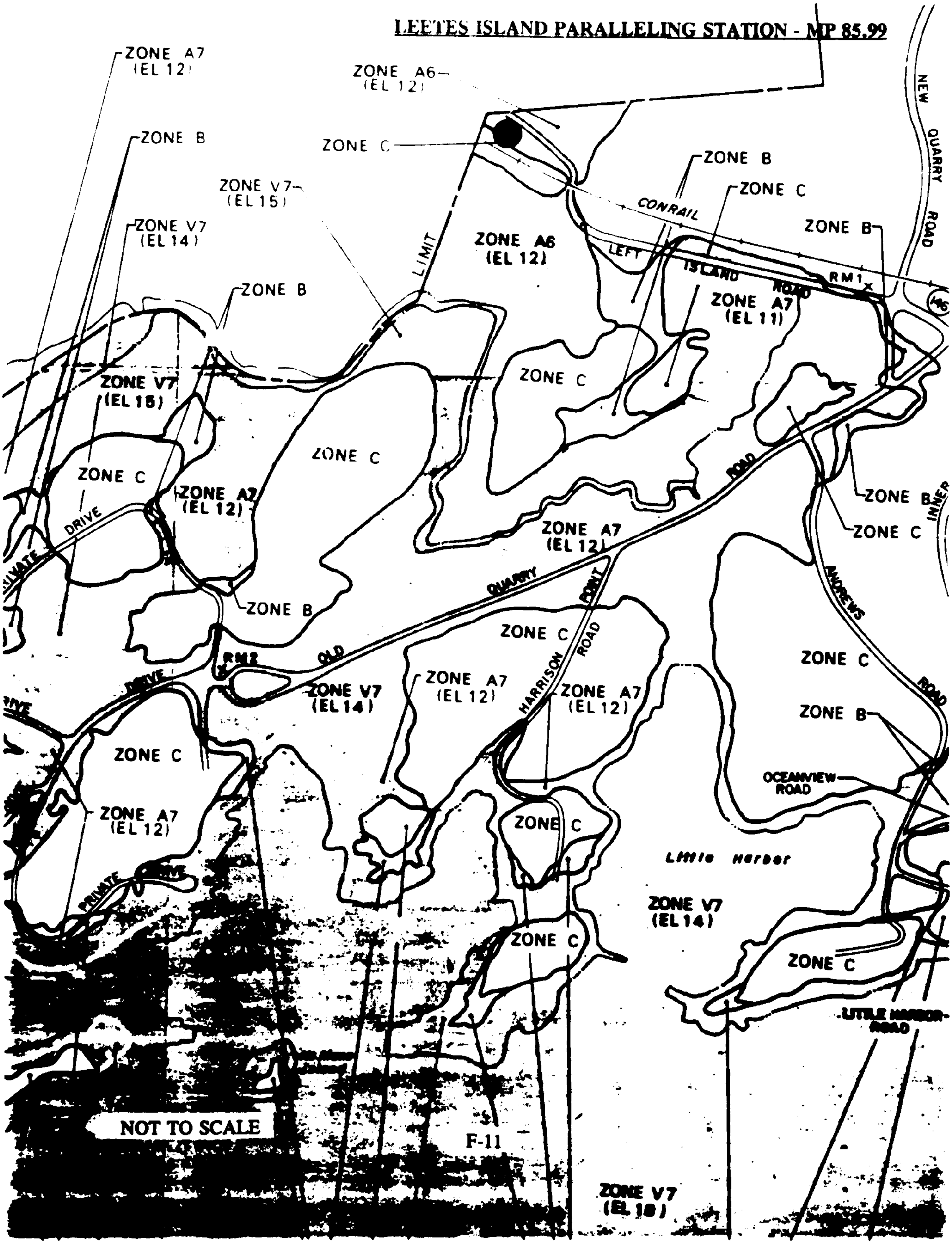
NOT TO SCALE



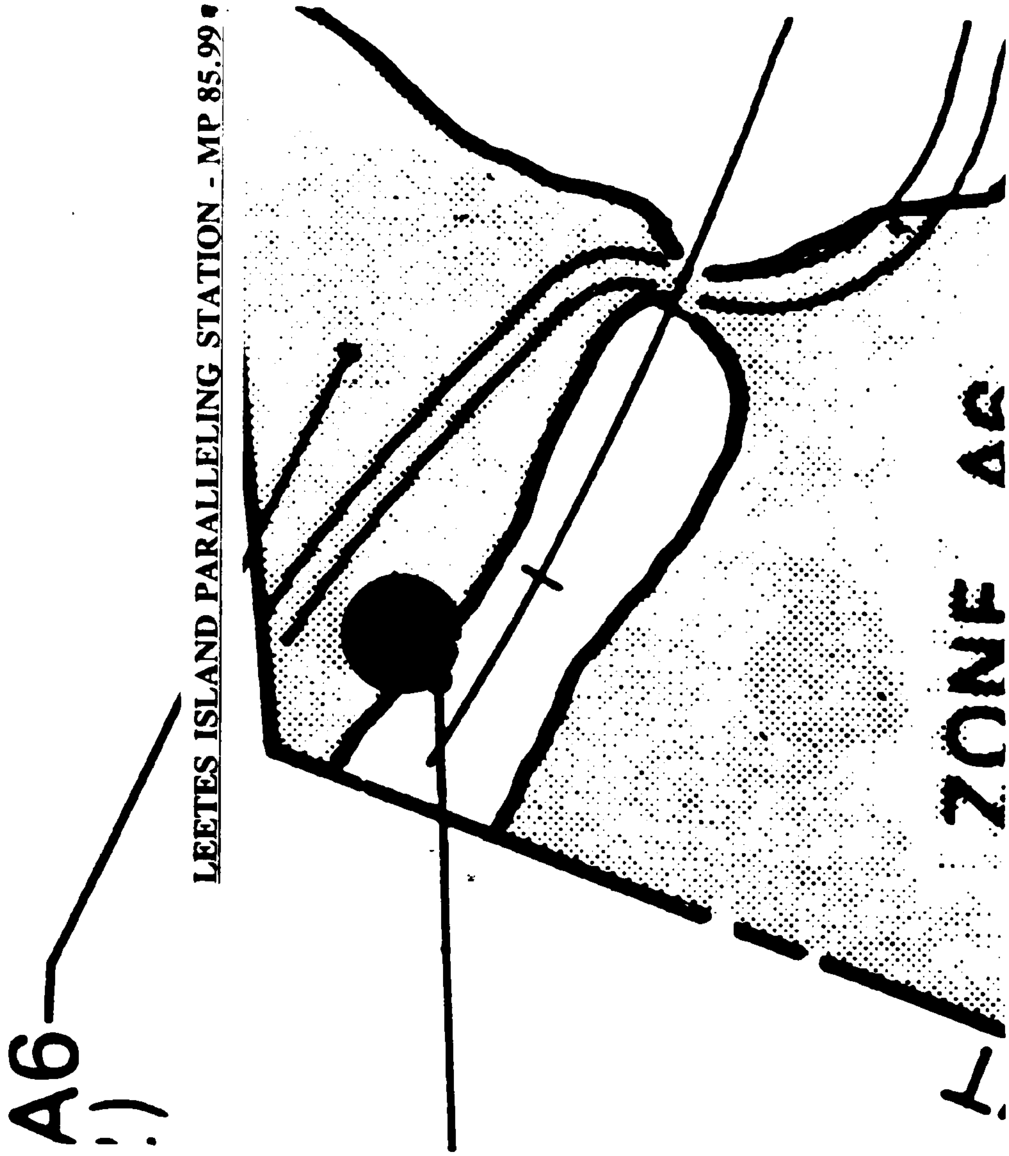
NORTON SWITCHING STATION - MP 198.99

SCALE 1" = 100'

LEETES ISLAND PARALLELING STATION - MP 85.99

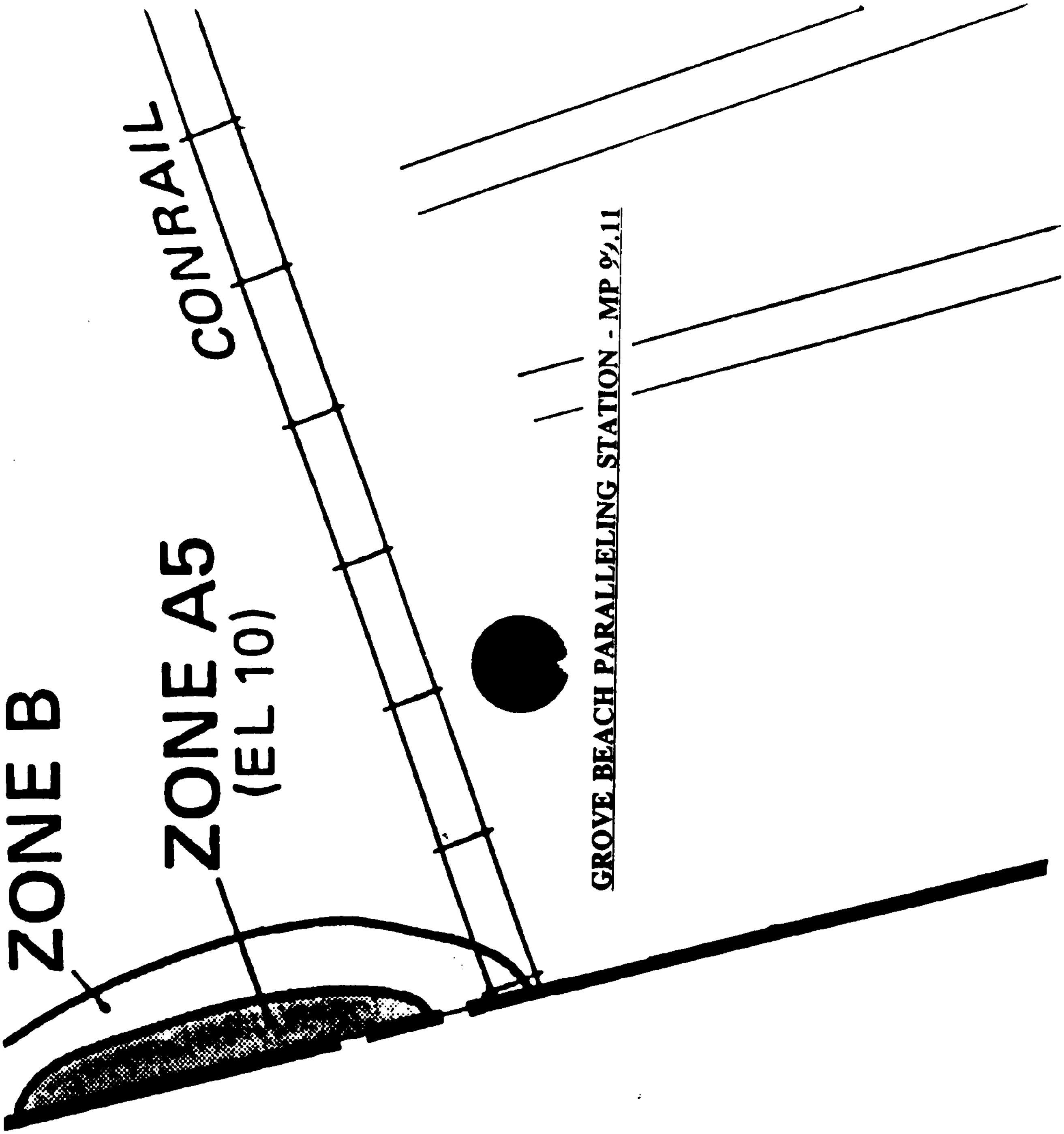


LEETES ISLAND PARALLELING STATION - MP 85.99



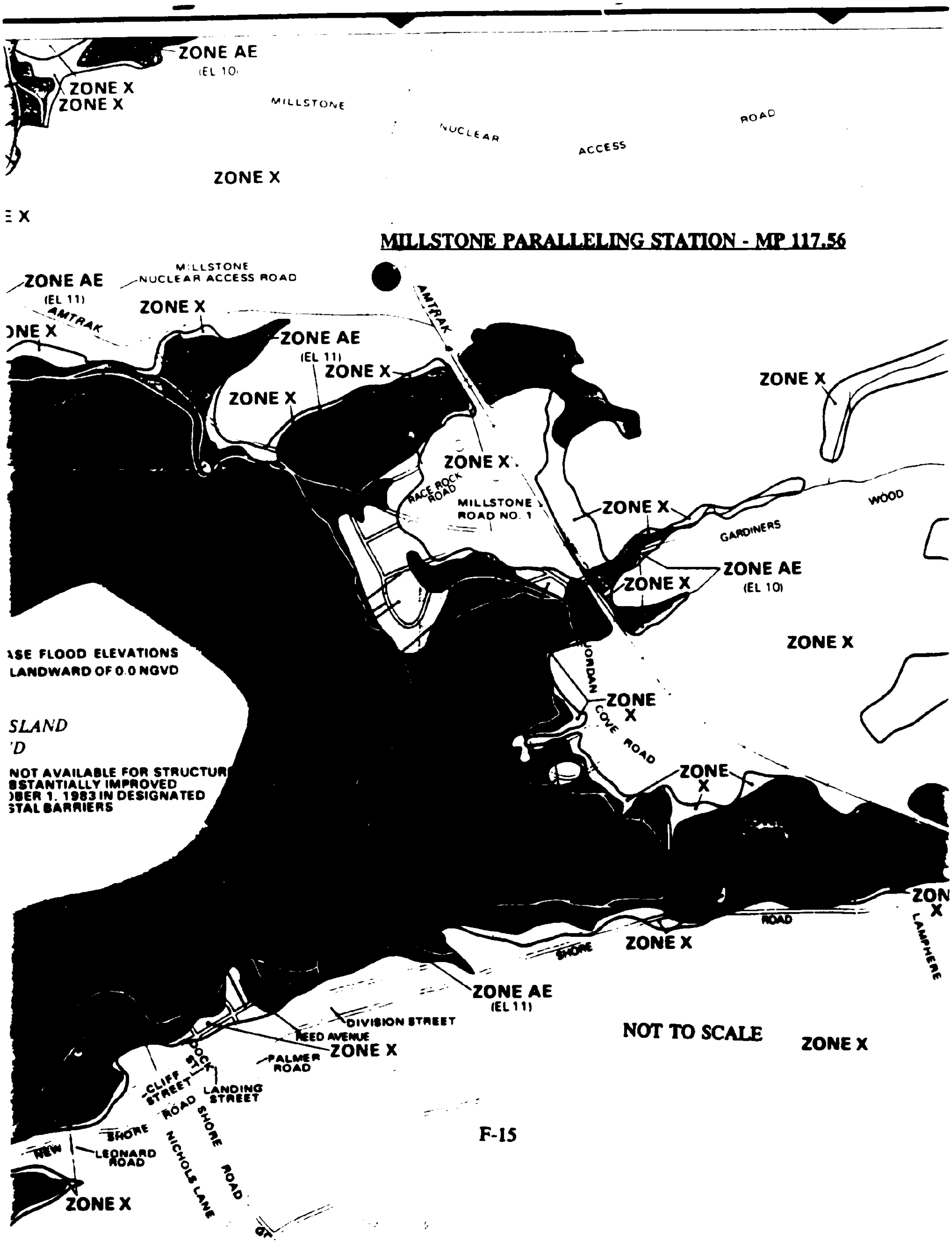
SCALE 1" = 100'

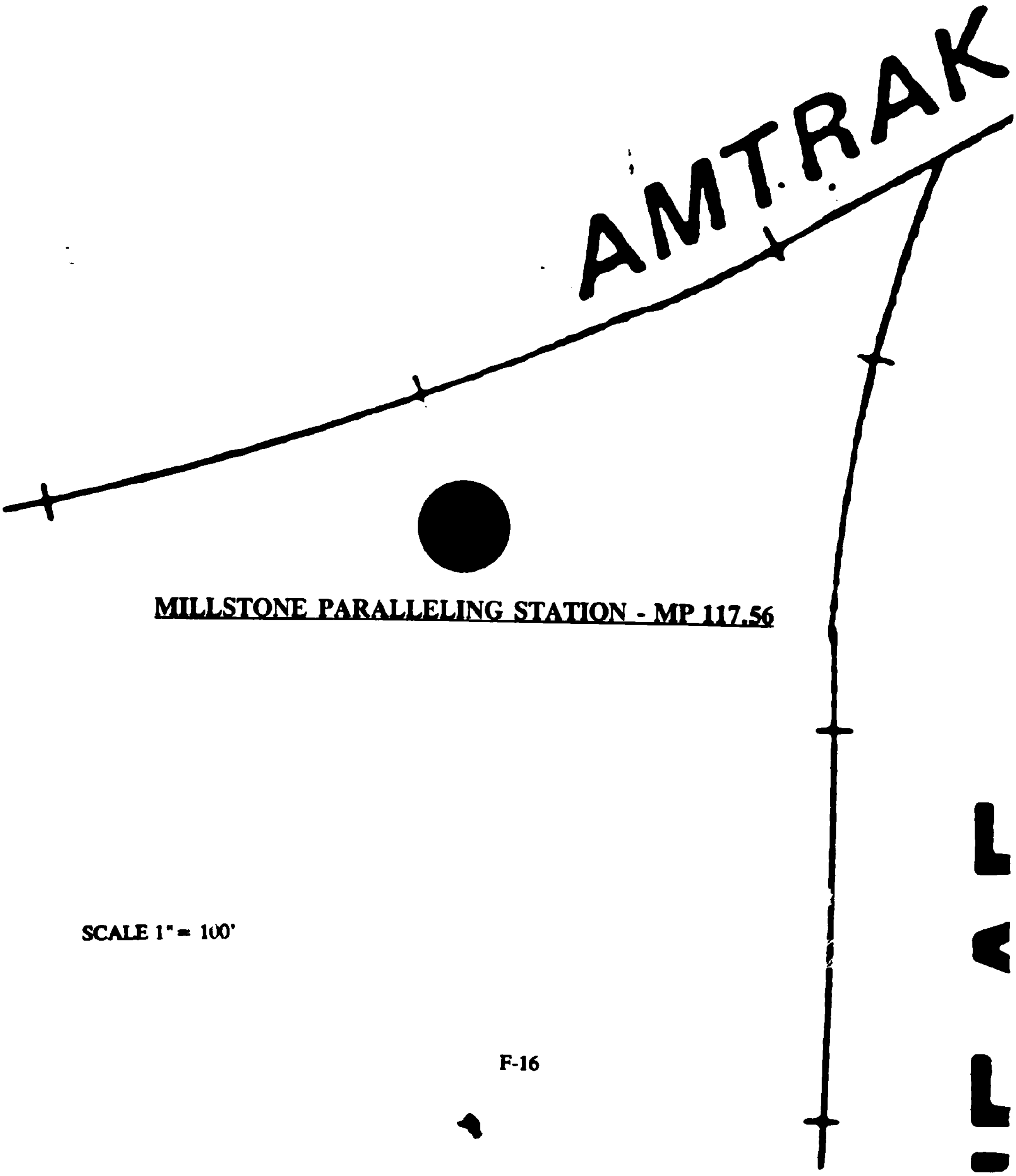
ZONE B
ROAD
POINT
MEADOW
TROUT LAKE
ROAD
MINNOW LANE
BLUE GILL
LANE
ZONE B
ZONE C
ZONE B
ZONE B
ZONE B
ZONE A5
(EL 10)
CONRAIL
GROVE BEACH PARALL
ZONE B
ZONE B
ZONE C
ZONE A6
(EL 10)
ZONE B
ZONE B
ZONE B
BROADWAY
LINDEN
ROAD
WANGUM ROAD
ZONE C
NOT TO SCALE
MENUNKETESUCK
AVENUE
ZONE B
ROAD
LILAC ROAD
F-13
ZONE C
ZONE B
UNCAS ROAD
BEACH
PRIVATE
DRIVE
GROVE
CONNECTICUT
AVENUE
ELM AVE
SUNRISE
ROAD
ZONE B
ZONE B
MOHICAN ROAD
ZONE B
INDIAN


CONRAIL
GROVE BEACH PARALLELING STATION - MP 92.11
ZONE B
ZONE A5
(EL 10)

SCALE 1" = 100'

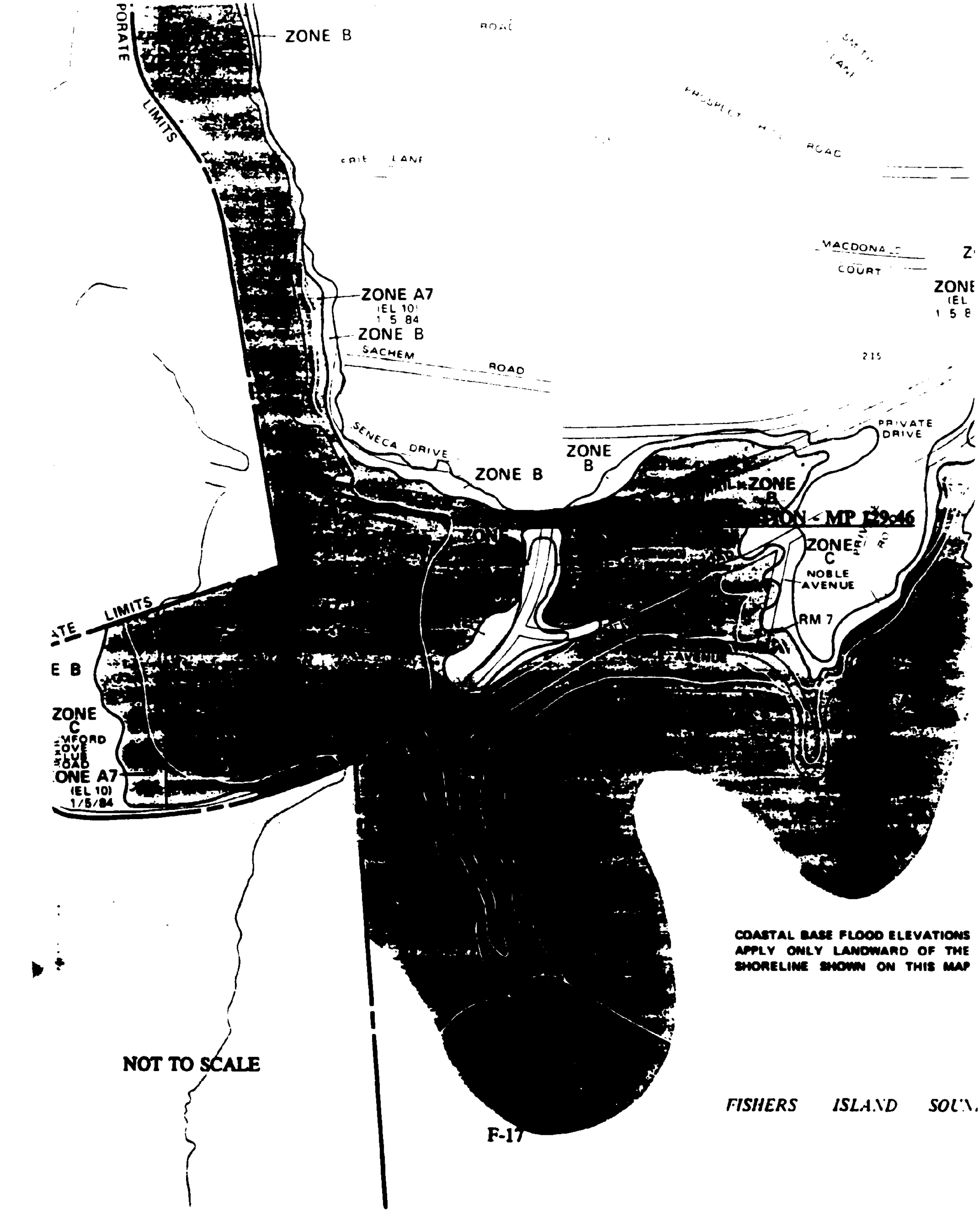
MILLSTONE PARALLELING STATION - MP 117.56

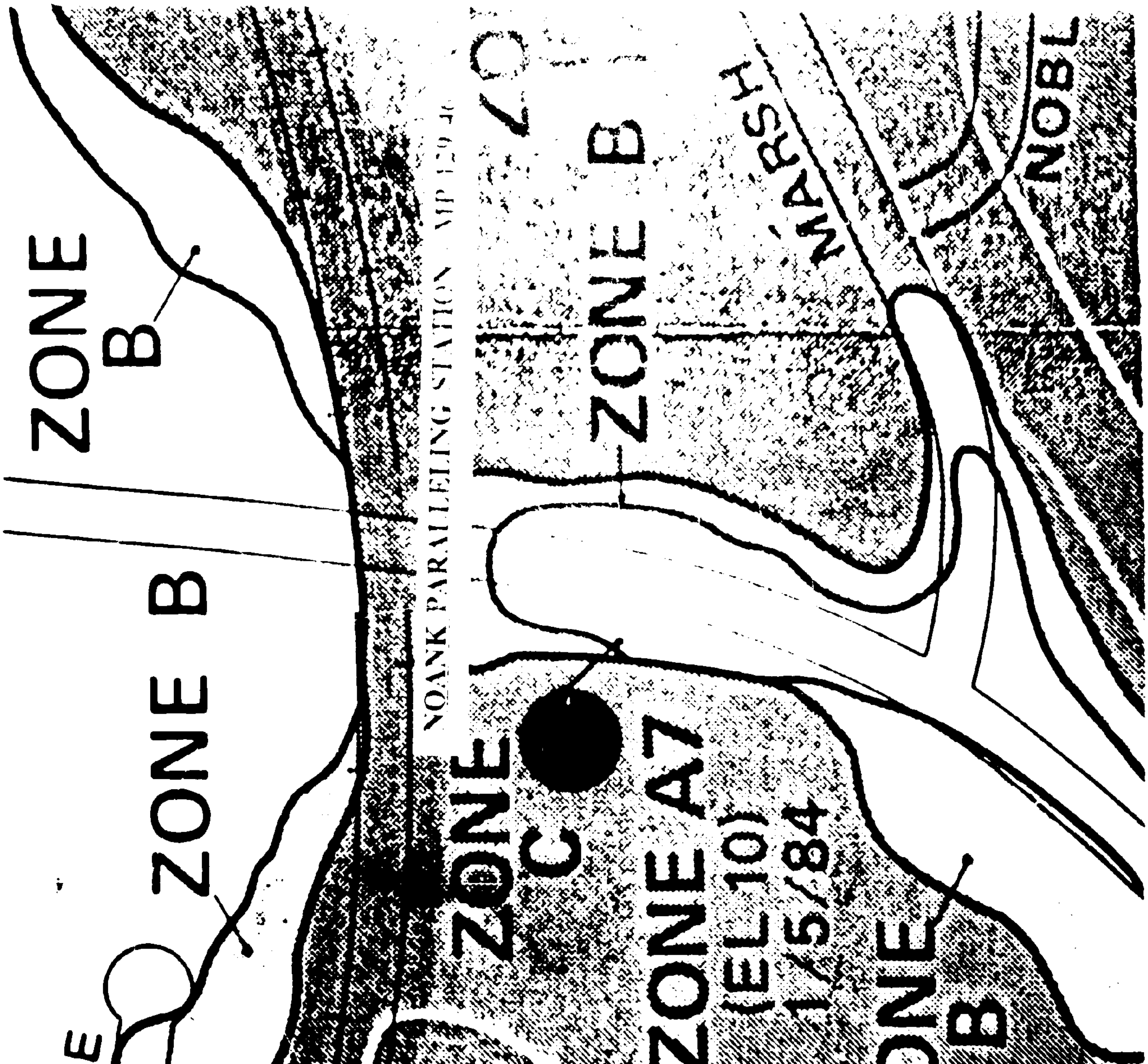




MILLSTONE PARALLELING STATION - MP 117.56

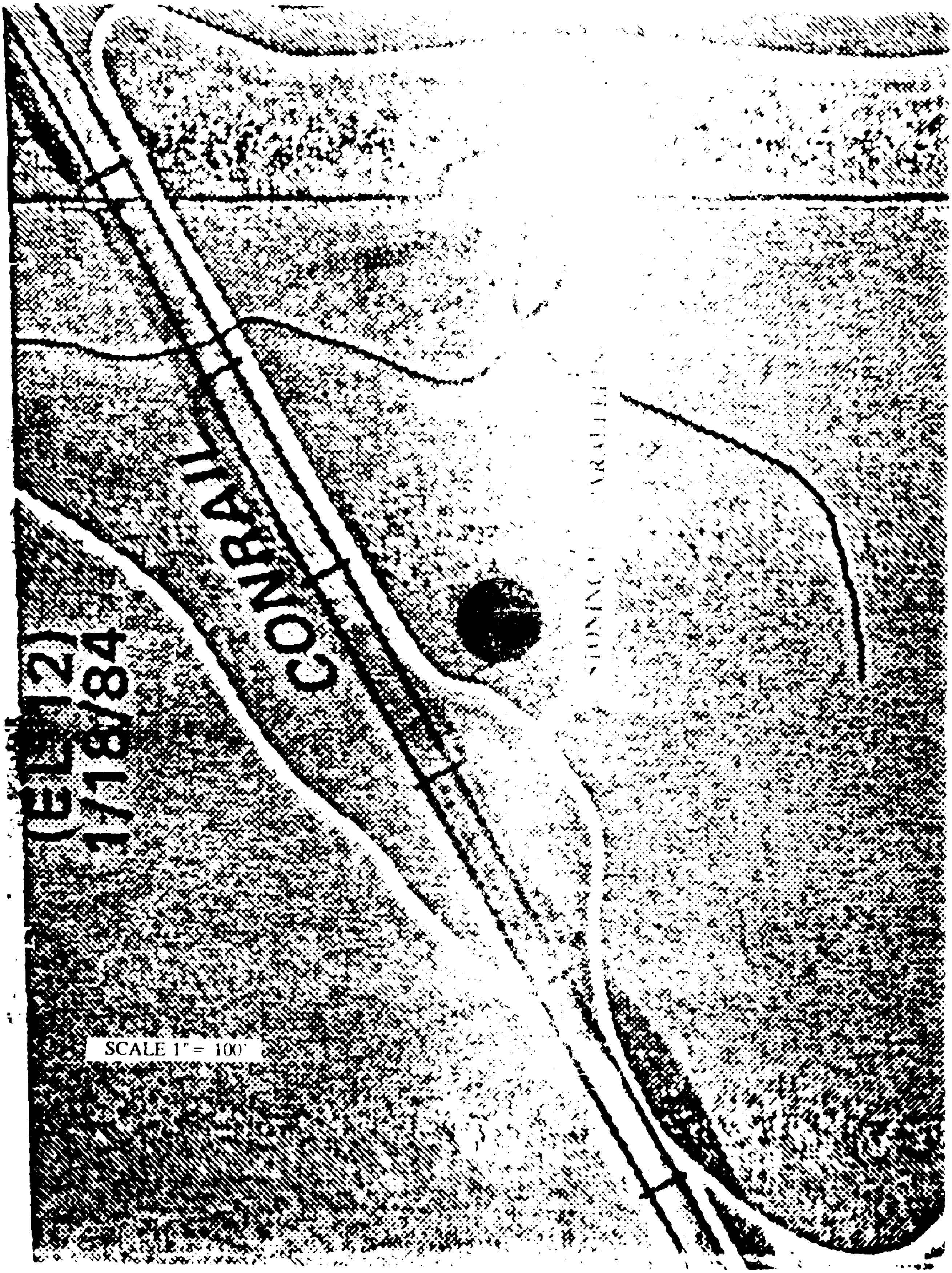
SCALE 1" = 100'

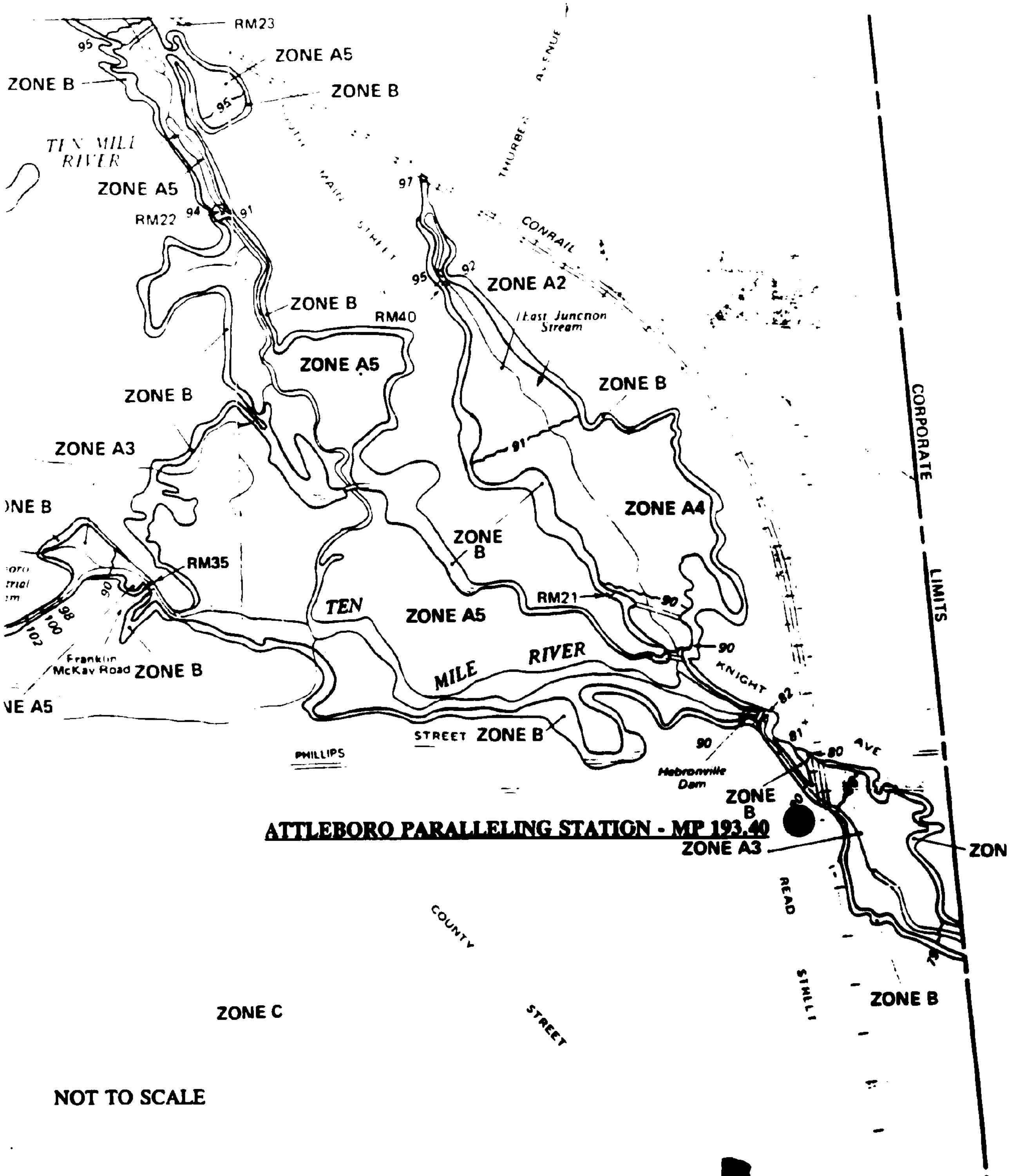

ZONE B
ZONE A7
(EL 10)
1/5/84
SACHEM ROAD
SENECA DRIVE
PRIVATE DRIVE
MACDONALD COURT
NOBLE AVENUE
RM 7
ZONE C
LIMITS
COASTAL BASE FLOOD ELEVATIONS APPLY ONLY LANDWARD OF THE SHORELINE SHOWN ON THIS MAP
NOT TO SCALE
FISHERS ISLAND

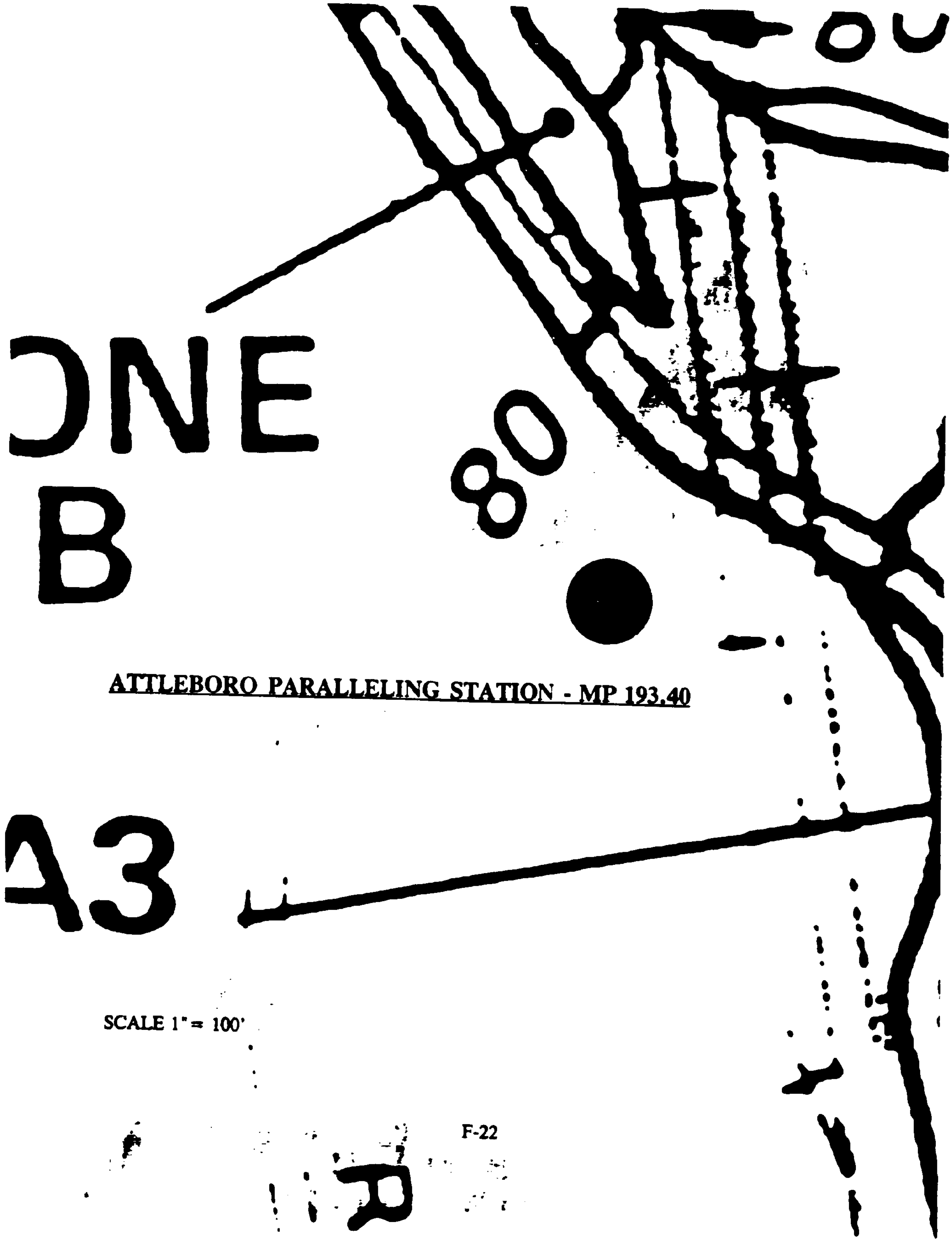

ZONE B
ZONE B
ZONE B
ZONE C
ZONE A7
(EL 10)
1/5/84
ZONE B
MARSH
NOBL
ECA DRIVE
NOANK PARALLELING STATION
SCALE 1" = 100'

NOT TO SCALE

F-19

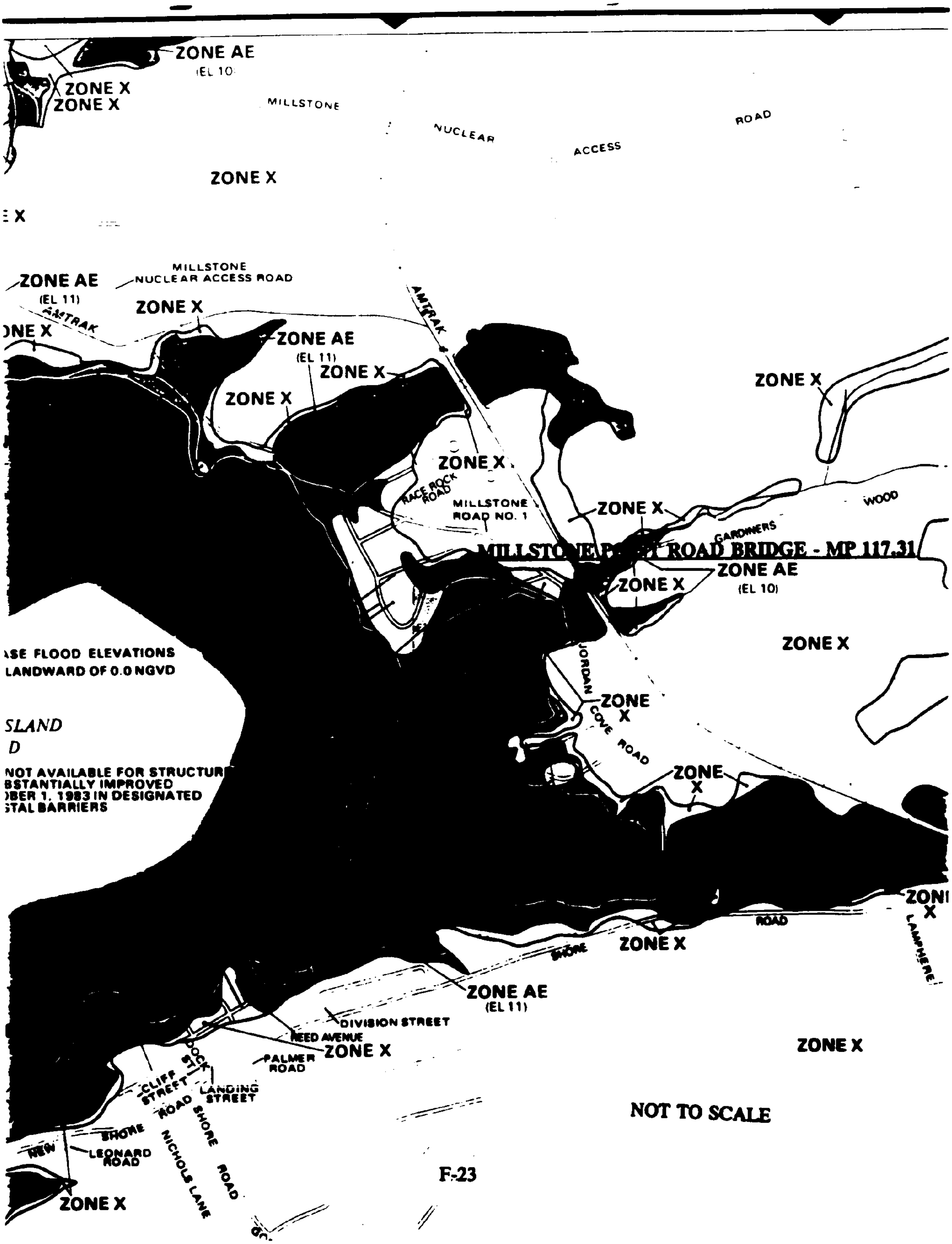

CONRAIL
1/18/84
SCALE 1" = 100'

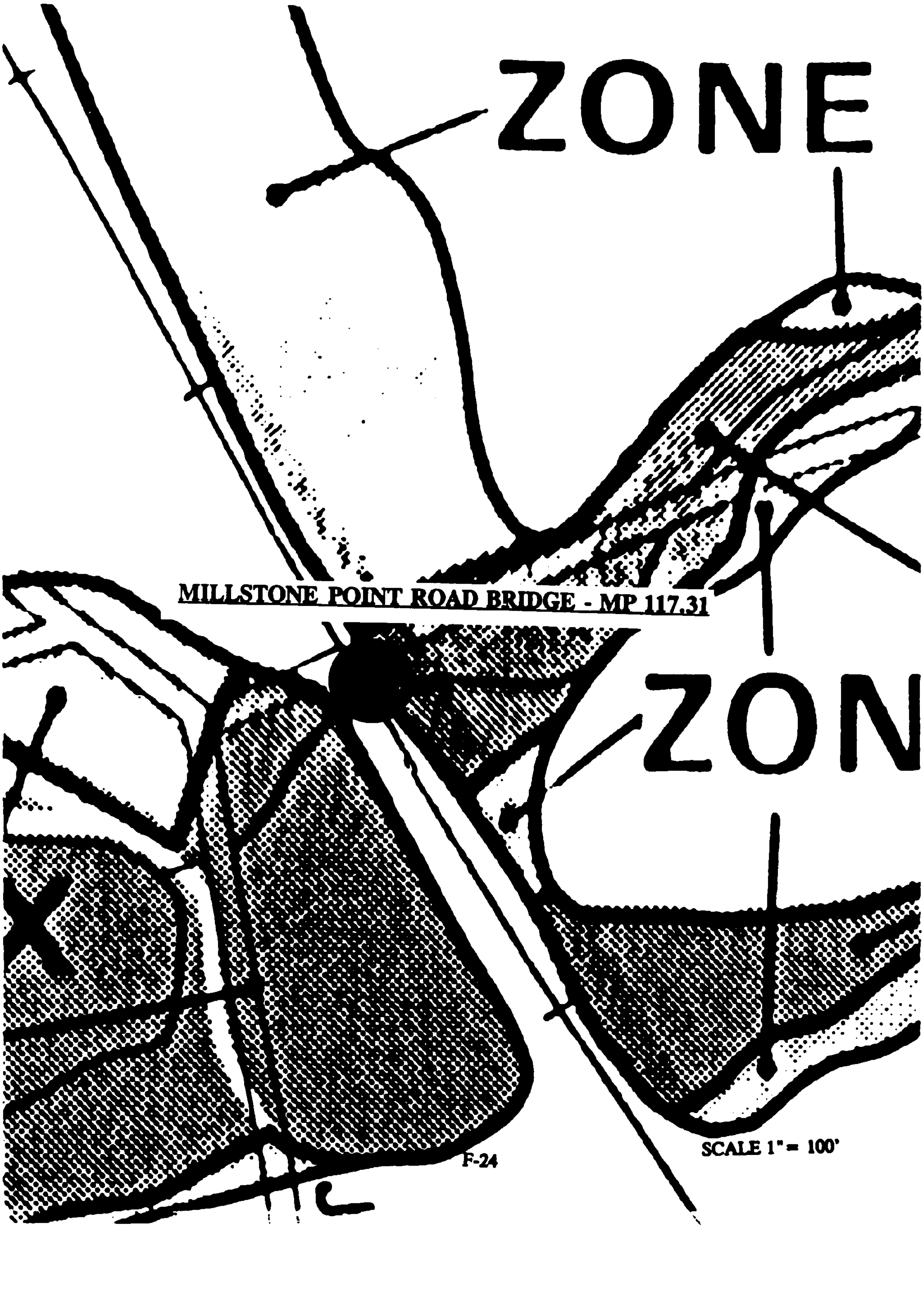

RM23
ZONE A5
ZONE B
ZONE B
TEN MILE RIVER
ZONE A5
RM22
CONRAIL
ZONE A2
East Junction Stream
ZONE B
RM40
ZONE A5
ZONE B
ZONE A3
ZONE B
ZONE A4
ZONE B
RM35
RM21
TEN
ZONE A5
MILE
RIVER
Franklin McKay Road
ZONE B
KNIGHT
AVE
STREET
ZONE B
PHILLIPS
Hebronville Dam
ZONE B
ATTLEBORO PARALLELING STATION - MP 193.40
ZONE A3
CORPORATE LIMITS
READ
COUNTY
STREET
ZONE B
ZONE C
NOT TO SCALE

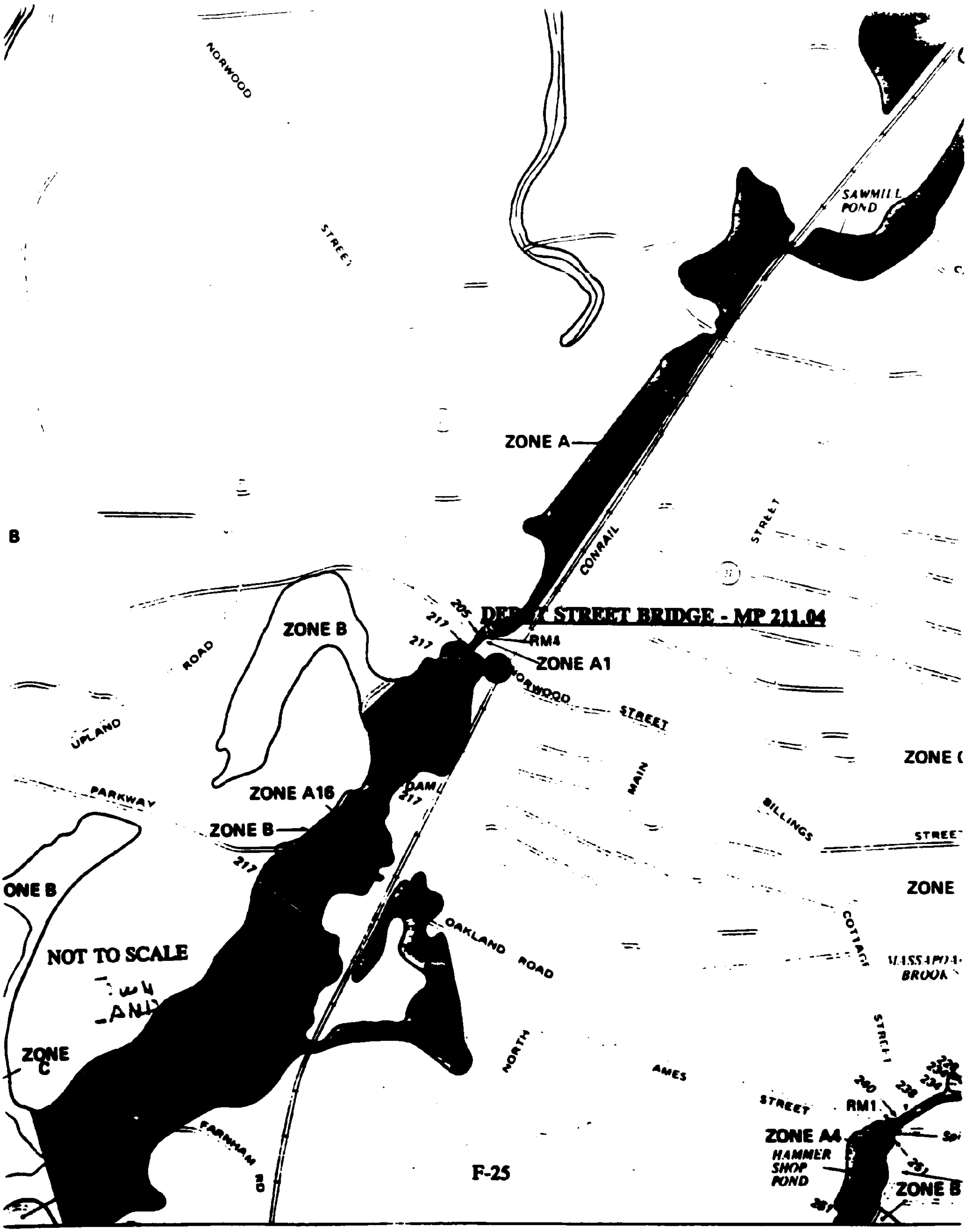


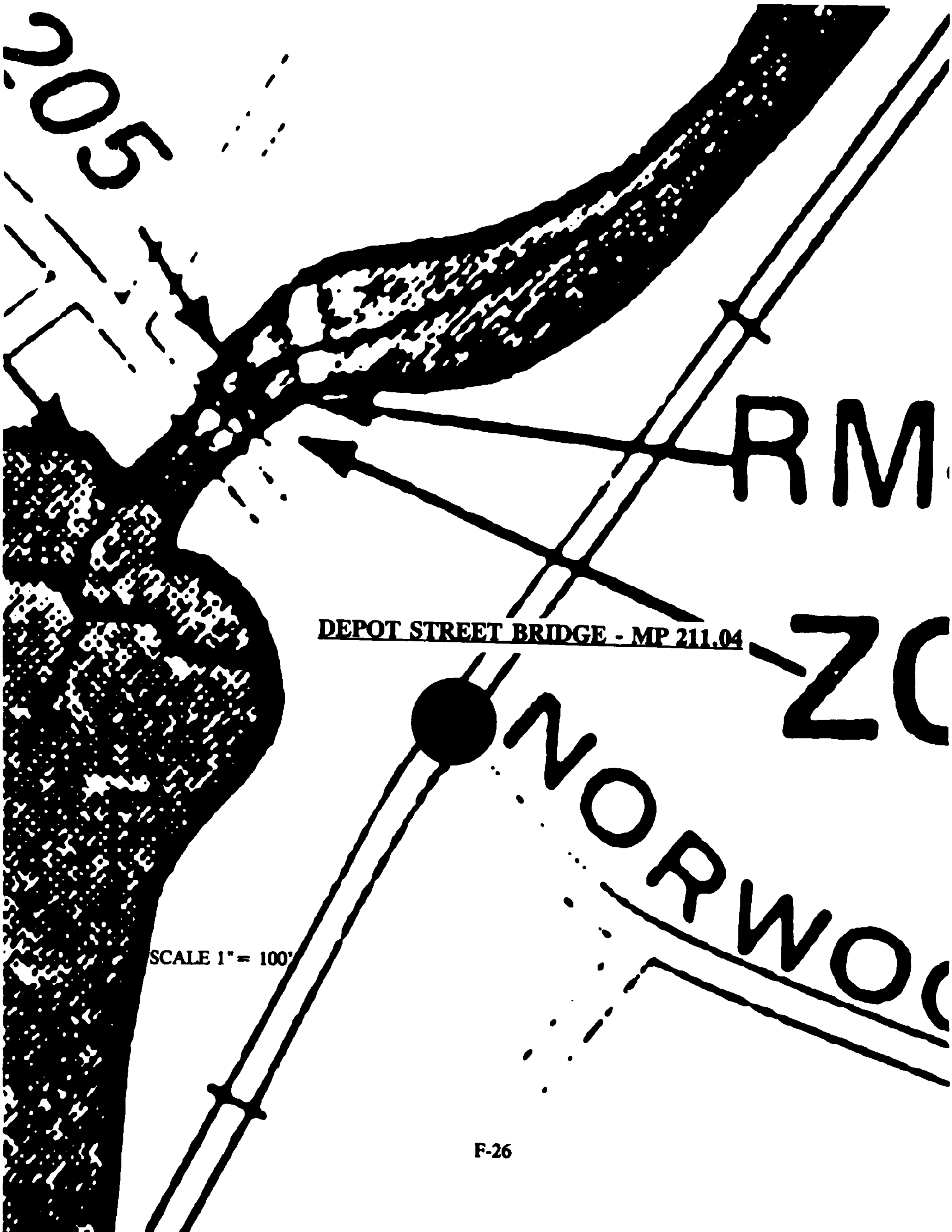
ATTLEBORO PARALLELING STATION - MP 193.40

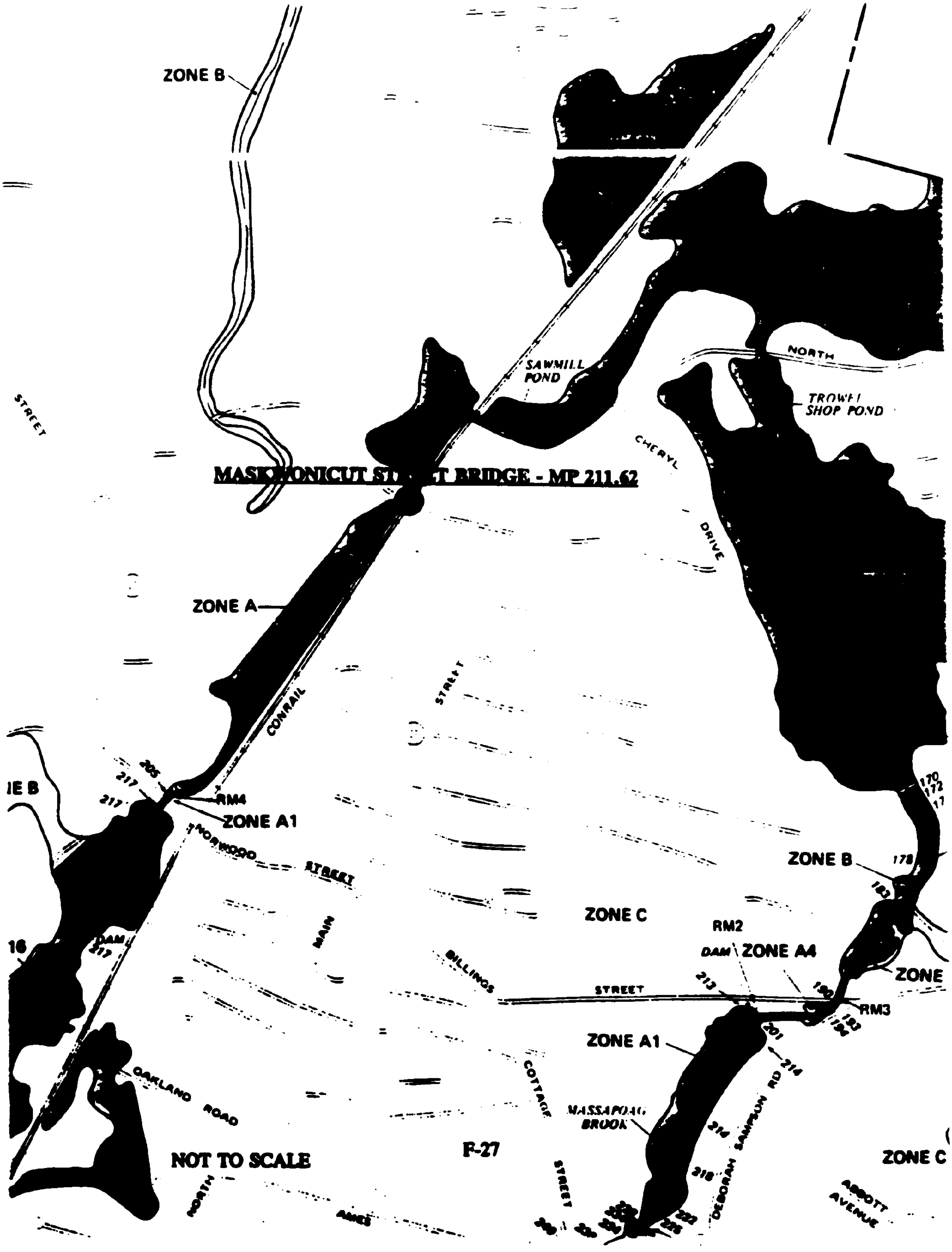
SCALE 1" = 100'

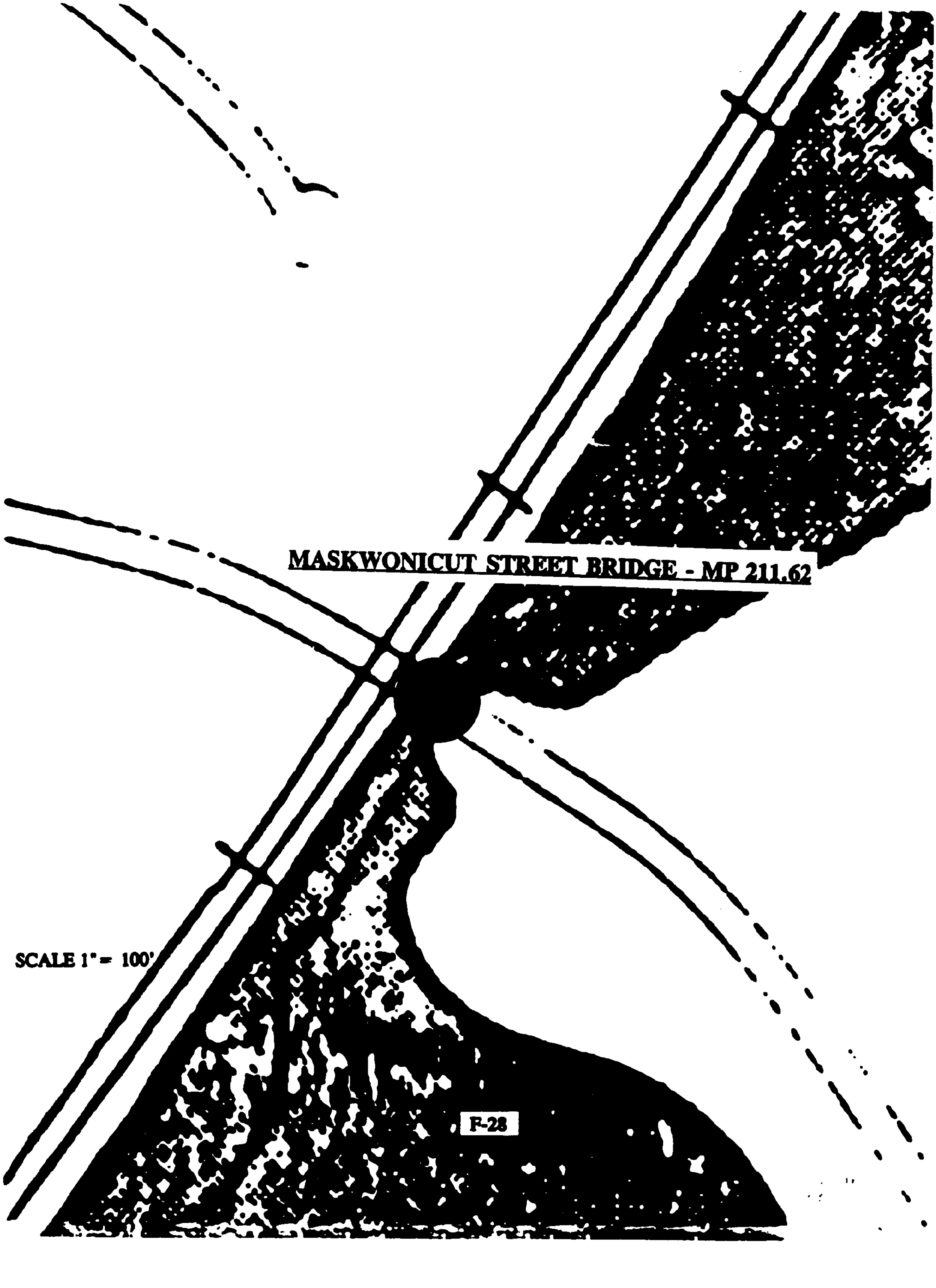

ZONE AE
(EL 10)
ZONE X
ZONE X
MILLSTONE NUCLEAR ACCESS ROAD
ZONE X
ZONE AE
(EL 11)
MILLSTONE
NUCLEAR ACCESS ROAD
ZONE X
AMTRAK
ZONE AE
(EL 11)
ZONE X
ZONE X
AMTRAK
ZONE X
ZONE X
RACE ROCK ROAD
MILLSTONE ROAD NO. 1
ZONE X
GARDINERS
WOOD
MILLSTONE POINT ROAD BRIDGE - MP 117.31
ZONE X
ZONE AE
(EL 10)
ZONE X
BASE FLOOD ELEVATIONS
LANDWARD OF 0.0 NGVD
JORDAN COVE ROAD
ZONE X
ZONE X
NOT AVAILABLE FOR STRUCTURES
SUBSTANTIALLY IMPROVED
OBER 1, 1983 IN DESIGNATED
COASTAL BARRIERS
ZONE X
ROAD
LAMPHERE
SHORE
ZONE X
ZONE AE
(EL 11)
DIVISION STREET
NEED AVENUE
ZONE X
PALMER ROAD
ZONE X
DOCK ST
CLIFF STREET
LANDING STREET
SHORE ROAD
SHORE ROAD
NICHOLS LANE
LEONARD ROAD
NEW
ZONE X
NOT TO SCALE


ZONE
MILLSTONE POINT ROAD BRIDGE - MP 117.31
ZON
SCALE 1" = 100'
F-24


NORWOOD
STREET
SAWMILL POND
ZONE A
CONRAIL
STREET
B
ZONE B
ROAD
UPLAND
PARKWAY
ZONE A16
ZONE B
ONE B
NOT TO SCALE
ZONE C
DEPOT STREET BRIDGE - MP 211.04
RM4
ZONE A1
NORWOOD STREET
MAIN
BILLINGS
ZONE
STREET
COTTAGE
OAKLAND ROAD
DAM
NORTH
AMES
STREET
RM1
ZONE A4
HAMMER SHOP POND
ZONE B
FARNHAM RD


205
RM
ZO
NORWO
DEPOT STREET BRIDGE - MP 211.04
SCALE 1" = 100'


ZONE B
SAWMILL POND
NORTH
TROWEL SHOP POND
CHERYL DRIVE
MASKWONICUT STREET BRIDGE - MP 211.62
ZONE A
CONRAIL
STREET
RM4
ZONE A1
NORWOOD STREET
ZONE B
ZONE C
RM2
DAM
ZONE A4
MAIN
BILLINGS STREET
RM3
ZONE A1
OAKLAND ROAD
COTTAGE STREET
MASSAPOAG BROOK
DEBORAH SAMPSON RD
NOT TO SCALE
ZONE C
ABBOTT AVENUE
NORTH
AMES


MASKWONICUT STREET BRIDGE - MP 211.62
SCALE 1" = 100'
F-28

APPENDIX G
Correspondence

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northeast Region
Habitat and Protected
Resources Division
One Blackburn Drive
Gloucester, MA 01930-2298

April 28, 1993

TSA ROUTING LIST
Melissa .... ☐
Bill .... ☐
Chron .... ☒
Project 42-1060 NE Corridor ☒
Other ☒

Jim Fougere
The Smart Associates
72 N. Main Street
Concord, NH 03301

Dear Mr. Fougere:

This responds to your letter requesting information regarding the presence of shortnose sturgeon (Acipenser brevirostrum) near several Connecticut bridges. Your letter indicated that plans for an Amtrak electrification project include burying electric cables beneath river bottoms at all of the noted bridge sites. As you identified on the maps enclosed with your letter, the Connecticut River bridge is the only proposed construction site located within sturgeon habitat.

Shortnose sturgeon typically migrate to the lower Connecticut River Estuary from upstream spawning grounds in summer where they are believed to feed mostly on mussels and insect larvae. Depending on the timing and extent of work required for this project, construction activities may affect shortnose sturgeon or their feeding habitat. An Endangered Species Act section 7 consultation concerning the impact of the Connecticut River bridge project on endangered shortnose sturgeon needs to be completed prior to issuing a permit for this activity.

If you have questions concerning these comments, please contact me at (508) 281-9388.

Sincerely,

Nancy J. Haley
Protected Species Program

cc:
Mike Amarol - US FWS, Concord, NH

File: 1514-05 COE-Nationwides 1993

United States Department of the Interior

FISH AND WILDLIFE SERVICE

New England Field Offices
400 Ralph Pill Marketplace
22 Bridge Street, Unit #1
Concord. New Hampshire 03301-4901

RE: Northeast Corridor (Transportation) Improvement Project

February 25, 1993

TSA ROUTING LIST
Melissa .... ☐
Bill .... ☐
Chron .... ☑
Project 92-1006 / ______ ☑
Other Jim ______________ ☑

Jim Fougere
The Smart Associates
?? N. Main St.
Concord, NH 03301

Dear Mr. Fougere:

This responds to your letter dated February 1, 1993 for information on the presence of Federally listed and proposed, endangered or threatened species in accordance with construction activities associated with the electrification of the AMTRAK line between New Haven and Boston.

Based on information currently available to us, no Federally listed or proposed, threatened and endangered species under the jurisdiction of the U.S. Fish and Wildlife Service are known to occur in the project area, with the exception of occasional, transient endangered bald eagles (*Haliaeetus leucocephalus*) or peregrine falcons (*Falco peregrinus*). However, we suggest that you contact Doug Beach of the National Marine Fisheries Service (NMFS), One Blackburn Drive, Gloucester, Massachusetts 01930; NMFS has jurisdiction for the endangered shortnosed sturgeon which occurs in the Connecticut River. (508) 281-9300

Migratory and wintering peregrine falcons, bald eagles and other birds will certainly encounter the new electrified powerlines. In locations where there are concentrations of birds (wetlands, river crossings, coastal areas and ponds), the likelihood for bird collisions with the powerline can be reduced by increasing the visibility of the line through the use of colored marker balls.

The lines (and associated facilities) may also pose an electrocution hazard to eagles and other large birds if insufficient distance between lines and poles allows phase to phase or ground to phase contact (Steenhof 1978, Management of Wintering Bald Eagles, U.S. Dept. of Interior, 59 pp.). While it is unlikely that eagles would attempt to construct a nest on a tower, ospreys or hawks might. Engineering and design solutions are available that eliminate the electrocution hazard to eagles and other large birds and their use is strongly encouraged.

This response relates only to endangered species under our jurisdiction. It does not address other legislation or our responsibilities under the Fish and Wildlife Coordination Act.

Lists of Federally designated endangered and threatened species in Rhode Island, Connecticut, and Massachusetts are inclosed for your information. Thank you for your cooperation and please contact Michael Amaral of this office at 603-225-1411 if we can be of further assistance regarding endangered species.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Offices

Inclosures

CC AFC/ES Reading File
NMFS
FWS
J. Victoria, CT DEP
C. Raithel, RI DFW
EN MAmaral:jd:2-[illegible]-93:603-225-1411

REFERENCES

Adamus, P.R., E.J. Clairain, Jr., R. Smith, and R.E. Young. Wetland Evaluation Technique (WET); Vol. II: Methodology. Operational Draft Technical Report Y-87-, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss. 1987.

American Geological Institute. Dictionary of Geological Terms. Dolphin Books, Exit 6, Gordon City, New Jersey. 1962.

Ammann, A.P. and Stone, A.L. Method for the Comparative Evaluation of Nontidal Wetlands in New Hampshire. N.H. Department of Environmental Services. Concord, N H. 1991.

Benyus, J.M. The Field Guide to Wildlife Habitats. Simon and Schuster Inc., New York. 1909.

Bridge, C.A. Wildlife Habitat Inventory Checklist. New Hampshire Fish and Game Department.

Cowardin, L.M., Carter, V., Golet, F.C., and LaRoe, E.T. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior. FWS/OBS-79/31. Washington, D.C. 1979.

Corps of Engineers Wetland Delineation Manual. U.S. Army Corps of Engineers. Waterways Experiment Station. Vicksburg, MS. Tech. Rep. 4-87--1. 1987.

DeGraaf, R.M. and Rudis, D.D. New England Wildlife: Habitat, Natural History and Distribution. Gen Tech. Rep. NE-108, Broomall, PA: U.S. Department of Agricultural, Forest Service, Northeastern Forest Experiment Station. 1986.

DeGraaf, R.M. and Witman, G.M. Trees, Shrubs and Vines for Attracting Birds. University of Massachusetts Press. Amherst, Mass. 1979.

Flood Insurance Rate Maps. Federal Emergency Management Agency, U.S. Department of Housing and Development.

Guide for Permit Applicants. U.S. Army Corps of Engineers New England Division. Waltham, Mass. 1991.

Hollands, G.G. and Magee, D.W. "A Method for Assessing the Functions of Wetlands." In: Kusler, J.A. and Reixinger, P., eds. Proceedings of the National Wetland Assessment Symposium. ASWM Technical Report 1. 1986.

Jaffe, M. and DiNevo, F. Local Groundwater Protection. American Planning Association, Chicago, Illinois. 1987.

Magee, D.W. Freshwater Wetlands, A Guide to Common Indicator Plants of the Northeast. The University of Massachusetts Press, Amherst. Mass. 1981.

Merrit, F.S. Standard Handbook for Civil Engineers. Third Edition. McGraw Hill.

National Wetlands Inventory Maps. U.S. Fish and Wildlife Service. Appropriate quadrangles for Connecticut, Rhode Island, and Massachusetts.

New Hampshire Department of Transportation. Conway Project, Technical Memorandum Number 6 Wetlands. The Smart Associates, Environmental Consultants, Inc. Concord, N.H. 1991.

Payne, N.F. Techniques for Wildlife Habitat Management of Wetlands. McGraw-Hill, Inc. New York. 1992.

Reed, P.B., Jr. National List of Plant Species that Occur in Wetlands: Northeast (Region 1). U.S. Fish and Wildlife Service Biological Report 88 (26.1). 1988.

Tiner, Jr., R.W. Field Guide to Nontidal Wetland Identification. Maryland Dept. of Natural Resources, Annapolis, MD. and U.S. Fish and Wildlife Service, Newton Corner, Mass. Cooperative Publication. 1988

Rhode Island Department of Environmental Management. Wellhead Protection Areas Map - Draft. Rhode Island Geographic Information Systems. 1993

*U.S. G.P.O.:1993-343-273:80290