MICHIGAN OHIO UNIVERSITY TRANSPORTATION CENTER
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Report No: MIOH UTC TS23p2 2010-Final

INCORPORATING ENVIRONMENTAL SUSTAINABILITY INTO TRANSIT-ORIENTED DEVELOPMENT ON DETROIT LIGHT RAIL TRANSIT SYSTEM

FINAL REPORT

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Report No: MIOH UTC TS23p2 2010-Final

TS23, Series, Project 2, September, 2010
FINAL REPORT

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SPONSORS

This is a Michigan Ohio University Transportation Center project supported by the U.S. Department of Transportation, the Michigan Department of Transportation, Wayne State University, and the University of Detroit Mercy.

ACKNOWLEDGEMENT

This research was conducted jointly at Wayne State University and at the University of Detroit Mercy. Significant matching support was provided by the Michigan Department of Transportation and the two partner universities. The authors would like to express their sincere appreciation to the project sponsors for their support. A number of agencies and individuals extended their support for the project by sharing their thoughts on various issues related to the project. Those that lent their support are listed in the second acknowledgement section.

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ABSTRACT

The term 'sustainability' is being used increasingly in policy debates about future transportation, and evokes strong reactions among policy-makers, users, and experts. In a broad sense, sustainability implies the 'capacity to endure over an extended period', and has become a wide ranging concept applied to nearly every facet of life. Sustainable development implies conscientious use of resources to meet human needs, present and future, while ensuring the preservation of the natural environment. The topic of discussion in this report is the degree to which sustainability can be incorporated into certain types of development, namely transit-oriented development (TOD) at, or in proximity to, light-rail transit (LRT) stations.

A set of goals, primarily from the existing literature for sustainable transportation is presented, and an effort is made by the project team to demonstrate how a majority of these goals can be achieved by proper planning of LRT systems. The project team contends that TOD can be used as a vehicle to attain sustainable LRT stations. When factors such as air quality and the depletion of natural resources are considered, LRT is thought to be superior to standard bus or bus-rapid transit (BRT) services. However, LRT systems are considered more capitally-intensive than BRT systems, a factor that would require a minimum population threshold value. The project team contends that environmental considerations should receive greater priority in the decision-making process for transportation projects. While the concept of environmental impact is based upon the minimization of adverse impacts, a stronger emphasis on sustainability can be realized by maximizing environmental performance.

The purpose of this study was to incorporate environmental sustainability into TOD packages that have been developed for two proposed rail-transit stations in the metropolitan Detroit area: one located in the city of Detroit and one located near the border shared by the suburban cities of Troy and Birmingham. Environmentally sustainable design considerations are proposed for each of the TOD sites and planning, economic, and institutional mechanisms that may ease the implementation process are identified.

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1.1. The Relationship Between TOD and LRT

The term transit-oriented development (TOD) is being used increasingly in the transit development literature, particularly in studies related to planning and design of urban rail transit. TOD relates to the integration of diverse (but desirable) land uses with transit, both temporally and spatially, designed to increase transit ridership and to promote desirable land uses surrounding the station areas. A TOD complex is characterized by high density development in the center with "progressively lower density development spreading outward from the center." A formal definition available in literature is as follows [*1*]:

> *"A transit-oriented development (TOD) is a mixed-use residential and commercial area designed to maximize access to public transport and often incorporates features to encourage transit ridership…TOD's generally are located within a radius of one-quarter to one-half mile from a transit stop, as this is considered appropriate for pedestrians"*

Although the aforementioned definition of TOD does not mention any specific transit mode, current development patterns in North America suggest that urban rail transit, particularly light-rail transit (LRT) is the most conducive mode to TOD. Over the last decade, there has been increased interest in North American cities (i.e., the United States and Canada) to plan and construct LRT systems in metropolitan areas with the intent of improving mobility. A preliminary search conducted by the research team has indicated the following concerning LRT systems in North America [*2*]:

- 27 cities/urban areas where systems are operational
- 13 cities/urban areas where systems are under construction, or under extension
- 40 cities/urban areas where LRT systems have been approved, or proposed (including the metropolitan Detroit area)
- At least 20 of the 27 cities/urban areas where LRT systems are operational have implemented some type of TOD program surrounding transit station locations

A recent study found that one of the major economic advantages of TOD is a significant reduction in transportation costs for households located in and around TOD areas. In the study, it was determined that American households having good access to transit stations (good access was considered to be within a 5-minute walk), spend about nine percent of their income on transportation. Households located in neighborhoods with average and poor access to transit (automotive dependent) on the other hand, spent significantly more: 19 to 25 percent of income, respectively (Figure 1) [*3*]. Recent instability in gasoline prices in North America is likely to increase this discrepancy even further. Thus, any savings in transportation costs that may be realized for households in a TOD environment would enable income to be spent on other pertinent items: housing, education, healthcare, etc. On a national level, those savings are likely to result in reduced dependence on foreign energy sources.

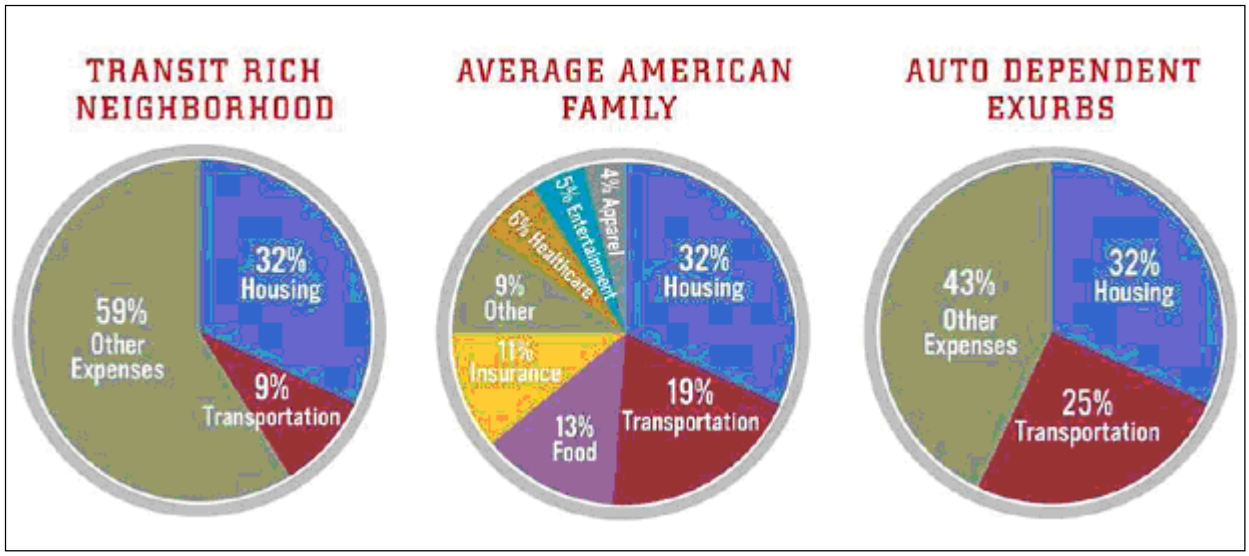


Figure 1. Distribution of Household Transportation Costs as a Function of Proximity to Transit Services
(Sources: Center for Transit-Oriented Development, Bureau of Labor Statistics)

Additional benefits that may be realized by the implementation of TOD include, but are not limited, to the following:

- Reduced motorized traffic congestion and traffic-related hazards
- Increased transit ridership as the result of denser land development in proximity to LRT stations
- Compatibility of land uses with accessibility to transit services
- Reduced household spending on transportation
- Reduced dependence on non-renewable energy sources
- Promoting pedestrian-friendly communities and desirable land uses
- Potential to reduce, or minimize, land development patterns that result in urban sprawl
- Vibrant transit station centers
- Reduced environmental pollution

The concept of transit land use integration for the mutual benefit of transit and urban growth dates back to the 1950's. This would later result in the development of towns and town centers in Europe, following the end of World War II. In North America, there have been many successful examples of transit land use integration around rail stations, including those located in Boston, MA; Washington, D.C.; San Francisco, CA; Atlanta, GA; Portland, OR; Denver, CO; and Houston, TX [*4,5*]. The terms joint development (JD) and value capture (VC) have been used to describe mechanisms to bring about transit and land use integration [*6,7*]. Studies conducted by the principal author have reported on past efforts to coordinate transit and land use integration along proposed transit stations in the metropolitan Detroit area [*8,9,10*] and elsewhere.

A major characteristic of TOD is the conscious efforts by planners to reduce the capacity of surface parking facilities, to narrow the right-of-way (ROW) for streets and roadways, to reduce posted speed limits, and to promote increased pedestrian safety and mobility. Those features make LRT stations natural candidates for TOD projects. LRT, by definition, is a rail system having a lower operating speed and passenger capacity than rapid-rail transit (RRT) systems, and is typically built along shared ROW (facilitating the operation of both motorized traffic and LRT vehicles). Thus, the scale of typical JD projects implemented on RRT systems is larger, often supplemented with convenient access for motorized vehicles and parking availability. The general scale of LRT operation, being smaller in magnitude, lends itself better to TOD type of projects because of its focus on pedestrian orientation.

1.1.1. Proposed LRT and TOD for Metropolitan Detroit

The Detroit metropolitan statistical area (MSA) consists of approximately 4.5 million residents, distributed across six counties: Lapeer, Livingston, Macomb, Oakland, St. Clair, and Wayne [*11*]. The MSA currently ranks as the 11th largest in the United States, and the largest without a regional rail-based transit system. Over past three decades, a number of studies have examined the feasibility of rapid transit services in the Detroit region including speed-link (rubber-tired, high-speed buses), LRT, commuter rail transit (CRT) and high-speed rail transit (HRT a.k.a. RRT) [*12*]. A recent study completed by the Detroit Department of Transportation (DDOT) identified the Woodward Avenue corridor (connecting the cities of Detroit and Pontiac) as the locally-preferred alternative (LPA) among a group of alternatives that included: Gratiot Avenue (connecting the cities of Detroit and Mount Clemens) and Michigan Avenue / Interstate 94 (connecting the cities of Detroit and Ann Arbor) [*13*]. The location of the city of Detroit with respect to the three aforementioned travel corridors is depicted in Figure 2.

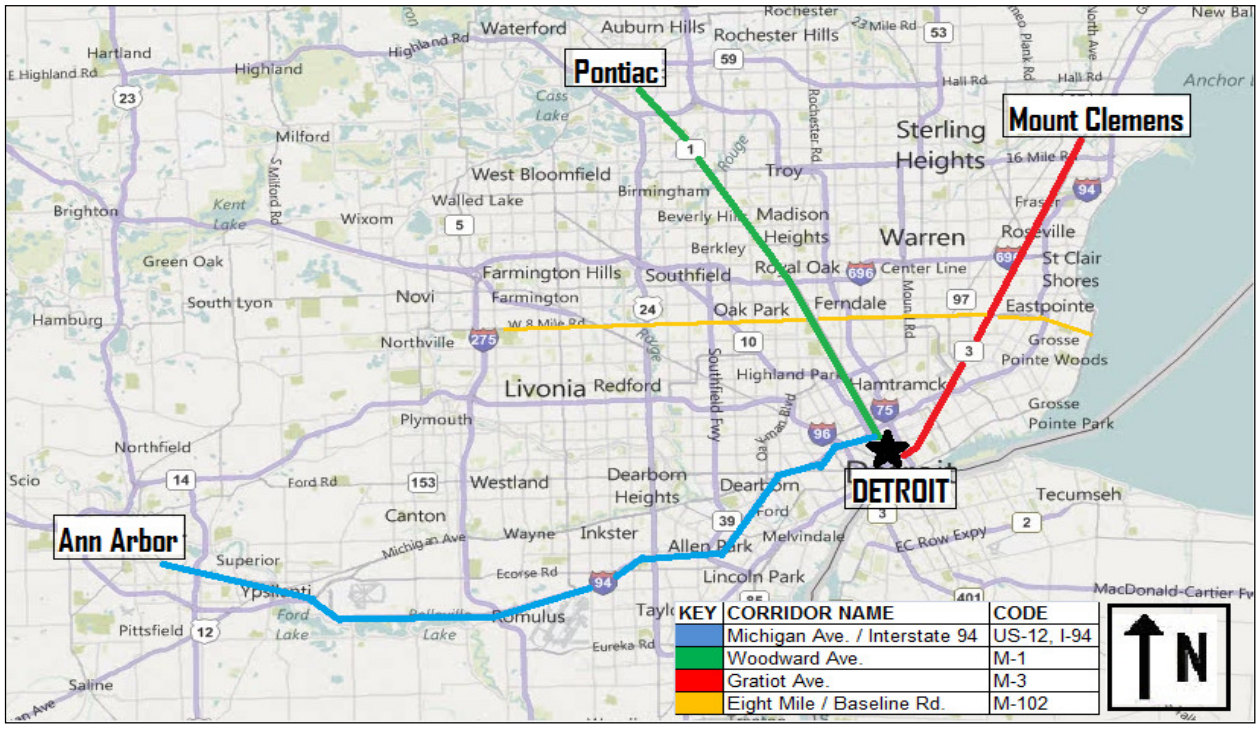


Figure 2. Predominant Travel Corridors in Metropolitan Detroit

When the two cities of Detroit and Pontiac are included, the Woodward Avenue corridor connects a total of ten cities and communities, six of which have historical CBDs (Table 1). The Woodward corridor also includes a number of major cultural and employment centers that are critical to the SEMCOG region.

Table 1. Cities Connected by the Woodward Avenue Corridor

	COMMUNITY	CBD?
1	Detroit	X
2	Ferndale	X
3	Pleasant Ridge	
4	Royal Oak	X
5	Huntington Woods	
6	Berkeley	X
7	Birmingham	X
8	Bloomfield Hills	
9	Bloomfield Twp.	
10	Pontiac	X

The LPA process has been established by the Federal Transit Administration (FTA), as the method for the selection of a proposed transit corridor, when FTA New Starts project funding is sought. Per the guidelines of the FTA New Starts program, the LPA must be selected by local and regional decision-makers and then approved by the appropriate metropolitan planning organization (MPO) [*14*]. The Southeast Michigan Council of Governments (SEMCOG) is the MPO for the seven-county region surrounding the city of Detroit, its most populous city, and its suburbs.

Plans are underway to construct an LRT system connecting the Detroit's central business district (CBD) and northern-most boundary, Eight Mile Rd., stretching 9.3 miles (shown as a gold line in Figure 2). Regional decision-makers at SEMCOG, however, have expressed the importance of the proposed regional system reaching the city of Pontiac (located approximately 26 miles northwest of the Detroit CBD. In addition to the efforts put forth by state and regional leaders in obtaining FTA funding, a group of Detroit-area business leaders have dedicated approximately $125 million in private funds for a 3.4-mile section of the proposed system [*15*]. Based on the recent developments in the pursuit of LRT in the metropolitan area, it is clear that the Woodward Avenue route has the greatest potential for success among the major travel corridors in the region.

1.2. What is Sustainability?

The term "sustainability" is being used increasingly in policy debates about future transportation, and is known to evoke strong reactions among policy-makers, users, and experts. In a broad sense, sustainability implies the "capacity to endure over an extended period", and has become a wide-ranging concept. Sustainable development implies a conscientious use of resources to meet human needs, present and future, while ensuring the preservation of the natural environment. One of the earlier interpretations of the term is given in a 1987 United Nations report (often referred to as the Brundtland Commission), defining sustainable development as "one that meets the needs of the present, without compromising the ability of future generations to meet their own needs."

Black [*16*] has extrapolated this concept to define sustainable transportation as one "that meets the current transportation and mobility needs without compromising the ability of future generation to meet their needs." Implied in the above definition is the concept of non-declining natural resources, deployed to meet transportation needs, existing and future. A strict interpretation of the aforementioned concept may imply that natural resources should not be used to meet transportation needs, unless a systematic effort is made to replenish the resources consumed in the development of the transportation infrastructure. Other factors that further complicate the issue of sustainability are as follows:

- A lack of consensus of the term "needs" (as opposed to demands)
- The "open-endedness" of the term "future generations" (how many generations?)
- The complexity surrounding the use of urban land for transportation purposes

A provision of transportation uses only results in the consumption of land (a valuable and non-renewable natural resource), but also has a tendency to change land use, often to the detriment of future generations. The definitions and concepts cited above raise the question as to whether current transportation projects are truly sustainable. The excessive use of non-renewable resources, air pollution problems, and a gradual deterioration of water quality due to excessive storm-water runoff are some of the factors that contribute to the lack of sustainability [*17*].

Clearly, the debate on sustainability is far from a resolution and is likely to become a critical factor in future transportation-related decisions and investments.

1.3. Implementing Sustainable TOD at LRT Stations

The conceptual definition of sustainable transportation in meeting current mobility needs, and the lack of specificity in this regard has been addressed in literature [*18*]. However, very little research is reported that incorporates environmental sustainability in TOD design related to LRT systems. While the U.S. lags behind many European countries in integrating sustainable development, a number of significant pieces of legislation have the potential to redefine collaborations by integrating transportation, land use, and environmental planning [*19*]. The Clean Air Act Amendments of 1990 authorize sanctions (e.g. loss of funding for highway construction) for failure to meet reduction targets in urban smog [*20*]. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, was mandated to develop transportation systems that are "economically efficient and environmentally "sound" [*21*]. Subsequent acts of Federal legislation commonly referred to as TEA-21 (1998) and SAFETE-LU (2005), increased the importance of environmental sustainability in the development of the nation's long-term transportation infrastructure. The aim of integrating transportation, land use and environmental planning combined with recent pieces of legislation provide the context to which a sustainability framework is ideally suited to achieve future objectives.

Recently, there has been a call to "adopt sustainability as a primary objective of transportation planning" [*22*]. While doing so, there is a need "to address transportation's unsustainable impacts, including depletion of nonrenewable fuels, climate change, air pollution, fatalities and injuries, congestion, noise pollution, low mobility, biological damage, and lack of equity". According to the 2004 World Energy Outlook of the International Energy Agency, transportation and the use of petroleum-based fuels are non-sustainable as they account for more than 20 percent of greenhouse gas emissions [*23*]. In addition to greenhouse gases, many pollutants produced as the result of transportation (sulfur dioxide, nitrogen oxides, particulate matter, ground-level ozone, etc.) significantly impact local air quality, thereby rendering current transportation programs as unsustainable [*24*]. To counteract upward trends in energy use and greenhouse gas emissions, new transportation methods need to promote less driving, energy efficient, low-carbon modes of transportation, along with better integration of transportation and land use infrastructure [*25*], all of which can be categorized as benefits of TOD.

1.4. Background

This report is the result of a study that may be considered as a continuation of an earlier study conducted jointly at Wayne State University (WSU) and the University of Detroit Mercy (UDM) with the objective of selecting two rail stations in the Detroit metropolitan area for TOD implementation. A total of four stations were initially identified following a preliminary network level analysis that included two stations in the city of Detroit, and two in two different suburban communities, based upon their land use, transportation, and other factors. Further analysis resulted in the selection of two stations.

The two sites are located in the cities of Detroit and Troy-Birmingham, representing typical urban and suburban development areas within the region. The proposed Detroit TOD is located at the intersection of Woodward Avenue and Temple St., east of the Masonic Temple Theater and just north of the Detroit CBD. The proposed Troy-Birmingham TOD is located approximately one-half mile west of the intersection of Woodward Avenue and 15 Mile / Maple Rd., along the Canadian National (CN) railroad tracks shared by both cities (Figure 3). The latter location is in Troy, proximate to an AMTRAK passenger boarding platform in Birmingham. Additionally, future plans call for regional bus and paratransit services to be provided by the Suburban Mobility Authority for Regional Transportation (SMART) at this location.

1.5. Objectives of this study

The purpose of this study is to explore the integration of environmental sustainability for the TOD programs proposed at the two stations in the earlier project. Environmental factors such as greenhouse gas emissions (GHG), pollutant loads, energy consumption, storm-water management, and beneficial uses of natural resources (e.g. rainwater capture) that may reduce the environmental impact of future TOD projects are explored in this study. The focus of this study is the integration of TOD at the two selected stations in the Detroit metropolitan area with an emphasis on maximizing environmental performance. Specific objectives of the study are:

1) Incorporating sustainability into planning for TOD programs at the two rail stations identified
2) Identifying planning, operational, and institutional mechanisms for effective implementation

Mechanisms that are expected to expedite the implementation process are identified. Examples of environmentally-sustainable design, planning, and constriction are discussed with the objective of fulfilling a set of sustainability goals presented later in this report.

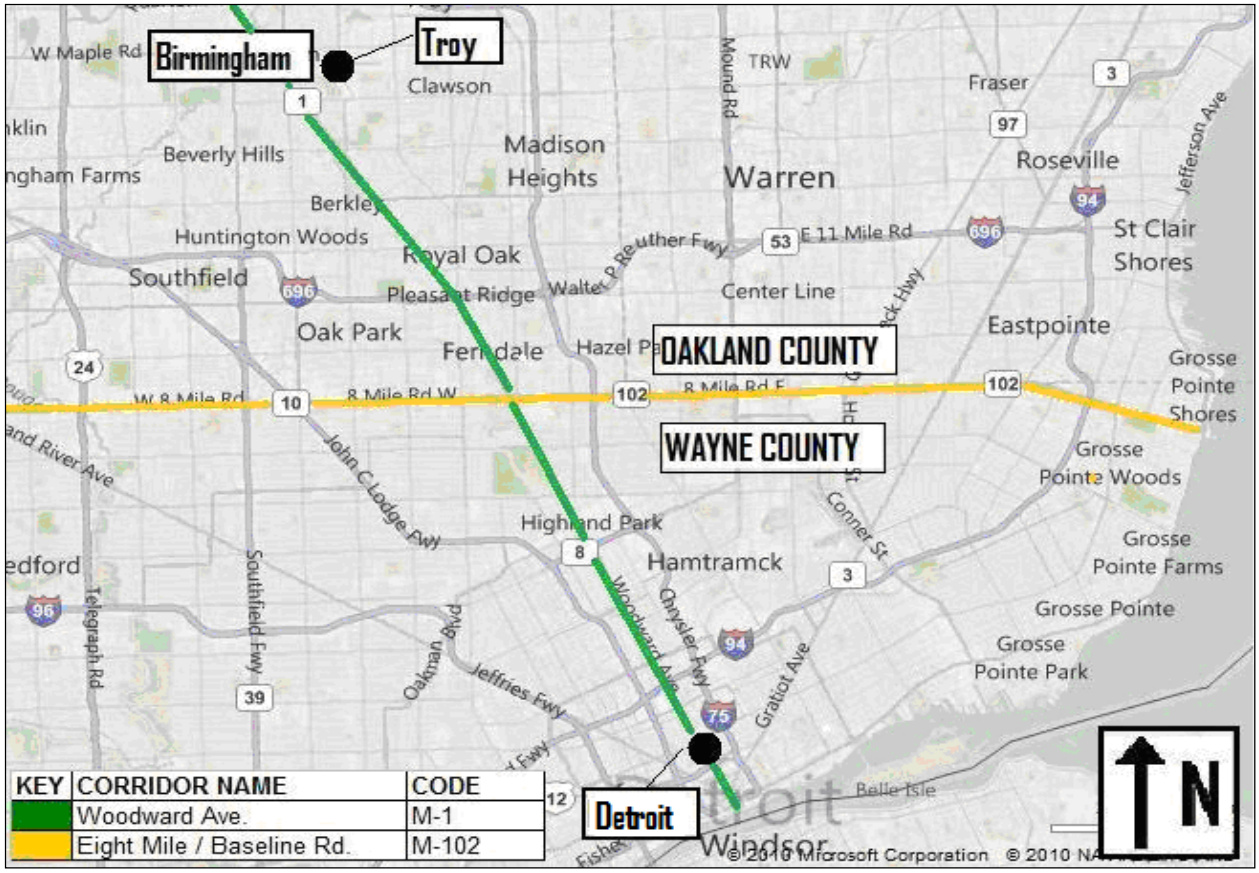


Figure 3. Proposed TOD in Metropolitan Detroit

2. LITERATURE REVIEW

2.1. Historical Perspectives

The passage of the 1969 National Environmental Policy Act (NEPA) marks the beginning of efforts by the United States to strike a balance between mobility and environmental concerns. As pointed out by Wachs [*18*]:

> *"While we have certainly not eliminated the negative environmental impacts of transportation, our society is better off as a result of the passage of NEPA, even if we can think of many short-comings of the NEPA process… To a large number of people, the environmental impacts of many transportation projects are still intrusive and unacceptable…but it has redirected, and not prevented investment in improved mobility."*

Furthermore, improved mobility opportunities have provided access to better education, employment opportunities, health care, economic growth, all resulting in an improved quality of life. As a result of NEPA, it has become a standard practice for projects seeking Federal funding to incorporate environmental impact of transportation in the planning process. However, one might argue that the process, even after 40 years of the passage of the original act, is designed more in a reactive mode. Environmental impact statements are intended to identify possible negative impacts of a project, as well as methods of mitigating them.

To many, NEPA has served the nation well, despite the fact that air pollution, water pollution, and other health-related impacts have not been eliminated. As Wachs [*18*] pointed out, there is an increased awareness among policymakers, as well as users, regarding the existence of transportation-related health hazards. As a result, the nation as a whole has demanded higher standards controlling environmental impacts.

Even though Federal programs have continued to emphasize environmental issues in funding decisions, there is a widespread feeling among the public that the nation is not sufficiently pursuing this issue. For instance, the U.S. showed reluctance in signing the Kyoto Protocol despite the compliance of many European nations to achieve an eight percent reduction of greenhouse gases as mandated in the Kyoto Convention [*18*]. Furthermore, Wachs [*18*] points out that a recent survey revealed that a number of states, on their own, have developed action plans for reduction of GHG emissions.

2.2. Best Practices for Sustainable TOD

This section provides examples of completed projects involving the implementation of sustainable design features for communities located in urban and suburban areas. The items included in this discussion may not necessarily involve TODs, but concepts presented are considered applicable to TOD.

2.2.1. Green Alleys, City of Chicago DOT

The Chicago DOT (CDOT) has been plagued with poor storm water drainage in many of the city's residential neighborhoods. Many of the neighborhoods are nearly a century old and utilize small alleys for vehicular access to homes and businesses. In the past, the alleys were designed to divert storm water flow onto local streets, instead of capturing the water directly into a sewer network or catch basins. CDOT, in collaboration with the Illinois DOT and local contractors and material suppliers, developed pilot programs for new alley designs. The new designs included water permeable and recycled pavement materials, pavement structure designs, and storm water management features. As the result of an initial three-year testing period, CDOT was able to successfully install permeable "green" alleys, walkways, and surface parking facilities in many Chicago neighborhoods. The installation of the "green" alleys was accomplished without the addition of new sewer or drain components. Additionally, the program utilized [*26*]:

- Pavement materials that contained recycled content
- High surface reflectivity to minimize the urban heat island effect

2.2.2. Rain Harvesting and Rain Gardens

In a paper by Seymour [*27*], two methods of rainwater capture for urban irrigation are discussed. The first method involves capturing the water in ponds, cisterns, or tanks (i.e. rain harvesting) for future use in irrigation or other purposes. The second method involves the use of captured storm-water to enhance the landscape and for aesthetic purposes (e.g., rain gardens). In the U.S., approximately 30 percent of potable water for residential areas is used outdoors [*27*]. The practice of utilizing storm-water for outdoor use minimizes the use of municipal water, saving money and reducing the amount of resource necessary for water treatment, as well to reduces the amount of storm water that must be managed, again saving money and reducing the amount of resources required to maintain expensive infrastructure - such as storm sewers and centralized wastewater treatment facilities - that are typically used to deal with storm water.

Both rain harvesting and rain gardens can relatively easily be incorporated into TOD as a part of new construction or retrofitting projects. As usual, from a cost perspective these types of systems are likely to be more economical when implemented into new constructions projects. Detailed guidelines for estimating outdoor and indoor water demand and specifications for harvesting and garden systems have been developed by many states, such as Texas, Georgia, North Carolina, and Maryland.

2.2.3. Patton Park Apartment Homes – Portland, OR

The Patton Park Apartments were developed in coordination with the Portland-area TriMet MAX LRT system in 2006. The development was planned with the following goals: the completed site should function as a TOD, land uses on the site should include a mix of uses (i.e., residential and commercial), and affordable rental housing should be created for larger families. Patton Park has been developed with a host of environmentally sustainable design features [*28*]:

- Low automobile parking ratios (approximately 0.6 spaces per resident)
- Mix of residential options: studio, one, two, and three bedrooms units
- Proximity to non-motorized transportation modes: located one block from MAX LRT station and adjacent to a city-dedicated bicycle route

- Decentralized storm water management (no water is sent to the city system), via pervious parking surfaces and pavements
- Energy conserving building constructed with: low-emissivity (low-E) windows, Energy-Star rated appliances, and exterior aluminum sunscreens to reduce solar gain

This development has incorporated environmental sustainability from a structural and systems approach. There are many examples of new construction projects where some effort has been made to develop a structure utilizing sustainable features (e.g., low-flush lavatories, recycled materials). The Patton Park Apartment complex has satisfied such trends, but has taken a larger, more important step: incorporating environmentally sustainable concepts into the design process. For instance, the reduction of surface parking provided at the site would likely have a positive effect on the storm water collected through the pervious pavements. Because there are fewer automobiles, and less automobile-related pollutants (e.g. metals such as cadmium from brake dust and organics such as carcinogenic polycyclic aromatic hydrocarbons (PAHs) from oil and grease drippings) entering the site, the quality of the water harvested is expected to minimize the amount of on-site treatment required for plant and green space irrigation, increasing the likelihood that environmentally sustainable systems will be implemented and at a lower cost.

2.3. Sustainability Goals

The World Business Council for Sustainable Development (WBC), in an effort to forecast how global mobility patterns might evolve through 2030, has developed a total of seven transportation-related sustainability goals that have received favorable responses from many experts [*18,20*]:

1. To reduce conventional transportation-related emissions
2. To reduce the emission of GHG from transport
3. To reduce the number of transportation-related fatalities and injuries
4. To reduce transportation-related noise pollution
5. To reduce automotive traffic congestion
6. To reduce "mobility divides" between the affluent and poverty-stricken demographics
7. To provide improved mobility options to society as a whole

Based upon a review of the current literature, two additional goals appear to be appropriate:

8. To reduce, or eliminate, transportation-related storm-water runoff so that water quality is not compromised
9. To reduce the consumption of land for transportation purposes

A review of the goals listed above is helpful in assessing the degree to which sustainable transportation may be achieved within the foreseeable future. The premise of "non-declining" natural resources that was discussed earlier makes it very difficult to provide sustainable transportation from a practical standpoint. Recalling that land, air, and water constitute primary natural resources, it would be virtually impossible to provide for transportation without depleting, or adversely affecting their quality. Hence, the premise used by the WBC, "to reduce" (as opposed to eliminate) the adverse impact reflects the Council's vision to set viable goals under the best of circumstances.

3. LRT and SUSTAINABLE TRANSPORTATION

There is a significant body of literature on comparative analyses of different transportation modes, a complete discussion of which is beyond the scope of this paper [*29,30*]. As indicated earlier, a large number of cities in the United States are either in the process of building, or planning for LRT systems. Furthermore, each of these cities has an existing transit base that serves as a springboard for transition toward a rail-based mode. The non-rail transit bases take the form of standard motorized buses or bus-rapid transit (BRT). LRT has unique characteristics for offering the transition as opposed to RRT: metro, subway, etc.

A recent paper analyzing BRT and LRT systems, written by Brand and Preston [*29*], concludes that "currently, electric propulsion appears to be the best option to mitigate air and noise pollution." The authors go on to say, "In terms of costs per bus/train-kilometer, environmental costs appear higher than accident costs, but lower than congestion externalities."

Based upon a review of the current literature, the authors feel that a completely sustainable transportation ("strong sustainability" as described by Black [*25*]) would be virtually impossible to achieve. However, LRT offers characteristics that meet the requirements of a majority of the eight goals when planned, designed, and implemented with sustainability factors as a major requirement. These factors are discussed below.

Goal 1 – To Reduce Conventional Transportation-Related Emissions

As discussed earlier, LRT has characteristics (electric propulsion) that provide more effective mitigation of air and noise pollution. In particular, ground level ozone emissions – known to cause significant human health problems (e.g. asthma [*31*]) – are greatly reduced with the adoption of higher efficiency electrical engines rather than the continued use of gasoline or diesel powered internal combustion engines [*32*]. Furthermore, LRT has been found to be a more favorable mode of transportation than standard motorized buses or BRT, despite recent advances made in BRT technology [*23*].

Goal 2 – To Reduce the Emission of GHG from Transport

Transportation-based emissions constitute nearly one-third of the emission that contribute heavily to atmospheric concentration of GHG [*18*]. Additionally, the electric power train typical of LRT offers a flexible platform for different fuel sources (e.g. fuel cells, existing electrical grids) making it possible to adopt more environmentally friendly power sources as they are developed [*32*]. Transportation-related emissions are a major contributor to GHG emissions and there is a clear indication in the literature that LRT development is more likely to result in an overall reduction of GHG emissions and other air pollutants.

Goal 3 – To Reduce Traffic-Related Fatalities and Injuries

The cost of fatalities and injuries that occur on the nation's highways is estimated to exceed $275 billion, annually. A majority of these losses can be attributed to private vehicles and commercial trucks. Rail transit, LRT in particular, has a "clean" track record in this regard and is considered by experts to be one of the safest urban travel modes.

Goal 4 – To Reduce Transportation-Related Noise Pollution

A number of studies have concluded that electric propulsion is a better option for reduced noise pollution. An exception to this conclusion is related to certain applications (sharp horizontal curvature, steep grades, etc.), where operational noise has been identified as a nuisance for rail modes. The proper design of alignment, as well as the deployment of modern technology may be effective in mitigating these issues.

Goal 5 – To Mitigate Automotive Traffic Congestion

The use of evolving communication technologies (traffic signal pre-emption, loop detection, automatic headway control, etc.) and the ability to carry a large number of passengers per unit of time, are considered as the most effective features of an urban rail system, including LRT. Recognizing that one LRT vehicle has the potential to replace twenty private automobiles, LRT clearly offers the prospect of significant automotive congestion mitigation.

Goal 6 – To Reduce "Mobility Divides" Between the Affluent and Poverty-Stricken Demographics

Rail transit systems are known to attract the "choice" rider, compared to competing bus-based modes. Choice riders are individuals who use transit, despite their accessibility to private automobiles. This phenomenon can be attributed to: improved reliability, on-time scheduling, increased comfort, increased safety, and convenience. On the other hand, traditional bus services are known to attract mostly "captive" riders. Captive riders are individuals that use transit as a necessity and are highly sensitive to the cost of fare.

Goal 7 – To Provide Improved Mobility Options to Society as a Whole

The LRT mode improves mobility options within a typical urban environment. As mentioned earlier, LRT systems significantly contribute to a growing transit share experienced in most cities in the United States. Because all rail systems have the capability to carry a large number of passengers (compared to private automobiles), in a comfortable environment (compared to standard buses), improved mobility options provided by LRT have been known to attract more passengers than originally predicted. Because LRT systems are likely to operate in a partially-controlled right-of-way, their reliability (likelihood of adherence to schedule) is much higher.

Goal 8 – To Mitigate or Eliminate Transportation-Related Storm water Runoff so that Water Quality is Not Compromised

Transportation infrastructure typically available in urban settings (private automobile, bus, rail, etc.) usually generates significant pollutant loads to nearby surface waters, presenting challenges in protecting water quality, as described in Goal 8. In particular, large impervious surfaces required for automobile and bus traffic generate enormous storm water runoff. The environmental impact of transportation infrastructure would be greatly reduced by simply reducing the amount of paved surfaces. Through proper design, LRT systems can be tailored to eliminate or greatly reduce storm water runoff and improve water quality. A recent National Cooperative Highway Research Program (NCHRP) study examined best management practices (BMP) for highway runoff control [*33*]. The study explored the use of treatment systems proximate to pollutant sources as well as distributed approaches known as low-impact

development (LID). Using efficient designs of such treatments at LRT stations (some of which are cited below), storm-water runoff can be greatly reduced and the impacts on water quality can be considerably curtailed. TOD projects would appear to be ideal entities for such treatments.

While all urban transportation modes will have some environmental impact, TOD projects can be designed to meet LID goals. Sustainable, "green" TOD could include [*33,34,35*]:

- *Minimized imperviousness area:* reducing the amount of concrete/asphalt surfaces in order to minimize the quantity of storm-water generated within the project area
- *Pervious surfaces:* include porous pavement materials, interlocking concrete tiles/slabs, have the ability to eliminate storm-water runoff, ultimately having the possibility to reduce/eliminate need for additional storm sewer infrastructure
- *Alternative pavements:* reduce the loading of toxic compounds to surface water (e.g. alternatives to asphalt which leach PAHs [*36*]), improved lighting through increased reflectivity, reduction of urban heat island effect
- *Green roofs:* increased energy efficiency, reduction of peak flow for storm-water runoff, reduction of urban heat island effect
- *Canopy trees:* provide natural shade to reduce urban heat island effect, natural shade leads to increased energy efficiency; reduced peak flow for storm-water runoff
- *Rain gardens:* reduce or eliminate storm-water runoff and sequester pollutants
- *Incorporate ecological systems:* provide wildlife corridors and land development within ecological constraints

Goal 9 – To Reduce the Consumption of Land for Transportation Purposes

Compared to highways and associated structures (e.g. interchanges, service drives/access roads, etc.), rail systems can be accommodated with minimum land requirements, while ensuring the provision of pervious surfaces to facilitate storm-water drainage. Furthermore, LRT vehicles have smaller dimensions (width, wheel diameters, floor height, etc.) than their RRT counterparts and can be considered more efficient in terms of the number of passengers carried per hour per square mile of track area.

4. REVIEW OF TOD PACKAGES

The objective of this section is to review a set of TOD packages developed in a previous project for two proposed TOD stations along with a set of institutional, planning, and economic mechanisms to aid the implementation of the respective TOD packages. A general discussion about the station-specific TOD packages is presented in this section.

4.1. Masonic Temple TOD Site

As one of the two stations selected, based primarily on the availability of vacant land, proximity to a transit line and the location of major activity/employment centers within a short distance. Detailed information about the location of the center, site characteristics, and the proposed TOD packages/mechanisms are presented as follows.

4.1.1. General Overview

Figures 4 and 5 are modified revisions of maps obtained from the records maintained by the city of Detroit Geographic Information Systems (GIS) and Planning and Development Departments. These maps depict the current zoning patterns of the area surrounding the Masonic Temple site, which is bisected by Woodward Avenue [*37*]. Each of the maps has been overlaid with descriptions of the current land uses.

Referring to Figures 4 and 5, the city of Detroit has made provisions for denser, infill-type development to occur in proximity of the Masonic Temple Theater area, particularly along the east side of Woodward Avenue (as reflected in R5 and R6 zoning classifications). Many of these parcels of land directly east of the Woodward Place Townhomes have been zoned as "Planned Development", and may be best described as a medium-density residential development (Figure 4). The land use definition "Planned Development District" (PD) refers to a zone established under Article XI, Division 2 of the Detroit Zoning Ordinance: Specialty Purpose Zoning Districts and Overlay Areas. The description for the PD zoning definition generally states that those plots of land classified as such may be useful when urban renewal and infill development projects are being considered. Furthermore, the PD zoning may be applied to allow a variety of land uses: residential, public/civic/institutional, retail/service/commercial, etc. [*38*].

The Masonic Temple Theater area located west of Woodward Ave. and south of Temple St., on the other hand, is entirely zoned as "General Business". Additionally, nearly half of the parcels of land have been observed to be vacant properties. The project team felt that this section of the Temple area would have the most opportunity for TOD implementation because of the availability of vacant land directly along Woodward Avenue.. Furthermore, the parcels are physically contiguous and are likely to be owned by the same entity, whether public (e.g., Wayne County, city of Detroit) or private (e.g., real estate holding company, business owner). Single-ownership of contiguous parcels of land (as opposed to multiple-ownership of scattered parcels) are better suited for planned development projects.

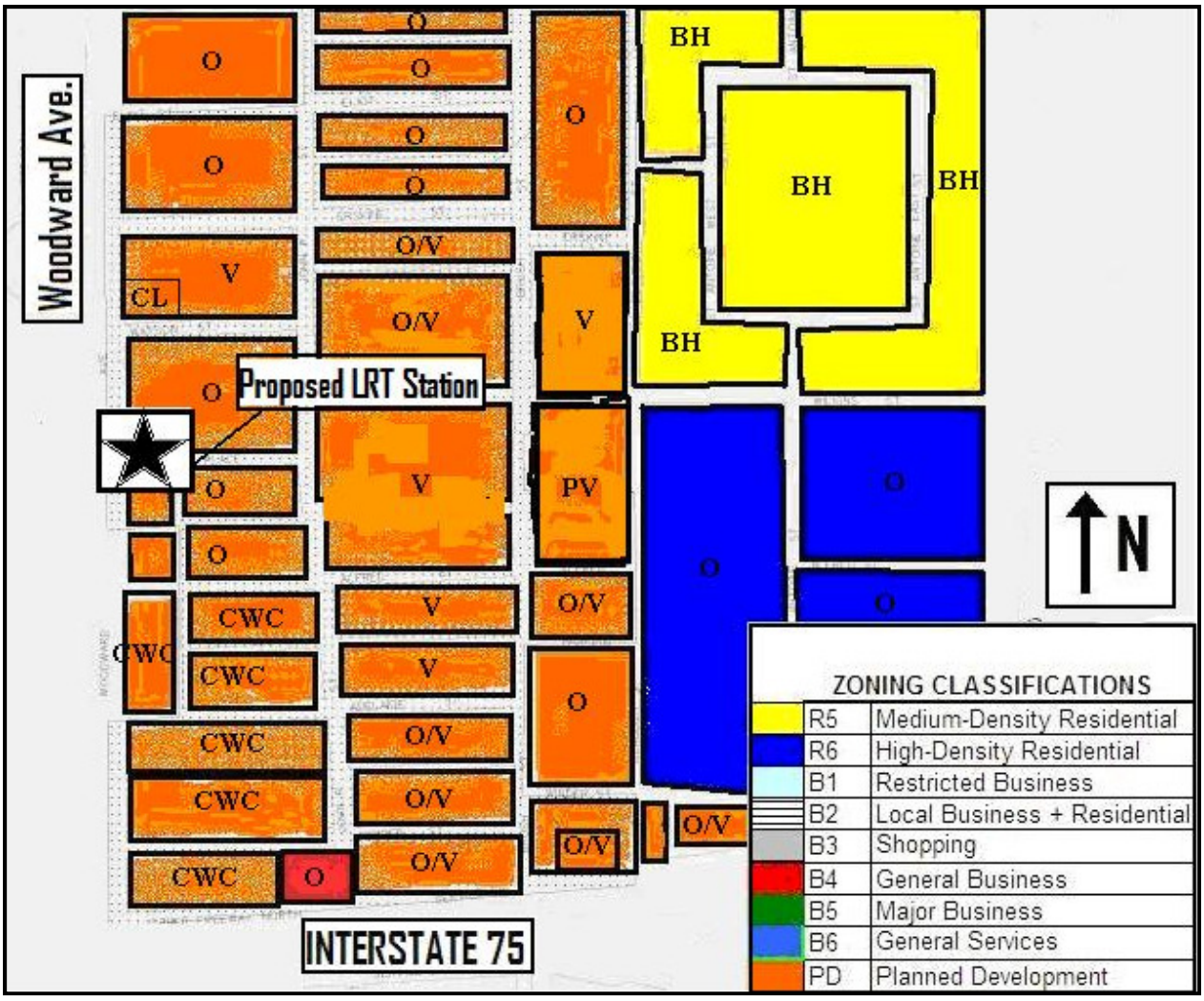


Figure 4. Masonic Temple Theater, East of Woodward Avenue

- O: occupied land, building(s) on-site
- V: mostly vacant land, building may be on-site
- O/V: building(s) on-site, mixed with vacant land
- CL: Crystal Lofts
- PV: Village-Brush Park Manor: Paradise Valley (Senior-Living Community)
- CWC: Crosswinds Communities, Woodward Place Townhomes at Brush Park
- BH: Brewster Homes

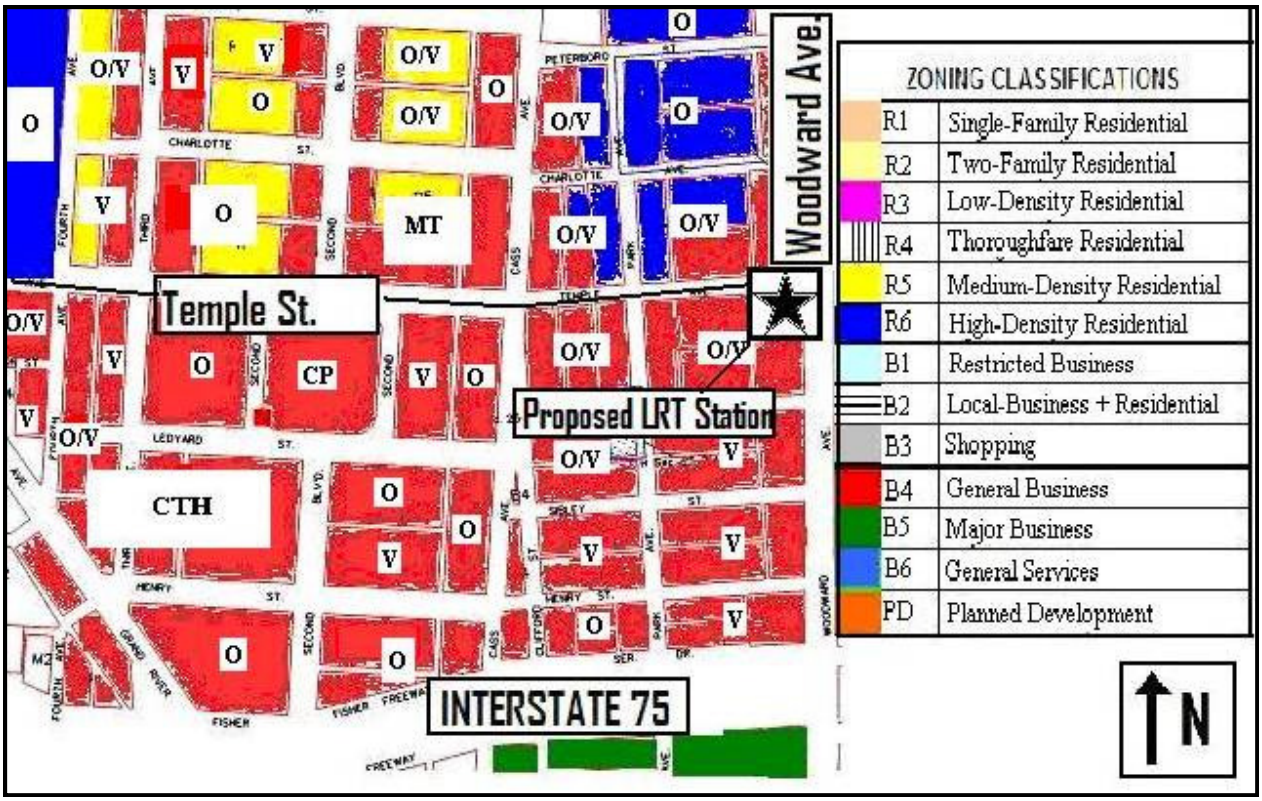


Figure 5. Masonic Temple Theater, West of Woodward Avenue

- O: occupied land, building(s) on-site
- V: mostly vacant land, building may be on-site
- O/V: building(s) on-site, mixed with vacant land
- MT: Masonic Temple Theater property
- CP: Cass Park
- CTH: Cass Technical High School

Aerial images of the vacant properties and occupied parcels of land, with respect to Woodward Avenue and Temple St. are shown in Figures 6 and 7. The total land area of the vacant land depicted is estimated at 5.5 acres (Table 4).

Figure 6. Masonic Temple Theater, West of Woodward Avenue and North of Temple St.

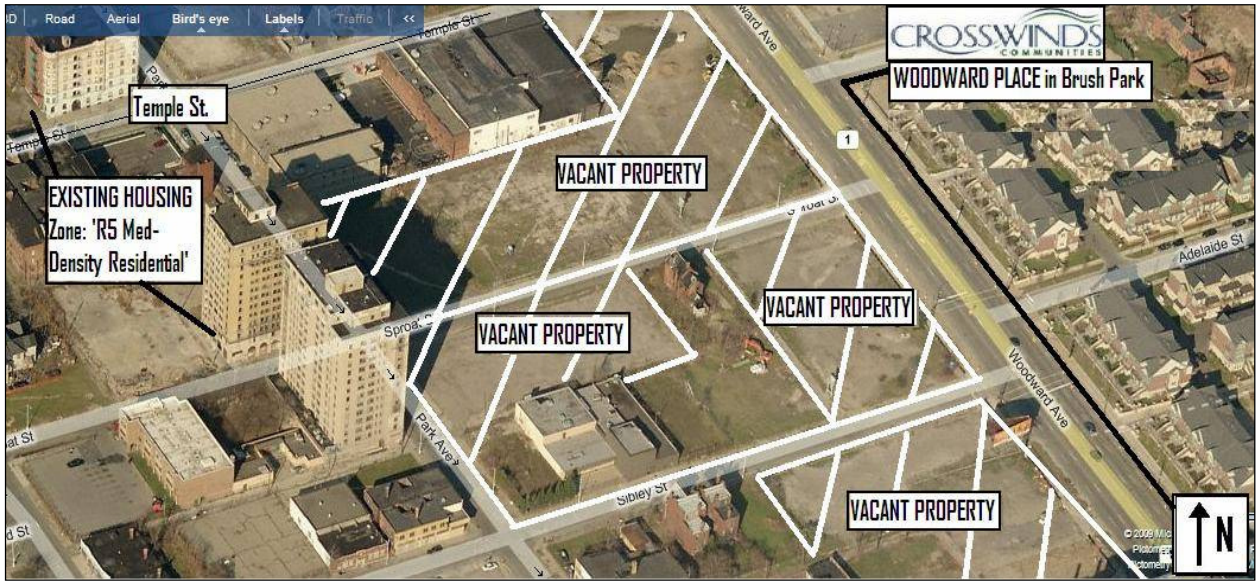


Figure 7. Masonic Temple Theater, West of Woodward Avenue and South of Temple St.

4.1.2. Site Characteristics and Land use activities Inventory

In the Masonic Temple Theater area, the influence area is centered on the intersection of Woodward Avenue and Temple St. The residential development in the Masonic Temple area has experienced significant growth in housing stock supply during the past decade, particularly along the Woodward Avenue corridor. Those new developments have largely been marketed toward individuals wishing to live closer to Detroit's Cultural Center (to the north) and Detroit CBD (to the south), consisting of a mix of contemporary loft-styled condominiums (i.e., The Ellington, Crystal Lofts) and more traditional-styled townhomes (i.e., Woodward Place at Brush Park). A summary of the residential market development inventory, within the influence area, is shown in Table 2 [*39,40,41,42*].

Table 2. Residential Market

NAME	WALK DISTANCE TO STATION (mi)	TYPE	MARKET	TOTAL # OF FLOORS	TOTAL # OF UNITS	ADDITIONAL INFO.
Woodward Place at Brush Park	<0.1	Condo, Townhome	For Sale	NA	180	2, 3-bedroom units (1,300-2002 ft²)
Village-Brush Park Manor: Paradise Valley	0.3	Senior	Rent	3	113	1-bedroom apts.
Heritage Senior Living	0.5	Senior	Rent	4	50	
Carlton Lofts	<0.2	Condo	For Sale	7	51	Studio (1 or 2-level), 1,2-bedroom units (700-1,800 ft²)
Crytal Lofts	0.1	Condo	For Sale	4	17	Studio, 1,2-bedroom units (1,137-1,885 ft²)
Ellington Lofts	0.4	Condo	For Sale	4	55	1,2-bedroom units (860-1500 ft²)
Peterboro Place Apartments	0.2	Rent	Rent	6	?	

Commercial development in the Masonic Temple Theater area, by contrast, has not experienced much growth recently. Most of the new commercial developments constructed have focused along the Woodward corridor, and are attached to the aforementioned residential developments as mixed-use facilities: first-floor commercial, second-floors and higher residential. The real estate market for residential and commercial spaces remains weak, as the hardships faced by the American automotive manufacturers (historically, the backbone of the Detroit-area economy) have had a ripple effect on the metro area, and the state of Michigan as a whole. Furthermore, the world economic crisis of 2008-2009 has severely deepened those effects. As a result, many of the newer residential developments (especially along the Woodward corridor) are sparsely occupied.

A summary of the commercial market development inventory, within the influence area, is shown in Table 3.

Table 3. Retail/Service/Commercial Market

NAME	WALK DISTANCE TO STATION (mi)	TYPE	MARKET	ADDITIONAL INFO
Park Sibley Market	0.2	Retail	Convenience	
Big Eagle Market	0.4	Retail	Convenience	
Source Apparel	< 0.1	Retail	Apparel	Woodward Avenue corridor
Detroit 1 Coney Island	0.2	Service	Restaurant (Casual)	
People's Records & Collectibles	0.2	Retail	General	
FedEx Kinko's	0.4	Service	General	Mixed Use Development (Ellington Lofts Structure)
Starbucks Coffee	0.4	Service	Restaurant	
T-Mobile	0.4	Retail	General	
Temple Bar	0.2	Service	Pub, Lounge	
Atlas Global Bistro	< 0.1	Service	Restaurant	

Public/civic/institutional land uses near a TOD are expected to improve the quality of life of the local residents. Many of these land uses, such as hospitals, schools, and libraries may present employment opportunities within the community as well. Considering these factors, the Masonic Temple area is strategically located near the Detroit Medical Center (DMC); approximately one mile north), a campus of medical research institutions that have strong relationships with many institutions of higher learning within the state of Michigan: University of Michigan (UM), Michigan State University (MSU), and WSU (located approximately one mile north of the proposed Temple transit stop). A summary of the public/civic/institutional land uses in the influence area (within one-half mile) surrounding the Masonic Temple is shown in Table 4.

One of the most prominent places listed is the St. John's Episcopal Church, located at the intersection of Woodward Avenue and the I-75 service drive (Figure 8). St. John's is the oldest functioning church located along Woodward Avenue in the Detroit metropolitan area, and in 1982 it was added to the NRHP [*43*]. Currently, the church remains as a local landmark in the Detroit lower Woodward Avenue/CBD area.

Table 4. Public/Civic/Institutional Market: Masonic Temple Area

NAME	WALK DISTANCE TO STATION (mi)	TYPE	ADDITIONAL INFO
Cass Park	0.3	Public Park	
University of Michigan - Detroit Center	0.4	Higher Learning	Satellite campus
Ecumenical Theological Seminary	< 0.1	Place of Worship	Training center
Cass Park Baptist Church / Hope Baptist Center	0.4	Place of Worship	
St. Patrick's Parrish Catholic Church	0.5	Place of Worship	
Jehovah's Witnesses Woodward	0.4	Place of Worship, hall	
St. John's Episcopal Church	0.4	Place of Worship	NRHP, 1982

Figure 8. St. John's Episcopal Church

The data presented in Tables 2-4 indicates features of the Masonic Temple area can be summarized as:

- The residential housing stock is diverse, but the newer developments are sparsely occupied (particularly the Ellington Lofts and Crystal Lofts).

- The commercial development market is largely open. The city of Detroit lacks a major chain-based grocery chain (e.g., Meijer, Kroger). Within the influence area, there are no developments consisting of: chain-based hardware retailer (e.g., Home Depot, Lowe's, Menards, ACO Hardware), drugstore (e.g., CVS, Walgreen's, Rite-Aid), casual dining restaurant (e.g., Applebee's, TGI Friday's, Chili's, Red Lobster), or general apparel (e.g., Old Navy, H & M, Marshall's, Kohl's, Target).

- There is a wealth of institutional land uses nearby (WSU, DMC, places of worship), but there is a lack of pedestrian facilities in the area, particularly along the Woodward Avenue corridor. Existing sidewalks are in good condition, but relatively narrow considering the urban location. Aside from the Cass Park property, located across from the Masonic Temple, there are no common areas or pedestrian plazas within the influence area.

- There are more than six churches within half-a-mile radius of the temple, attracting in excess of 1000 worshipers on Sundays. However, no high-quality eating establishment for these patrons can be found nearby.

4.1.3. Pedestrian Access

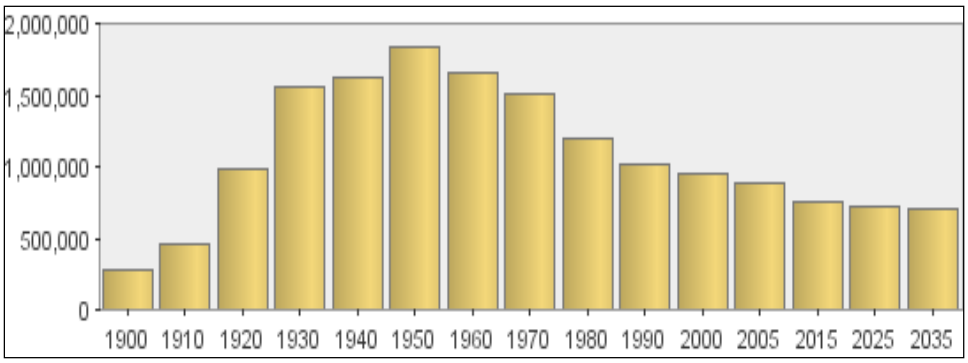


Figure 9. Population Forecast: City of Detroit
(Source: U.S. Census Bureau, SEMCOG 2035 Forecast)

From an engineering standpoint, the configuration of the Woodward Avenue corridor and its adjacent streets in the Masonic Temple area are not conducive to pedestrian mobility or TOD. The most challenging issue in this regard is that the large width of the Woodward Avenue In this area, the right-of-way consists of nine lanes which include:

- Through movements (six lanes): three lanes in each direction of travel (northbound and southbound)
- Left-turn movements (LT): one center lane
- Curbside parking (two lanes): one lane in each direction of travel

According to aerial imagery obtained for the area, the crossing width for the Woodward Avenue ROW is approximately 10 feet per lane, or a total of 90 feet [*44*]. Although traffic along this corridor is not particularly heavy along this highway segment (ADT: 10,168 vpd - vehicles per day, PHV: 971 vph - vehicles per hour), pedestrian safety would be questionable even under non-peak traffic conditions due to the large crossing width that pedestrians must overcome when traveling from one side of Woodward Avenue to the other [*45*] (Figures 10-12). Further analysis of geometric highway and traffic signal design in this area revealed the lack of the following pedestrian-friendly features:

1. Properly delineated crosswalks
2. Pedestrian relief center island
3. Pedestrian crossing signals

The T-shaped intersection configuration for cross-streets in the area (moving from north to south: Charlotte St., Edmund Pl., Temple St., Alfred St., and Sproat St.; represented by locations 1-5 in Figure 10), make it difficult to implement pedestrian crossing signals while simultaneously maintaining vehicular traffic along Woodward Avenue The cross-streets at locations 1-5 are controlled by 'STOP' signs only. Past efforts to improve pedestrian safety at un-signalized intersections have included the installation of pavement markings/delineation and warning signs. Such improvements, however, have had limited success in achieving goals to increase pedestrian safety. One of the most challenging problems in solely relying on signage and markings is that they are often ignored by drivers and pedestrians [*46*].

Although the technology used in traffic and pedestrian signals has increased dramatically in the past twenty years (e.g., video detection) and methods to stop vehicular flow along Woodward Avenue in order to allow safer pedestrian crossing movements are achievable, the main function of Woodward Ave/ is to function as a primary arterial roadway. Thus, the addition of five traffic signals within a distance less than one-quarter mile (the exact distance between Charlotte and Sproat Sts. is one-sixth of a mile) is likely to have adverse effects on throughput capacity.

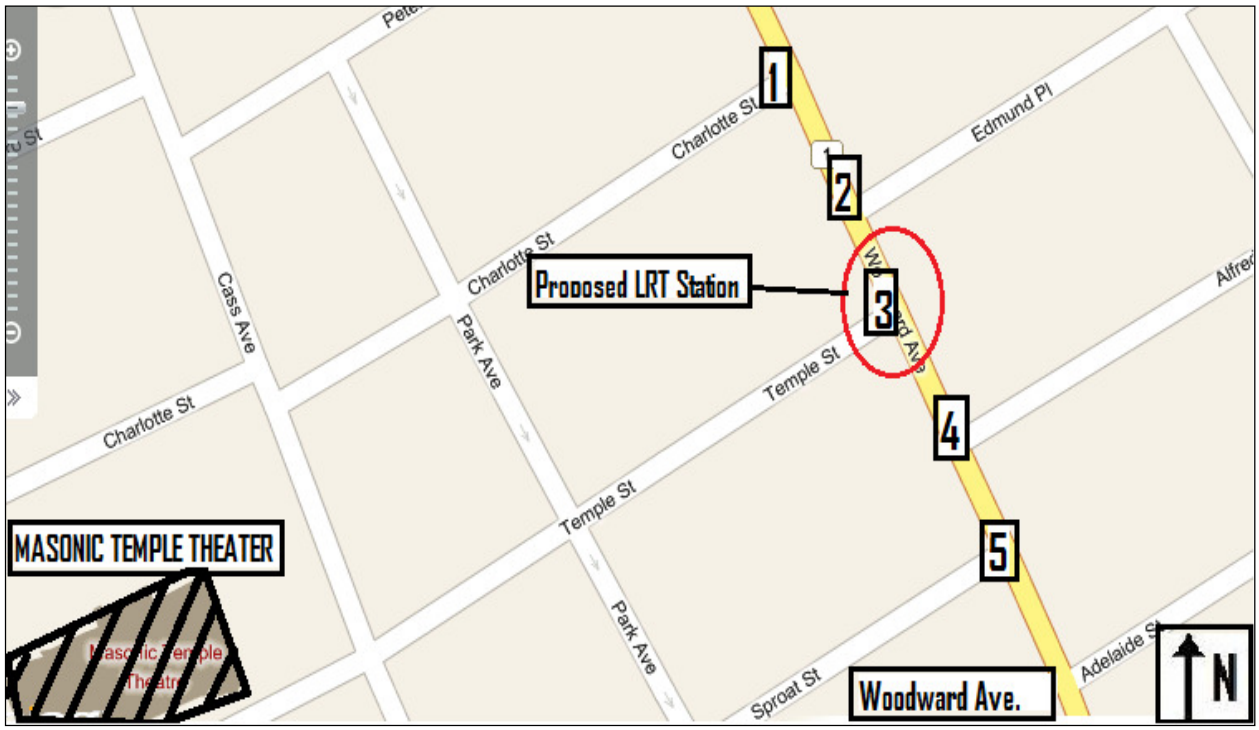


Figure 10. Proposed LRT Station Locations

Preliminary plans for the M-1 Rail LRT system, call for the LRT vehicles (LRTV) to travel along Woodward Avenue by utilizing the second travel lane from the curbside. Using this convention, northbound LRT passengers would need to access the east side curb of Woodward Avenue, so that they may board the system, and vice-versa. Based upon the existing conditions of the site, it would appear that successful implementation of LRT would require significant improvement in pedestrian safety. In order for the area near the Masonic Temple LRT station to function as a true TOD, the east and west sides of the Woodward Avenue must be better connected for pedestrian movement.

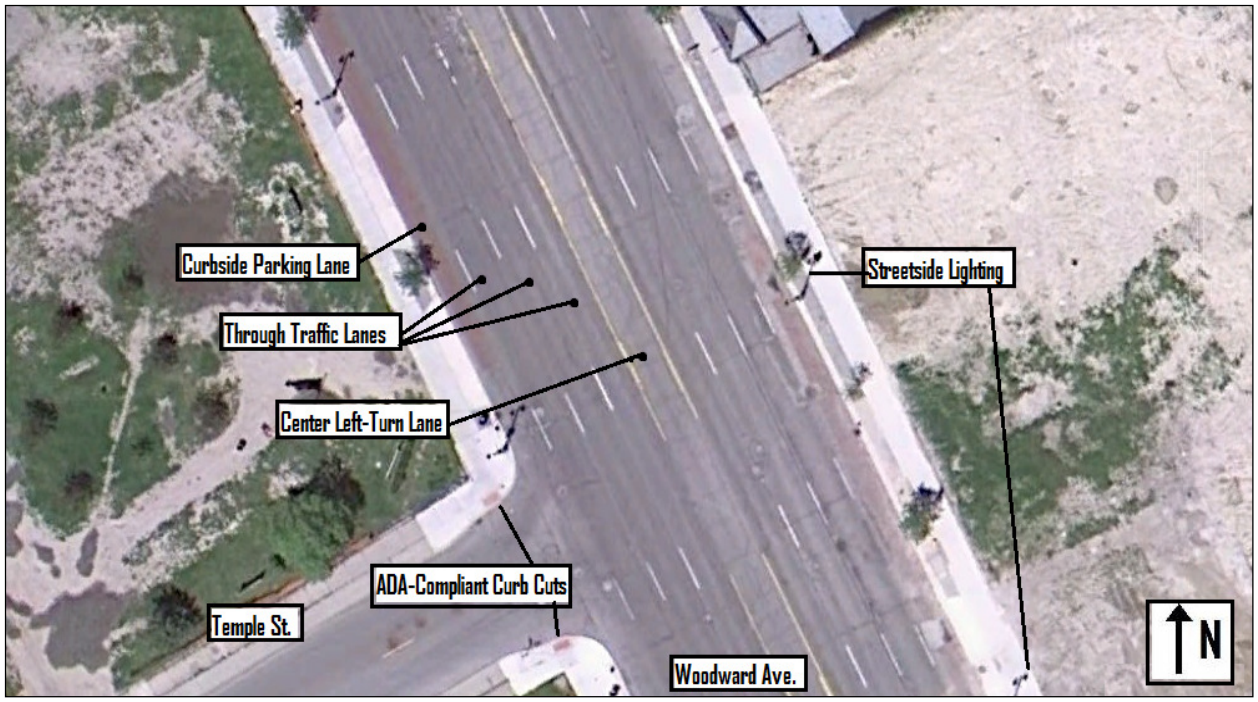


Figure 11. Aerial View of Woodward Avenue ROW

Figure 12. Street View of Woodward Avenue, Looking South (Figure 10, Location 3)

4.1.4. TODs Proposed

The records maintained by the city of Detroit indicate that the real estate property surrounding the proposed LRT station at Woodward Avenue and Temple St. (referred to as location 3 in Figures 10 and 13) consists of a total of eight parcels currently city-owned. The total area of these parcels, located adjacent to Woodward Avenue and north of Sproat St., are approximately 2.63 acres (Figure 13). The parcels are conducive to any efforts taken by the city to construct passenger boarding/alighting facilities for the proposed LRT system, and are strategically located to support a system that operates LRTV's through the median (where two sets of track are laid side-by-side), or along travel lanes (where one track is laid in a traveled lane, for each direction of travel). In regard to future development in the Masonic Temple area, this scenario would largely represent the most conservative scenario.

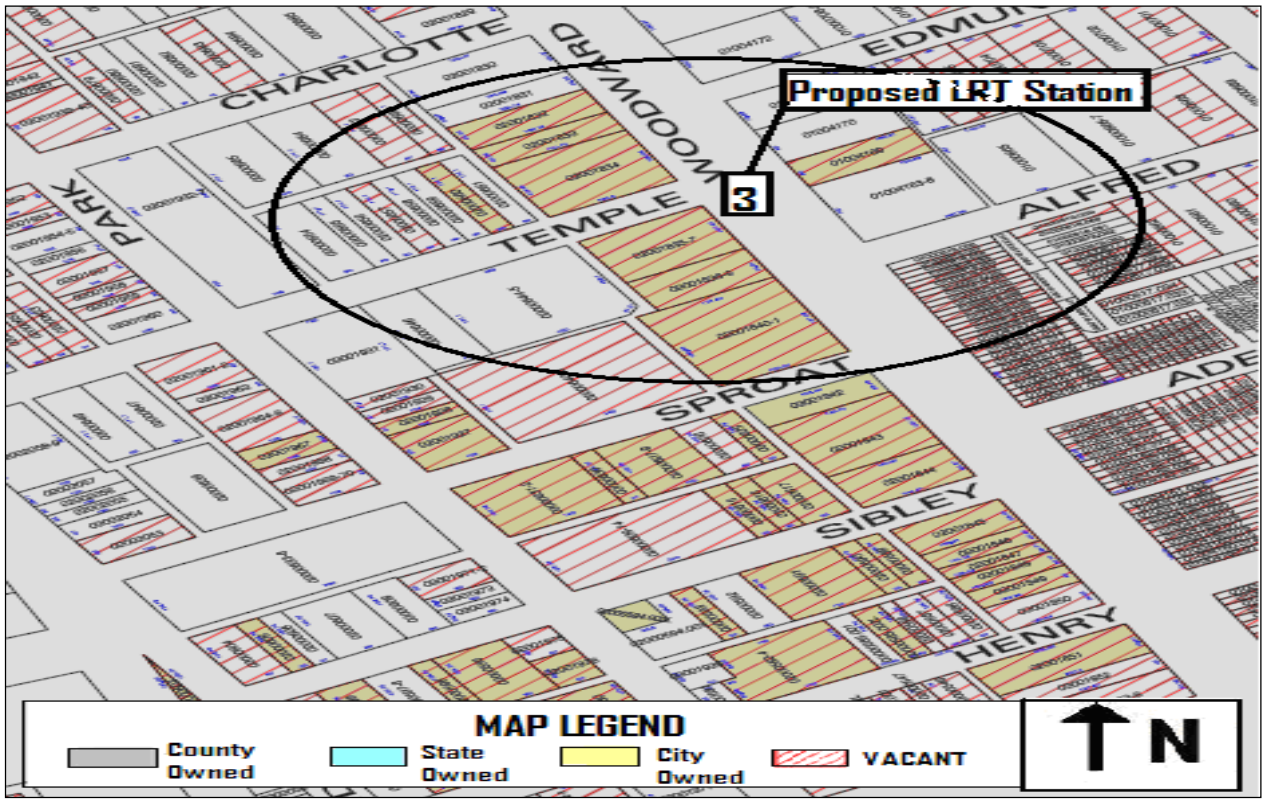


Figure 13. Land Use and Property Ownership

The Temple area was selected for consideration in this study primarily due to its potential for future growth. The area currently lacks many features that are typical of an ideal TOD. Of particular importance is the lack of connectivity across Woodward Avenue, as well as the land uses within walking distance of the proposed LRT station. Table 8 lists land uses that may be added to the area with the intent to improve the quality of life and livability for the local residents. A discussion of possible mechanisms to complement proposed land uses is provided in the next section. Lastly, a spatial reference with respect to the area near the proposed Masonic Temple LRT station is provided for each proposed land use. It should be noted that the proposed changes for the area are subject to change and other alternatives may be implemented for TOD.

Table 5. Proposed Land Uses

	LAND USE TYPE	DESCRIPTION	ADDITIONAL INFO
1	Retail/Service/Commercial	Child Care Center	
2		Bookstore	e.g., Borders Books & Music, Schuler's Books & Music
3		Casual Dining Restaurant	e.g., Chili's, Applebee's, TGI Friday's, Denny's
4		Grocery or General	e.g., Meijer, Kroger, Target, Wal-Mart
5	Public/Civic/Institutional	Transit Station w/ Shelter	May be integrated into mixed-use structure, located on street-level
6	Residential	Apartment Complex	For Rent, Marketed toward students (WSU, UM, MSU)
7	Public/Civic/Institutional	Traffic calming/Pedestrian facilities	e.g., pedestrian relief island (Woodward Avenue), HAWK pedestrian signals, capacity reduction (Woodward Avenue), "zebra" crosswalk markings

The land uses and improvements listed in Table 5 are all proposed for the area encircled in Figure 13. Items 1-6 could be sited in the circled area, on the west side of Woodward Avenue, if they were incorporated into a large, mixed-use structure. Using this convention, land uses that typically generate pedestrian traffic (such as the non-residential types of development listed), could be located at street-level of such mixed-use structures. Residential units (preferably rentals) or additional retail (such as a large grocery chain) could then be planned for the higher floors of the proposed structure. The amount of first-floor space available for tenants, such as a large grocery chain or general retailer, may be a limiting factor when implemented in the area encircled in Figure 13. To mitigate this, additional parcels of land (located south of Sproat St. and west of Woodward Avenue) could be released from city ownership. Examples of mixed-use structures are depicted in Figures 14 and 15. The density of such a development and its precise location would largely depend on the willingness of the administration/policy makers of the city of Detroit to release the city-owned land parcels and the willingness of developers to pursue such projects.

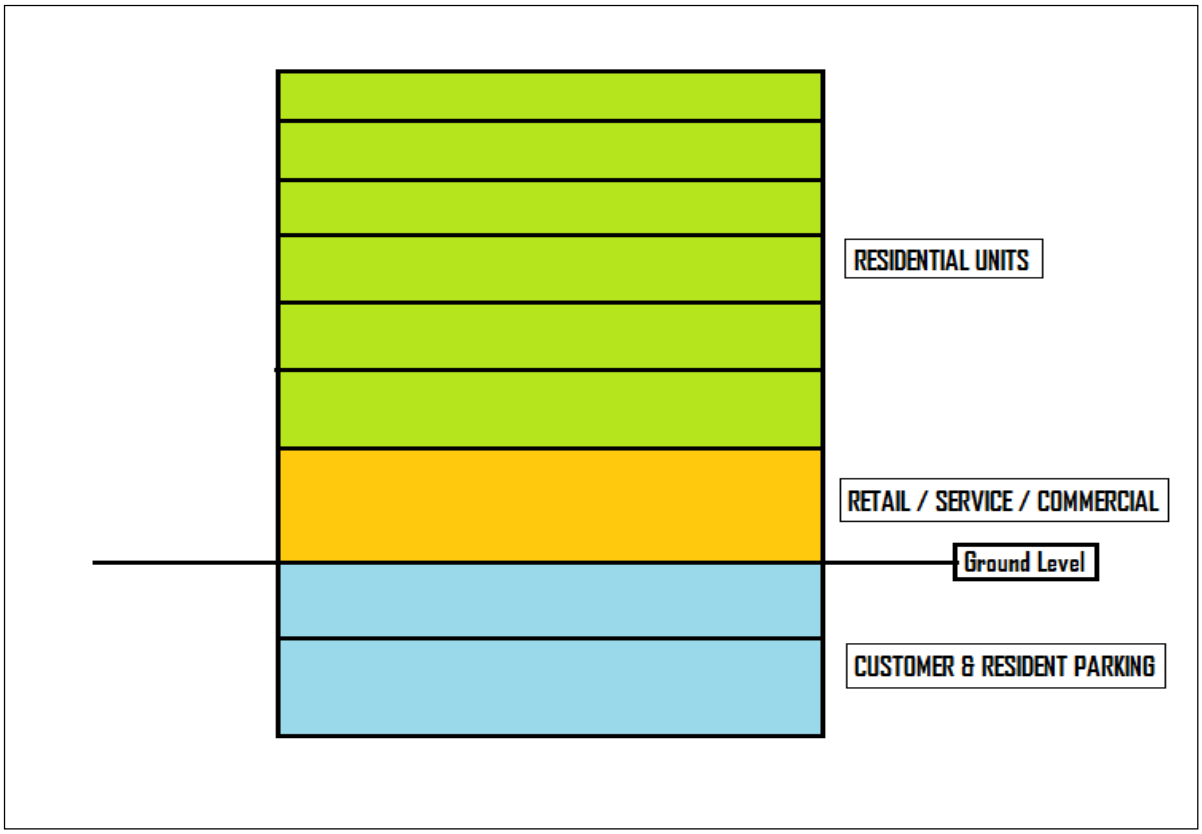


Figure 14. Diagram of Typical Mixed-Use Structure

In the spirit of TOD, it is also suggested that plans for additional parking facilities are significantly reduced or omitted if possible. This suggestion parallels research conducted for Transit Cooperative Research Program (TCRP) Report 128: Effects of TOD on Housing, Parking, and Travel [*47*]. In the study, trip generation and parking data were collected from 17 completed TOD projects located in four metropolitan areas in the United States: Philadelphia/NE New Jersey, Portland, San Francisco Bay, and Washington, D.C. It was determined that residential TOD's generate approximately 50 percent less vehicle trips, during the peak periods (i.e., A.M. and P.M. peaks), than the most current rate estimates established by the Institute of Transportation Engineers (ITE) [*47*]. Furthermore, it is suggested that if additional parking is considered absolutely necessary for the development, that such parking be located as an underground facility (blue portion of Figure 14), to maintain the pedestrian friendliness of the general area at the street level.

Each of the land uses proposed in Table 5 are intended to complement, and in many cases to provide for, the needs of the community living in proximity to the Masonic Temple area (community areas listed in Table 2). For instance, there is a lack of a major bookstore chain in the area. With the added advantage of the proximity of the MSU and UM-based facilities, and those currently maintained by WSU, UDM, and the DMC, additional book sellers could be valuable to metro Detroit residents affiliated by those institutions. Another example would be the lack of a major grocer or general retail chain within the city limits. The lack of such a facility requires that the residents of the city, including the temporary student populations and

existing Temple-area residents, generally must travel outside of the city of Detroit (e.g., Dearborn, Warren, Redford Twp.) for such retailers, or settle for limited options available at local convenience stores.

Figure 15. Completed Mixed-Use Structure
(Source: http://yochicago.com/mixed-use-shops-and-lofts-in-grand-boulevard-to-feature-140-new-apartments/13924/)

4.2. Troy-Birmingham AMTRAK Station

The second site selected for possible implementation of TOD was based primarily upon the proximity to a rail station, potential interface with the proposed LRT station on Woodward, strong pedestrian friendliness in the design of the streetscape of the partner city of Birmingham, and potential to incorporate a pedestrian orientation with the retail development in Troy, and the availability of a relatively large high-density residential development around the station area. Detailed discussion of these features and proposed TOD and associated institutional mechanisms are presented below.

4.2.1. General Overview

Figure 16 is an aerial photograph obtained from the City of Troy Planning Department that displays what the area looked like in 1990, when a Ford plant occupied the land and before major development occurred. Zoning maps for the cities of Troy and Birmingham were also obtained from records maintained by their respective city planning departments. Figures 17 and 18 have been modified from those records, and depict the current zoning definitions and their distribution for the cities of Troy and Birmingham, respectively [*48,49*]. Each of the zoning maps has been overlaid with descriptions of the current land uses that have been observed in the area.

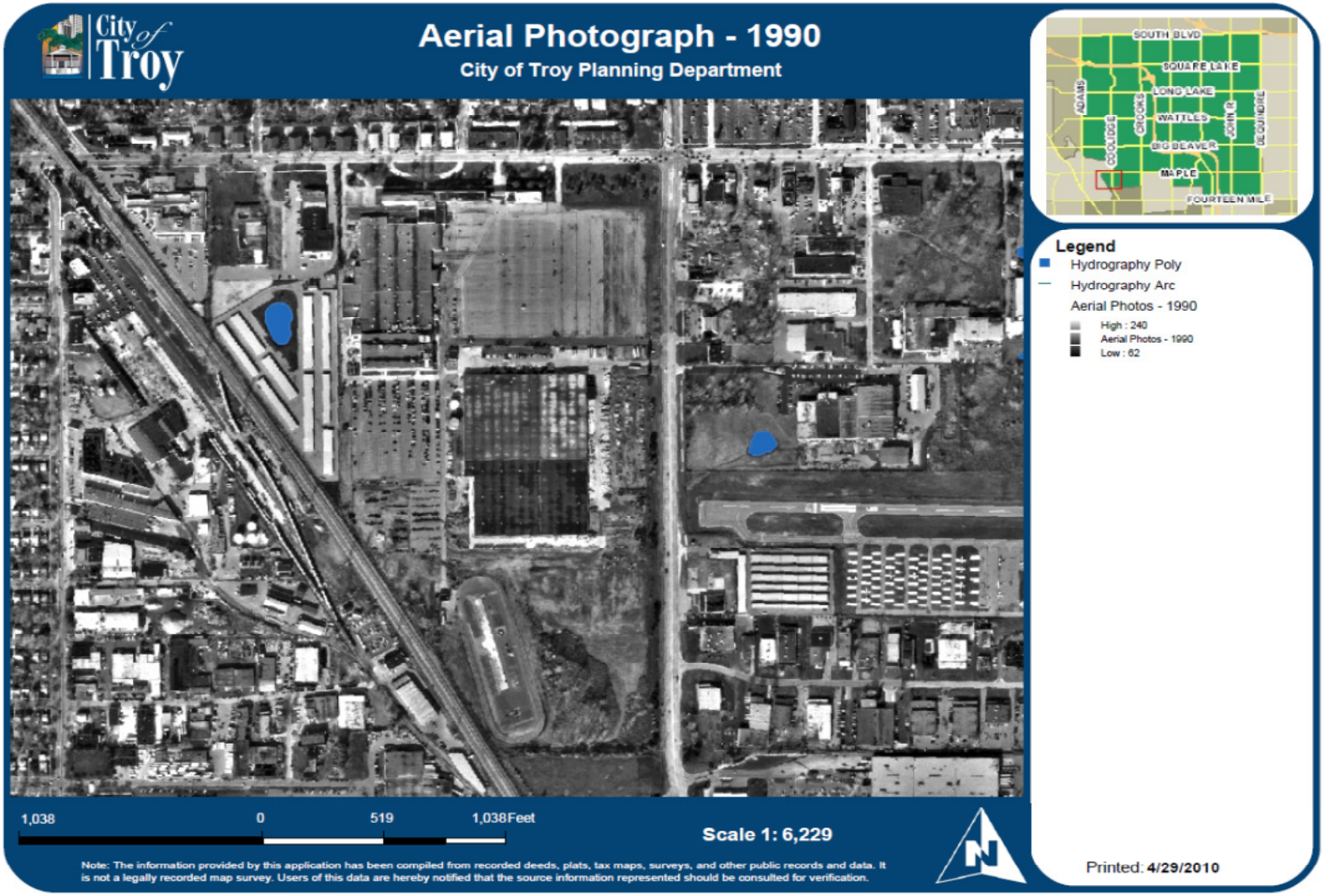


Figure 16. Ford Tractor Plant – Circa 1990

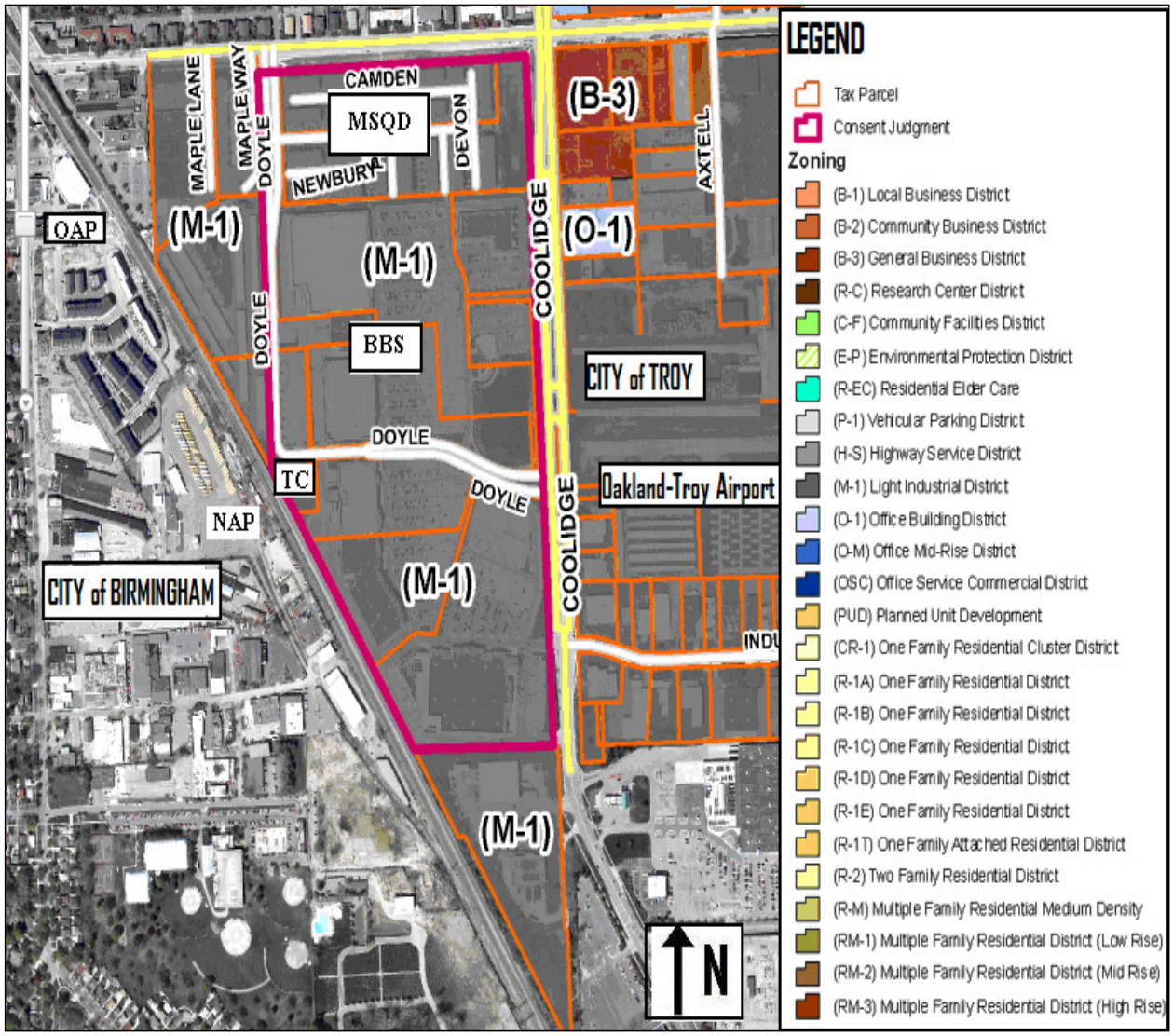


Figure 17. Troy-Birmingham AMTRAK Station: City of Troy (North of Railroad Tracks)

- TC: proposed Troy-Birmingham Multi-modal Transit Center (MTC)
- OAP: existing AMTRAK station
- NAP: proposed AMTRAK platform
- BBS: Midtown Square Shopping Center (big-box retailers)
- MSQD: The Village at Midtown Square

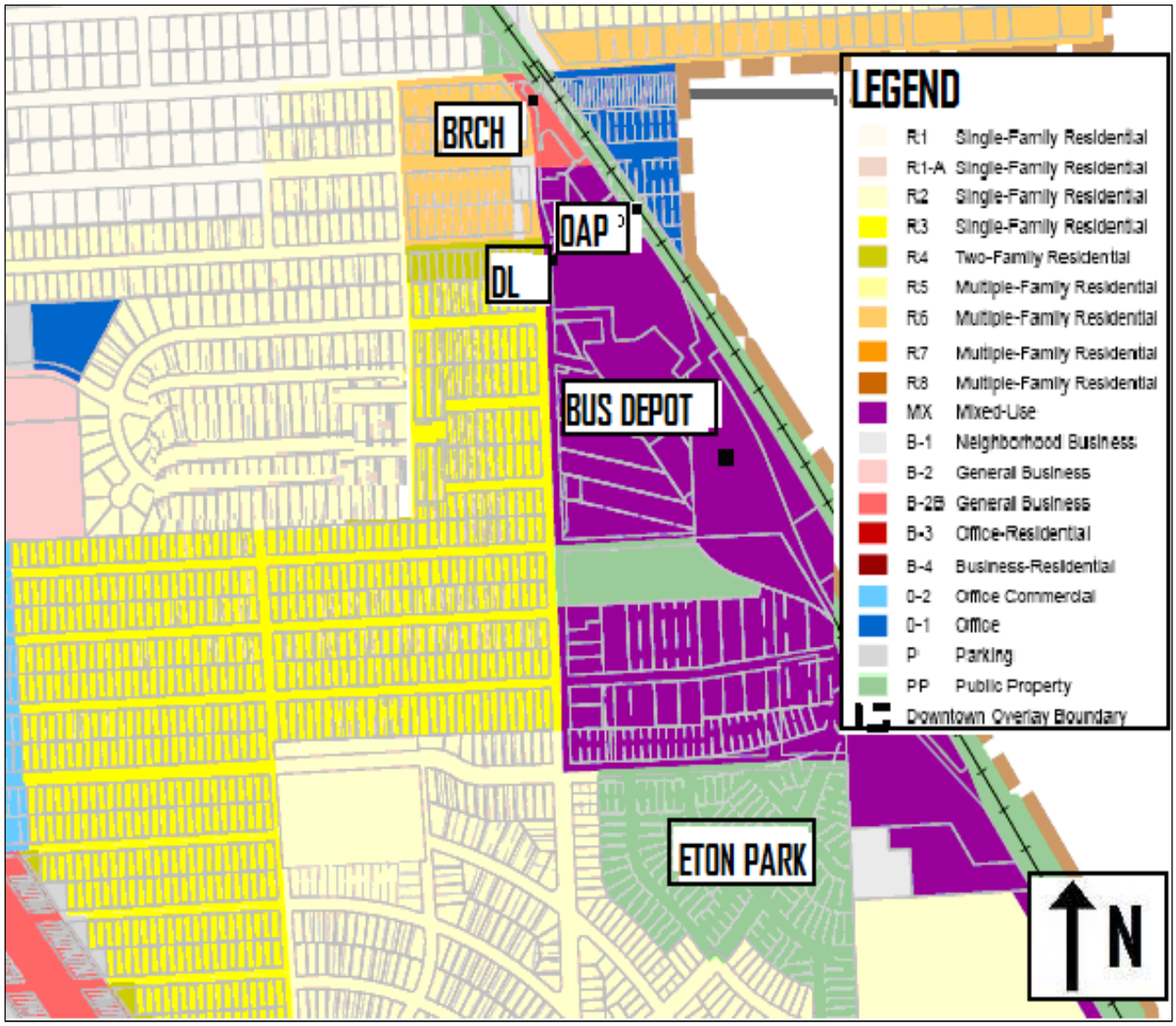


Figure 18. Troy-Birmingham AMTRAK Station: City of Birmingham (South of Railroad Tracks)

- BRCH: Big Rock Chop House
- OAP: existing AMTRAK platform
- DL: The District Lofts
- BUS DEPOT: surface school bus parking and maintenance facility for the City of Birmingham School District.

An aerial image of the Rail District, near the proposed Multi-modal Transit Center (MTC) is shown in Figure 19. The boundary of the MTC site is depicted as the white triangular area north of the railroad tracks, which are depicted by purple lines. The location of the Birmingham School District bus depot and Midtown Square Shopping Center can also be identified to the east and west of the railroad tracks, respectively. The records maintained by the cities of Troy and Birmingham appear to indicate that the bulk storage area (located just south of the bus depot in Figure 19) will remain.

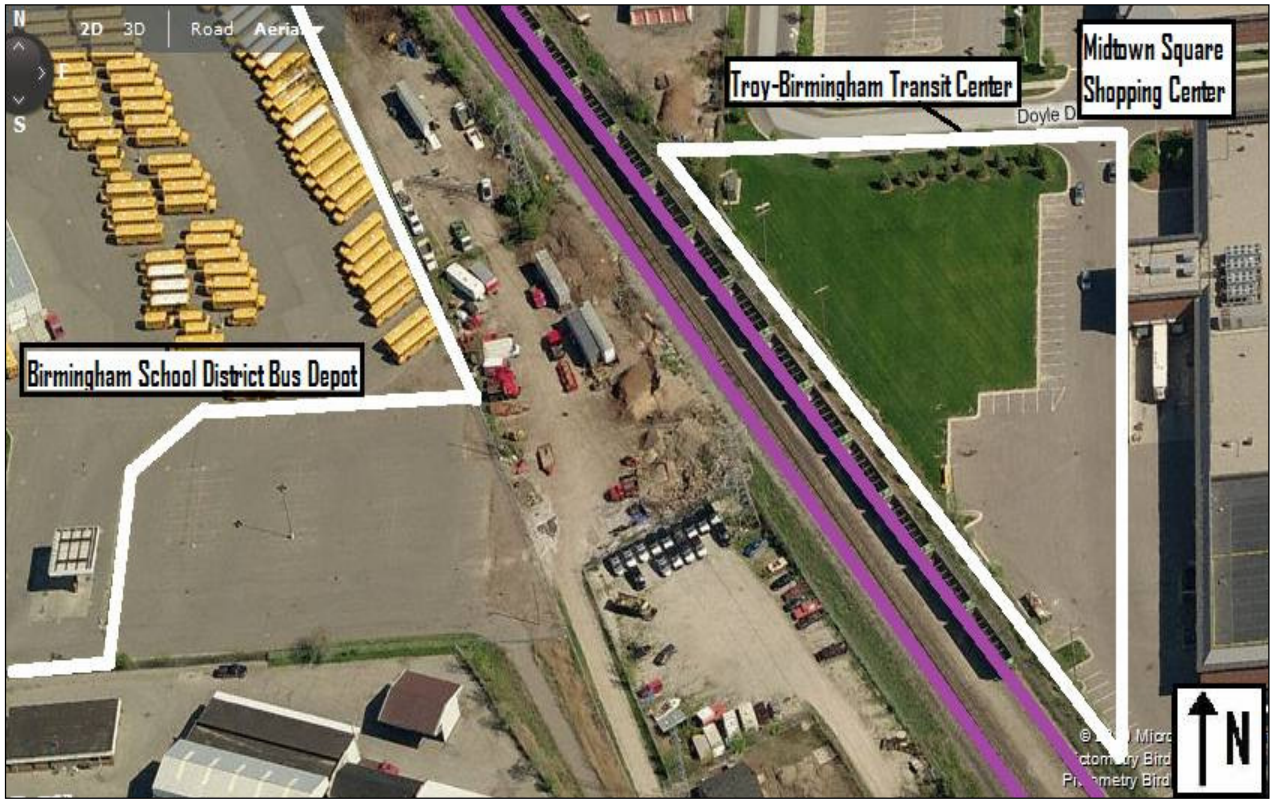


Figure 19. Proposed Troy-Birmingham Multi-modal Transit Center (MTC) Site

The lack of vacant property within the Rail District has been validated and was based on field observations made by the project team and aerial imagery. Although the amount of vacant land in the Rail District has diminished as the result of the completion of development projects (e.g., The District Lofts, Lofts at Eton St. Station), the addition of pedestrian-friendly features is expected to further improve the quality of life for those who frequent the area. In particular, pedestrian activities will be greatly facilitated on the Troy portion of the district, along the Midtown Square Shopping Center that borders the proposed MTC site. For the Troy-Birmingham AMTRAK station, the influence area is centered near the proposed MTC site, along the railroad tracks located there (Figures 17 and 19).

Two local organizations have a key role in the development programs currently underway at this site. The descriptions of those organizations are described below [*50,51*]:

- **Birmingham-Bloomfield Chamber of Commerce (BBCC):** The BBCC is an organization that intends to build strong relationships with the government, education, and communities to create and maintain a prosperous business climate for its members: cities of Beverly Hills, Bingham Farms, Birmingham, Bloomfield Hills, Bloomfield Twp., and Franklin. Among those cities, the city of Birmingham is of particular interest because of the speculation of rail transit in the Detroit metropolitan area.

- **Troy Chamber of Commerce (TCOC):** An organization formed with the intent to promote an environment that builds successful businesses and a thriving community, through service and regional collaboration.

In the midst of the proposals for rail transit investments in the Detroit metropolitan area, the BBOC, TCOC, and the cities that they represent have collaborated to ensure that their member cities are able to capitalize on new mobility improvements. An example collaboration was the planning and execution of a transit design charette, intended to bring groups of professionals (e.g., designers, architects, engineers, and planners) together to share ideas and thoughts about the (then) proposed Troy-Birmingham Multi-modal Transit Center (MTC). Although the participants of the charette were rather diverse (with respect to their fields of interest and profession), it was generally understood that the implementation of TOD was critical in meeting the mobility needs in the Detroit metropolitan region.

4.2.2. Site Characterization and Planning Perspectives

The residential market in the area surrounding the rail district is very diverse in nature. The relative proximity to the city of Troy, which is generally known to be more affordable and less walkable than the city of Birmingham, creates additional diversity in housing type (rentals versus for-sale), price ranges (senior, low-cost, moderate, or upscale), and development configuration (apartment, townhome, loft, or single-family).

A telephone survey of the residential developers (leasing management companies and sales offices for for-sale units) appears to indicate that vacancy rates in the influence area surrounding the proposed MTC are relatively low. A partial list of multi-family residential developments within the influence area for the MTC has been presented in Table 6 [*52,53,54*].

Table 6. Residential Market

NAME	WALK DISTANCE TO STATION (mi)	TYPE	MARKET	TOTAL # FLOORS	TOTAL # UNITS	ADDITIONAL INFO
The District Lofts	< 0.1	For Sale, Rent	Upscale condo	4	24	all units are 2 bedoom, 2 bath (1,500 - 1,950ft^2)
Eton Street Station	0.1 - 0.2	For Sale	Townhomes (40), Live/Work Studio (60)		110	Studio units are live/work artisan units, offering commercial retail space on first floor.
Eton Square Apartments & Townhomes	0.3	Rent	Apartments, townhomes		158	Troy side; Apartments (1,2 bedrooms), Townhomes (3 bedrooms)
Maplecrest Apartments	0.3	Rent	Apartments		68	Troy side; 1 bedroom (64 units), 2 bedroom (4 units)
2755 E. Maple Rd.	0.5	Rent	Apartments		6	Troy side; 1 bedroom
The Village at Midtown Square	0.3	For Sale	Townhomes		285	Troy side; 2 bedroom (1,480 - 2,321 ft^2)

The commercial markets in the cities of Troy and Birmingham are among the most coveted areas in the Detroit metropolitan region, and arguably in the entire state of Michigan. In the city of Troy, the Somerset Collection is located approximately two miles north of the proposed MTC. This retail development is renowned as the most upscale commercial center in the state of Michigan. For the city, the mall serves as a local landmark, where a number of office buildings, hotels, and restaurants have been constructed in the last decade as the result of its success. In Birmingham on the other hand, the most attractive shopping destination is located in the CBD, located approximately one mile west of the Rail District. Like the Somerset Collection, the Birmingham CBD is considered a desired destination for shoppers in the Detroit metropolitan area, and a local center of lifestyle for the residents of both Troy and Birmingham.

The Rail District has been marketed toward a younger and affluent demographic, a stark comparison to the demographics of Troy and Birmingham: older, affluent residents often living with at least one child in a single-family home. Much of the land uses located on Cole St. (Birmingham side), have been renovated and redeveloped from what were once industrial-related structures: warehouses, factories, etc. Table 7 summarizes the commercial developments located in the influence area for the Rail District.

Table 7. Commercial Market

NAME	WALK DISTANCE TO STATION (mi)	TYPE	MARKET	ADDITIONAL INFO
Whistle Stop	0.3	Service	Restaurant (Casual)	Birmingham side
Big Rock Chophouse / The Reserve	0.4	Service	Restaurant (Upscale)	Built on the site of the former Birmingham rail depot
Baja Fresh	0.4	Service	Restaurant (Casual)	Troy side
Target	> 0.4	Retail	General, Apparel	Troy side; Midtown Square Shopping Center
Dunham's		Retail	Apparel, Sports	
Kohl's		Retail	Apparel	
Old Navy		Retail	Apparel	
Petco		Retail, Service	Pets	
Famous Footwear		Retail	Apparel	
The Home Depot		Retail	Hardware, Tools, Materials	
Cole St. Salon & Spa	0.5	Service	Beauty parlor	Birmingham side (Cole St.)
Moran's Flora		Retail	Florist	

Public/civic/institutional land uses in the Troy-Birmingham MTC influence area include the Goldfish Swimming School, located on Cole St. Although there are a number of parks in both cities, there is a general lack of pedestrian facilities around the proposed MTC area.

In summary, collection of the data obtained for this section has indicated the following:

- Residential housing market is robust, despite the economic downturn, where newer developments (for-sale) have been successful and older ones (rental) have largely remained occupied. Additionally, the newer developments in the Rail District have successfully attracted a younger, more urban-influenced (e.g., a desire to reside in walkable communities, reduced dependence on private automobiles for travel) demographic sector.

- Commercial developments have been successful. The commercial offerings within the Rail District are diverse, but will remain separated from one another until completion of the MTC.

4.2.3. Population Characteristics

The populations of the cities of Troy and Birmingham are characterized by the relatively high median household incomes that they earn (according to the 2000 Census). The incomes are well above the averages for both Oakland County and the seven-county SEMCOG region [*55*].

Table 8. Comparison of Median Incomes in Oakland County, SEMCOG Region

COMMUNITY	POPULATION	MEDIAN HOUSEHOLD INCOME ($ in 1999)
Birmingham	20,570	80,861
Troy	80,084	77,538
Oakland County	1,204,053	61,907
SEMCOG Region	4,782,407	49,979

Considering these data, it is expected that the development market in these cities would be stronger than the market in other parts of the Detroit area. The strength of that market may be a sign of hope for Metropolitan Detroit land developers; however, it may also be the biggest barrier to the success of new developments. The challenge for these two affluent cities to implement TOD will be to attract and retain a demographic that is naturally attracted to transit service and TODs. Although there are rental options available for those demographic groups that typically earn less than their wealthy counterparts (i.e., senior citizens, young professionals), there does not seem be many that cater to those that typically inhabit TODs. Since the housing market in the area has fared better than most communities in the SEMCOG region, it could be argued that additional housing developments would have success here.

The Troy portion of the Rail District generally lacks features expected to promote pedestrian-oriented development. One exception is the Village at Midtown Square Development. This high-density community has been constructed with sidewalks adjacent to every unit of the development, but those facilities do not sufficiently connect pedestrians to shopping centers because the parking area at Midtown Square is likely to be prohibitive to those pedestrians. To mitigate this, an additional set of walkways could be constructed that "criss-cross" the large parking area, so that pedestrian travel time is shortened.

While exact measures used to mitigate these issues have not been determined, the project team suggests that improvements in pedestrian safety and walkability and can be realized. Examples of these improvements and the mechanisms that may ease their implementation will be discussed later in this report.

The proposed MTC, as planned, would expose AMTRAK passengers that enter or exit trains in the area to the (rear) service-entry elevations of the retail outlets located in the Midtown Square Shopping Center: Target, Kroger, Dunham's, etc. These areas are often used for the storage of waste dumpsters, recycling containers, loading docks and platforms, and building utilities (e.g., HVAC, water control). Additionally, the shopping center has been constructed using a layout that is typical of "big-box" retail outlets: large expanses of surface parking facilities, limited pedestrian facilities, limited common/green spaces, and significant separation between the development and the roadways adjacent to it. The existing layout of the Midtown Square Shopping Center is shown below in Figure 20, in which the lack of pedestrian-friendly facilities can be observed. The posted speed limit for the parking area has not been determined, but it is expected that excessive vehicle speed may be a cause for concern and pedestrian safety could be improved upon.

Figure 20. Midtown Square Shopping Center: Street-Level View

4.2.4. TOD's Proposed

The Rail District has undergone significant changes in the last 20 years, but more may be needed so that it may approach an idyllic TOD. As mentioned in the previous sections, the amount of undeveloped land here is limited. Projects such as The District Lofts, Eton Street Station, and Midtown Square have consumed the vacant land in the area. However, additional growth may be realized along Cole St., located at the southern end of the Rail District in the city of Birmingham. The city planning department has rezoned most of the Cole St. corridor as "Mixed Use", according to records maintained by the city government (shown as the purple-shaded area, located south of the proposed MTC, in Figure 18).

Cole Street has lately undergone significant development and property reinvestment. The Rail District is now considered an affordable alternative to the Birmingham CBD for entrepreneurs wishing to relocate their operations to the city. New businesses that have relocated to this growing community are diverse and include architects, engineers, florists, swim instructors, interior designers, and beauty salons. Considering this trend, the area may be the most viable option for redevelopment projects in the Rail District because most of the remaining sections in Birmingham and Troy have been occupied.

Suitable areas for new development and reconstruction may be the low-density developments that are adjacent to Cole St., shown in Figure 21. The area shown in the image has historically been utilized for light-to-medium industrial land uses (e.g., warehousing, auto repair), but is now well-equipped to accommodate TOD, as a result of zoning modifications by the city of Birmingham (institutional mechanism). It should also be noted, that much of the Cole St. corridor is strategically located within half a-mile walking distance from the proposed MTC across the CN ROW. The addition of affordable, medium to high-density residential land uses along the corridor may be a boon to the MTC investment, and the quality of life for those living there. The mechanisms that may hasten the implementation of such development, and details of such land uses, are listed in Table 9.

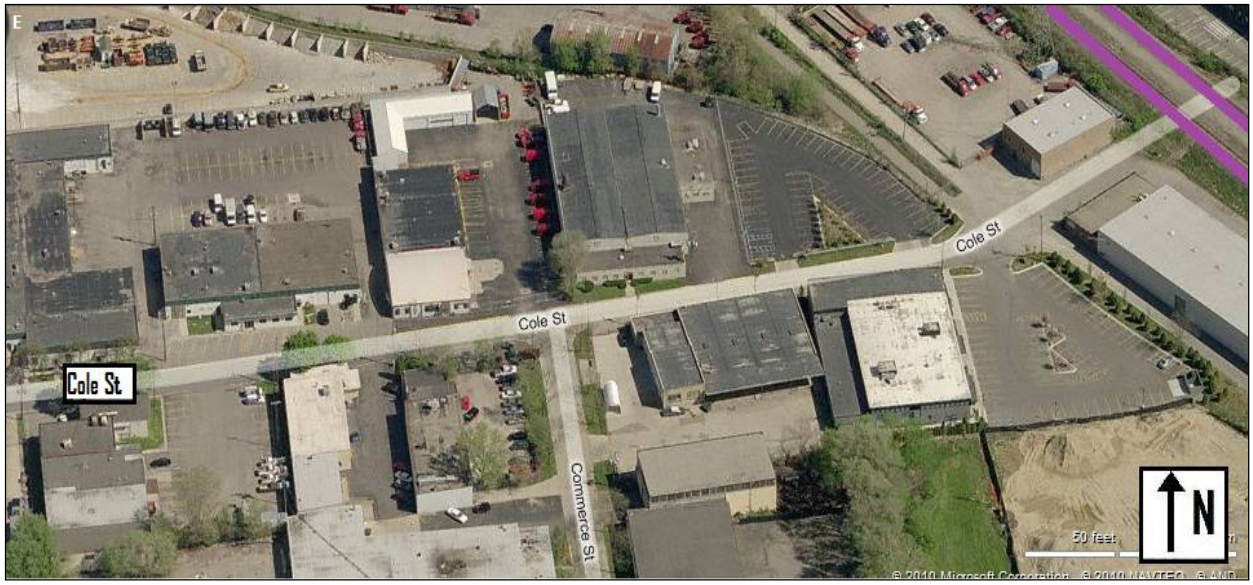


Figure 21. Rail District: Cole Street Corridor

It has been observed that there is a lack of a major bookstore or bookseller within an approximate one-mile radius surrounding the Rail District. While such retail outlets can be found near the Somerset Collection in Troy, and the Birmingham CBD, it would be expected that demand for an additional bookstore would be generated by growth in the area. Oakland County boasts a demographic of highly-educated residents, where more than 23 percent hold a bachelor's degree, and an additional 15 percent hold graduate or professional degrees (relatively high values when compared to Wayne County: corresponding values of 10.9 and 6.4 percent, respectively) [*55*].

Again, the most critical limiting factor for redevelopment in the Birmingham section of the Rail District is the availability of vacant land. Although additional development is possible, its magnitude and pattern (in terms of acres redevelopment) would ultimately be subject to the willingness of the entities that own the properties discussed, to participate in the project.

In order to create a more people-friendly environment, existing stores such as Target, Kohl's, Kroger, Old Navy and others should consider adding another exit/entry point at the other side of the store, so that transit patrons may get in/out from both sides.

Pedestrian improvements, on the other hand, may be the missing link in connecting both communities in the Rail District. Some of these improvements could include, but are not limited to, the following: speed bumps, improved pedestrian crossing markings, widened walkways dedicated to pedestrians, ADA-compliant curb cuts, and traffic calming measures (e.g., narrowed lanes, warning signal/signs). Those facilities, in addition to the CN ROW pedestrian tunnel planned for the MTC project, would truly connect the two cities of Birmingham and Troy, and would have the potential to stimulate additional economic investment. A complete list of the proposed land uses suggested for the area, as well as the mechanisms that may strengthen or hasten their implementation, are shown in Table 9.

Table 9. Proposed Land Uses

LAND USE TYPE	DESCRIPTION	SUGGESTED EXAMPLES
Retail/Service/Commercial	Bookstore	Borders Books & Music, Schuler's Books & Music
	Child Care Center	
Public/Civic/Institutional	Common spaces (Troy)	pedestrian plaza, small park, landscaping, sidewalks/pathways
	Traffic Calming/Pedestrian Facilities (Both cities)	pedestrian crossing signals & crosswalks, curb cuts, pedestrian lighting, wayfinding facilities
Residential	Apartment complex (Birmingham)	Affordable senior living community, affordable rental units

5. TOD AND SUSTAINABLE ELEMENTS

A brief discussion on sustainable elements in general was presented in Chapter 3. In this chapter, a more detailed description of those elements pertinent to TOD is presented along with examples of specific applications, if available. Implementing these features may increase the overall capital cost of the project, but in the long run, the annual savings in energy costs and other fees (e.g. storm-water discharge fees) may make them cost effective, particularly as these costs are expected to increase in the future. Furthermore, building sustainable and "green" facilities comes with a host of additional, often intangible, benefits such as greater public visibility (e.g. via news reports) and a public image that is often more conducive to attracting commercial tenets and customers, as well as private and corporate residences.

LEED Rating

Implementing sustainable/green features can boost the Leadership in Energy and Environmental Design (LEED) rating of any type of construction/development. To become LEED Certified, the developers must be aware of the features of a sustainable/green environment. Developed by the U.S. Green Building Council (USGBC), LEED provides an outline for building owners and operators that allow them to recognize and execute realistic measures for the design, construction, operation, and maintenance of green buildings.

Internationally recognized, LEED is a certification program that verifies whether or not a building or community was designed and built with the following principles in mind: energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, as well as the impact of the various aspects [56].

The LEED program is comprised of several rating systems, as shown in the figure below. The New Construction rating system guides commercial and institutional projects, which include: office buildings, high-rise residential buildings, government buildings, recreational facilities, manufacturing plants, and laboratories [57], and can be applied to both the Masonic Temple and Troy-Birmingham TOD sites.

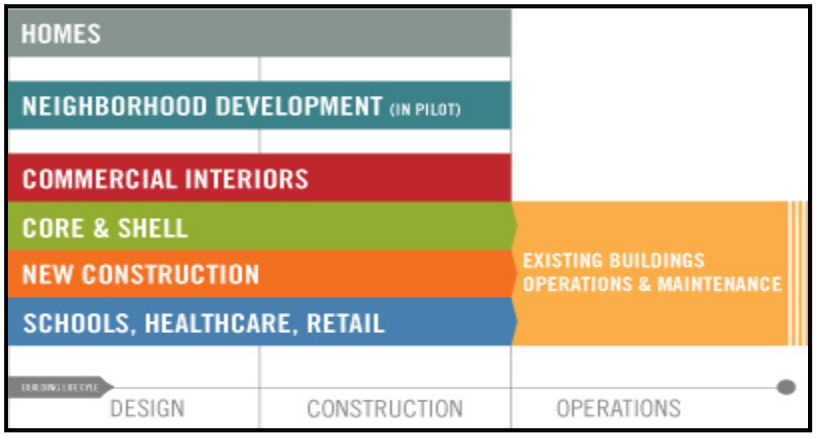
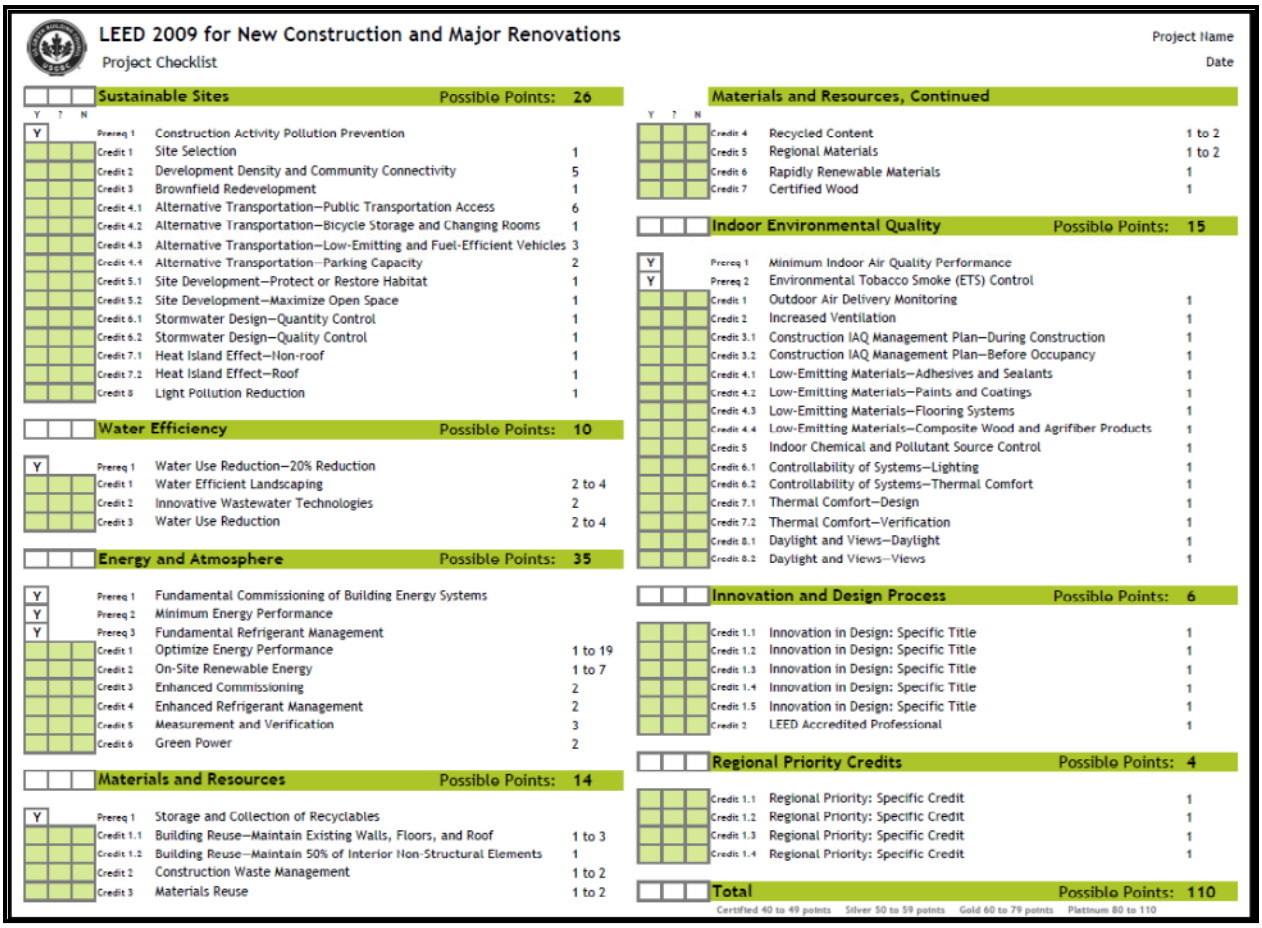


Figure 22. LEED Rating Systems
(Source: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=222)

The following figure is the one-page checklist for the New Construction rating system. It lets project teams know how points can be obtained in each category in order to achieve a certain rating, whether it be certified (40-49 points), silver (50-59 points), gold (60-79 points), or platinum (80 points and above).



LEED 2009 for New Construction and Major Renovations

Project Checklist

Project Name

Date

Y	?	N			
Sustainable Sites				Possible Points:	26
Y			Prereq 1	Construction Activity Pollution Prevention	
			Credit 1	Site Selection	1
			Credit 2	Development Density and Community Connectivity	5
			Credit 3	Brownfield Redevelopment	1
			Credit 4.1	Alternative Transportation—Public Transportation Access	6
			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3
			Credit 4.4	Alternative Transportation—Parking Capacity	2
			Credit 5.1	Site Development—Protect or Restore Habitat	1
			Credit 5.2	Site Development—Maximize Open Space	1
			Credit 6.1	Stormwater Design—Quantity Control	1
			Credit 6.2	Stormwater Design—Quality Control	1
			Credit 7.1	Heat Island Effect—Non-roof	1
			Credit 7.2	Heat Island Effect—Roof	1
			Credit 8	Light Pollution Reduction	1
Water Efficiency				Possible Points:	10
Y			Prereq 1	Water Use Reduction—20% Reduction	
			Credit 1	Water Efficient Landscaping	2 to 4
			Credit 2	Innovative Wastewater Technologies	2
			Credit 3	Water Use Reduction	2 to 4
Energy and Atmosphere				Possible Points:	35
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
			Credit 1	Optimize Energy Performance	1 to 19
			Credit 2	On-Site Renewable Energy	1 to 7
			Credit 3	Enhanced Commissioning	2
			Credit 4	Enhanced Refrigerant Management	2
			Credit 5	Measurement and Verification	3
			Credit 6	Green Power	2
Materials and Resources				Possible Points:	14
Y			Prereq 1	Storage and Collection of Recyclables	
			Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
			Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
			Credit 2	Construction Waste Management	1 to 2
			Credit 3	Materials Reuse	1 to 2

Y	?	N			
Materials and Resources, Continued					
			Credit 4	Recycled Content	1 to 2
			Credit 5	Regional Materials	1 to 2
			Credit 6	Rapidly Renewable Materials	1
			Credit 7	Certified Wood	1
Indoor Environmental Quality				Possible Points:	15
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
			Credit 1	Outdoor Air Delivery Monitoring	1
			Credit 2	Increased Ventilation	1
			Credit 3.1	Construction IAQ Management Plan—During Construction	1
			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
			Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
			Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
			Credit 4.3	Low-Emitting Materials—Flooring Systems	1
			Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1
			Credit 5	Indoor Chemical and Pollutant Source Control	1
			Credit 6.1	Controllability of Systems—Lighting	1
			Credit 6.2	Controllability of Systems—Thermal Comfort	1
			Credit 7.1	Thermal Comfort—Design	1
			Credit 7.2	Thermal Comfort—Verification	1
			Credit 8.1	Daylight and Views—Daylight	1
			Credit 8.2	Daylight and Views—Views	1
Innovation and Design Process				Possible Points:	6
			Credit 1.1	Innovation in Design: Specific Title	1
			Credit 1.2	Innovation in Design: Specific Title	1
			Credit 1.3	Innovation in Design: Specific Title	1
			Credit 1.4	Innovation in Design: Specific Title	1
			Credit 1.5	Innovation in Design: Specific Title	1
			Credit 2	LEED Accredited Professional	1
Regional Priority Credits				Possible Points:	4
			Credit 1.1	Regional Priority: Specific Credit	1
			Credit 1.2	Regional Priority: Specific Credit	1
			Credit 1.3	Regional Priority: Specific Credit	1
			Credit 1.4	Regional Priority: Specific Credit	1
Total				Possible Points:	110

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

Figure 23. LEED New Construction Checklist
(Source: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220)

Green Roofing (SE 1)*

A green or vegetated roof provides the function of a conventional roof while allowing plants to grow on the surface. A vegetated roof includes water proofing, a drainage system, filter layer, a lightweight growing medium, and plants. The technique is well established in Europe and is beginning to be applied in the U.S. for both commercial and residential applications. Factors such as the slope, loading capacity, existing drainage systems, electrical supply, maintenance, etc. must be considered. Proper installation of the roof structure is an important prerequisite to the realization of full benefits of green roofs that include [*58*]:

- Cost savings resulting from increased storm water retention.
- Reduction of "Urban Heat Island Effect" (realized as energy savings)
- Opportunities to recycle aggregate and compost
- The production of agriculture
- Improved air quality

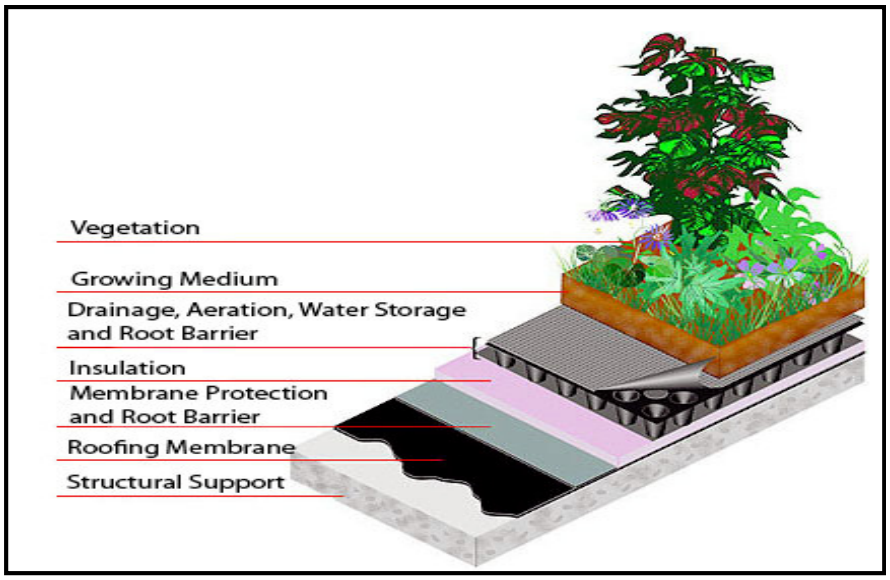


Figure 24. Vegetated Roof Diagram
(Source: http://adventures-in-climate-change.com/wendeeholtcamp/?p=432)

***Sustainable Element 1 (SE 1)**

Figure 25. Chicago City Hall Green Roof
(Source: http://science.howstuffworks.com/environmental/green-science/green-rooftop.htm)

Permeable Pavement (SE 2)

Pervious/porous/permeable pavements are designed to allow seepage of storm-water into the ground through a reservoir where the underlying layers act as a natural filter, thereby reducing the amount of runoff. Beneath the permeable surface are layers of gravel and rock on top of soil, to act as natural filters. There can be different types of permeable surfaces; asphalt or concrete, consisting of little to no fine material resulting in interconnected voids, and structural pavers, which can be open-celled preassembled grids made of plastic filled with gravel or soil, or interlocking blocks of concrete, brick, or other materials [*59*]. The aesthetical appeal of each type can vary.

Ideally, porous pavement is found in low traffic or overflow parking lots. However, porous pavement can also be found in dense urban areas where redevelopment is planned. Porous pavements are also used on highways to reduce hydroplaning. Porous pavement is beneficial in several ways: the amount of groundwater recharge is increased, there can be a decrease in the amount of pollutants/contaminants in storm-water runoff, and the possibility of flooding is also reduced. [*60*]

In a TOD setting, porous pavement can help make walkways more inviting and pleasing to a pedestrian. Pavers, especially, of various colors, shapes, and sizes can add to the overall aesthetic appeal of the TOD.

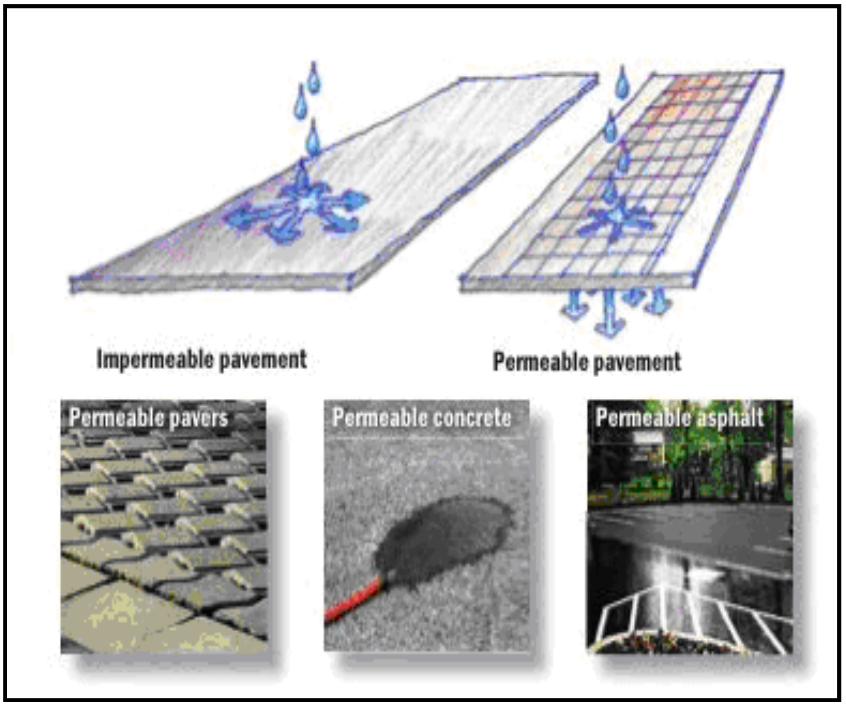


Figure 26. Types of Permeable Pavement
(Source: http://www.re-nest.com/uimages/re-nest/06-08-09greenpermeable.jpg)

Figure 27. Kings Courts Plaza (Haddonfield, NJ)
(Source: http://www.traditional-building.com/Previous-Product-Reports/3-paving-APRIL2010.htm)

Figure 28. Justison Street (Wilmington, DE)
(Source: http://pathwaycafe.com/2010/07/30/brick-industry-association-announces-brick-in-architecture-winners/)

Rain Gardens (SE 3)

Rain gardens are designed to capture storm water runoff, with a depression to contain the runoff and to reduce the probability of flooding. They are typically used for landscaping in residential areas to absorb and temporarily store rainwater that flows off building roofs, pavement and other hard surfaces. Rain gardens act as natural filters and storage units for precipitation, which reduce the amount of storm water runoff in an area. As a result, there is less impact on the surrounding bodies of water. Rain gardens can have an aesthetic appeal because they can be integrated with various types of trees, shrubs, and other plant life, while also providing green space. Rain gardens can also provide a habitat for various wildlife [*61*].

Figure 29. Rain Gardens in Portland, OR
(Source: http://sf.streetsblog.org/2009/11/13/portlands-greenstreets-program-a-sterling-best-practice-model/)

Canopy Trees (SE 4)

Canopy trees can provide natural shade to reduce the urban heat island effect caused by the buildings, roads, and other infrastructure. A series of canopy trees carefully planned and planted along a street may give it the appearance of an "urban forest" and its shade can [*62*]:

- Reduce a building's need for air conditioning
- Improve the air quality of the surrounding area
- Help manage and improve storm-water runoff quality
- Help lengthen the life of the surrounding pavement
- Reduce noise, can provide a habitat for wildlife
- Raise the aesthetic value of an area.
- Improve the overall quality of life of the people using the facilities

Various species of trees are available to use, with cost and the surrounding environment being major factors, along with maintenance, pest and disease control, and irrigation.

Figure 30. Canopy Trees in Downtown Portland, OR
(Source: http://denverinfill.com/blog/2007/09/downtown-portland-perspectives-part-2.html)

Greenspace (SE 5)

By providing patches of grass/plants, etc., a neighborhood's aesthetic value can be enhanced. In the form of various landscape alternatives such as small parks, green walkways, and gardens, green space can provide numerous benefits. People are able to "feel" nature while in an urban setting. Green spaces have many of the same benefits as green roofs and rain gardens.

Figure 31. San Diego State University Multi-modal Transit Station
(Source: http://www.chi-athenaeum.org/archawards/2007/missionvalleyrail.html)

Figure 32. Holly Street Village-Memorial Park Metro Station Civic Center Greenspace (Pasadena, CA)
(Source: http://transitorienteddevelopment.dot.ca.gov/station/stateViewStationPhotos.jsp?stationId=11)

Lighting (SE 6)

Proper lighting design can contribute to improved sustainability of the area [*63*]. While street lights help make a neighborhood safer and more secure, they can also provide some environmental benefits. Street lights that are implemented in a proper manner can:

- Focus lighting to necessary areas, thereby reducing energy usage
- Through the use of LED or solar powered fixtures, energy usage can be more efficient
- Reduce glare, or "obtrusive" light that may affect drivers, pedestrians, and residents

A streetscape that is brightly lit provides pedestrians with a greater sense of security and can boost the attractiveness of an area. A station that is well lit at night may seem more vibrant to people travelling to and from the area.

Figure 33. Ohlone/Chynoweth Light Rail Station (San Jose, CA)
(Source: http://www.fta.dot.gov/planning/programs/planning_environment_6932.html)

Figure 34. LED Street Lights (Ann Arbor, MI)
(Source: http://www.gabreport.com/gabreport/2010/03/city-of-ann-arbor-pilots-led-street-lights-and-reduces-costs.html)

Streetscape (SE 7)

Benches and tables, designed aesthetically, contribute to the overall ambience and are conducive to a pedestrian-friendly environment. In an urban setting, especially one consisting of a TOD, furniture such as benches and tables can act as gathering spots for people near the places where they shop, eat, read, study, etc.. Furniture should not be placed sporadically; rather, there should be some strategic planning involved to allow for efficient pedestrian traffic and encourage loitering in appropriate areas.

Figure 35. Benches Near Gateway Plaza – Union Station (Los Angeles, CA)
(Source: http://transitorienteddevelopment.dot.ca.gov/station/stateViewStationPhotos.jsp?stationId=7)

Figure 36. Seating Around a Canopy Tree (Potrero Hill, San Francisco, CA)
(Source: http://sf.streetsblog.org/2009/01/23/eyes-on-the-street-diy-street-furniture-enlivens-potrero-hill-street/)

Energy Efficient Windows (SE 8)

Energy efficient windows can reduce a building's heating and cooling costs [*64*]. These windows, by virtue of their design, are constructed to retain heat during the winter, and to prevent rising temperatures during the summer. They can be built with low-emissivity glass, heat-absorbing glass and with a reflective coating to help keep excessive sunlight from entering a building. Multi-paned windows can reduce the amount of condensation and can also reduce outside noise. The space between the panes can be filled with gas (argon, krypton, etc), which are more effective insulators than regular air. Adjustable blinds can also be placed in between the panes to help reduce heat transfer.

In a TOD, energy efficient windows can be installed in existing buildings and can be part of a plan for new construction. An office building, a coffee shop, an apartment, a clothing store, etc. may utilize energy efficient windows to not only save on various costs, but to also help create a more inviting environment.

Low-Flow Plumbing (SE 9)

Low-flow plumbing, which includes low-flow faucet aerators, low-flow toilets and showers, and waterless urinals, can be found in buildings looking for higher water efficiency while also striving for sustainability in a TOD. The existing plumbing fixtures can be replaced by low-flow fixtures which are expected to result in lower water bills due to the reduced water usage. This particular plumbing system can be installed in buildings of various types, including office buildings, schools, and residential structures. These are ideally suited for large buildings, such as stadiums, amusement centers, transit centers, etc. that typically attract masses of people. Greater water efficiency is a welcome feature all over the country, but in a TOD environment where there is a sustained level of human activity, it is a definite advantage. For example, the Brewery Blocks TOD in Portland, OR is just one of many TODs that utilize low-flow plumbing fixtures, along with numerous other environmentally-friendly design features.
[*65,66,67*]

Figure 37. Waterless Urinals
(Source: http://www.waterwisetech.net/waterless_urinals.htm)

Geothermal Heating/Cooling (SE 10)

Geothermal energy is a renewable resource. This type of heating and cooling system, which can be more energy and cost efficient than an electric heating and cooling system, can be installed under the street surface or within a building [*68*]. During the cooler seasons, heat that is pulled from the earth can be used to maintain desirable, ambient temperatures inside buildings. Likewise, the cool air from the ground can be used to provide relief during the warmer seasons. In outdoor use, the heating feature can be used in times of rain, ice, and snow; when dangerous conditions due to snow buildup and icy walkways would occur less often because the sidewalks and paths are kept warm. This system can be installed in homes and businesses to replace regular heaters and air conditioners.

In a TOD setting, this feature would be a useful addition. Pedestrians taking advantage of the nearby transit station or the various businesses/residences would be able to walk around the area with comfort and ease. Furthermore, the cost of such a system during winter becomes competitive with normal paved surfaces when the additional cost of snow removal and the liability of a slip and fall accident are taken into account.

Figure 38. Geothermally Heated Sidewalk (Klamath Falls, OR)
(Source: http://www.impactlab.net/2010/03/21/geothermal-energy-used-in-oregon-town-to-stay-warm/)

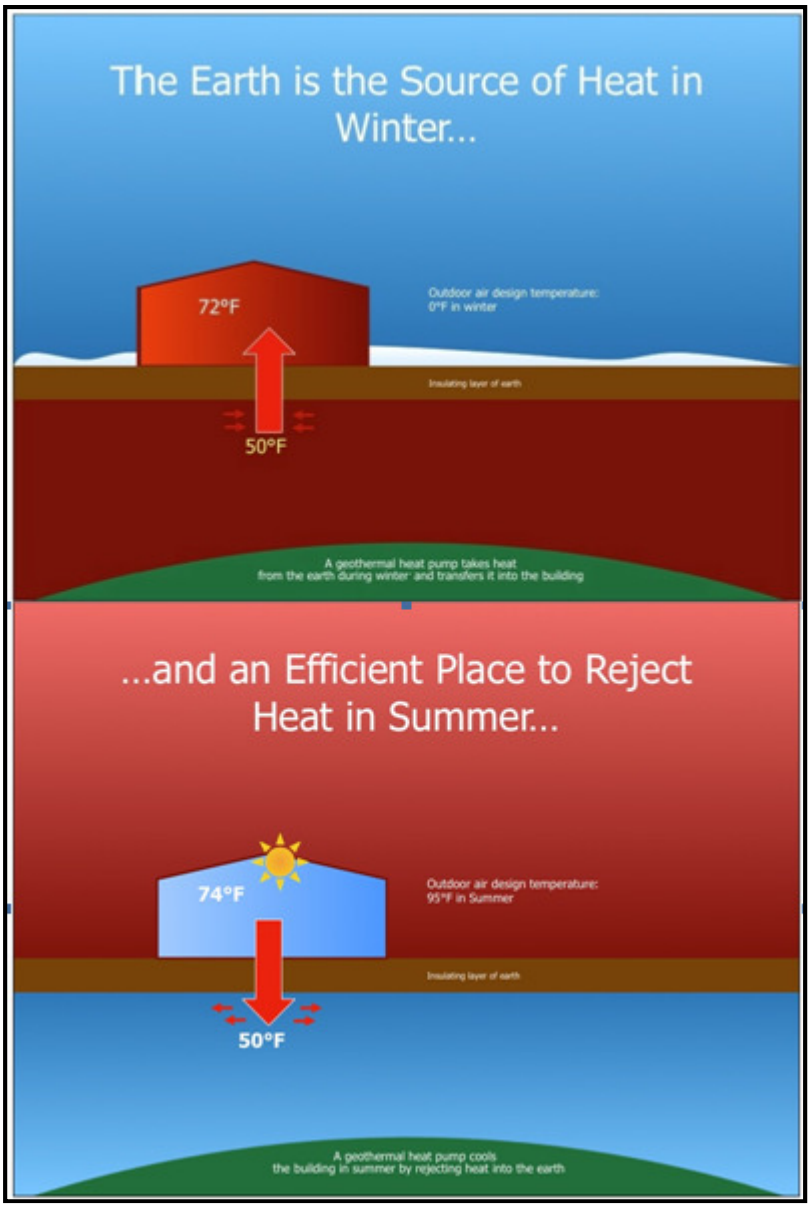


Figure 39. Geothermal Heating and Cooling
(Source: http://www.enercoretech.com/products-services/geothermal-heating-cooling/)

Brownfield Rehabilitation (SE 11)

Brownfield rehabilitation/redevelopment is a term that can be used to describe the rehabilitation of land properties of various types [*69*]. The land may be designated as environmentally contaminated, blighted, abandoned, or underutilized. Brownfields can be redeveloped for productive and sustainable use through the implementation of previously discussed green features. The definition of a brownfield is somewhat broad, and the designation of a piece of property as blighted or unusable, is a matter of consent judgment among the participating entities, including cities, municipalities, community groups, and developers. Thus, the speed with which land designated as a brownfield is redeveloped can vary depending on tax incentive. When successful, brownfield rehabilitation can result in a more useful and attractive landscape. In a TOD, it would be wise to have land that would not discourage people from visiting. When a transit line is built, brownfields may comprise some of the desired land area in which a station is to be located. They will no doubt have to be redeveloped for more productive land use.

Figure 40. Dr. Nina Scarito Park (Lawrence, MA)
(Source: http://www.mass.gov/envir/smart_growth_toolkit/pages/mod-brownfields.html)

6. INCORPORATING SUSTAINABILITY IN TRANSIT STATION PLANNING & DESIGN

6.1. Masonic Temple Site

To achieve greater sustainability, it is suggested that the Masonic Temple TOD site should implement many of the previously discussed sustainable elements. Concerning LEED Rating, this site should follow the New Construction system also previously discussed.

Table 10. Masonic Temple Sustainability

MASONIC TEMPLE TOD SITE ATTRIBUTES	POSSIBLE SUSTAINABLE ELEMENTS	DESIGNATIONS (refer to CH. 5)
Large areas of vacant land	Any land designated as a brownfield may be rehabilitated to allow for new development	SE1, SE2, SE3, SE4, SE5, SE6, SE7, SE8, SE9, SE10
Wide street that is not conducive to TOD	Greenspace such as small parks and gardens can be utilized to beautify the area	
Residential buildings within a 1/2 mile radius	Buildings may be built/retro-fitted with green roofs, low-flow plumbing, energy-efficient windows, geothermal heating/cooling	
Businesses along Woodward Ave..	Benches and tables may be placed along Woodward Ave. and throughout the site	
Located between two high activity areas; upper Midtown & the Central Business District (Downtown)	Existing pavement around buildings may be replaced with permeable pavement and geothermal heating systems	
	Various plantlife (small trees, bushes) may be used to enhance the corridor	
	Lighting fixtures may be placed in such a way to help promote safety, security, and vibrancy	

6.2. Troy-Birmingham Site

Table 11. Troy-Birmingham Sustainability

TROY-BIRMINGHAM TOD SITE ATTRIBUTES	POSSIBLE SUSTAINABLE ELEMENTS	DESIGNATIONS (refer to CH. 5)
Much of the site is already developed	Greenspace such as small parks and gardens can be utilized to beautify the area and to reduce the asphalt/concrete surfaces	SE1, SE2, SE3, SE4, SE5, SE6, SE7, SE8, SE9, SE10
Large areas of asphalt/concrete	Existing buildings may be built/retro-fitted with green roofs, low-flow plumbing, energy-efficient windows, geothermal heating/cooling etc.	
Small parcel of land available for new construction	Existing pavement around buildings may be replaced with permeable pavement and geothermal heating systems	
High-activity areas	Lighting fixtures may be placed in such a way to help promote safety, security, and vibrancy	
An AMTRAK station serves as the major tranportation source	Benches and tables may be placed throughout the site	

The project team also recommends utilizing greener product whenever possible at these two sites to maintain the spirit of sustainability. Selection of greener product can be accomplished by using assessment software, such as Sustainable Minds [*70*]. This software provides the following information for each product:

- The amount of CO_2 footprint.
- Amounts of materials that will end up in the landfill.

7. MECHANISMS (GENERAL)

The implementation of any new program such as sustainable TOD is often hindered by different barriers. In order to overcome these barriers, it may be necessary to deploy a different set of mechanisms or techniques. The mechanisms described below may be executed by TOD stakeholders, a broad range of groups and organizations that may include, but are not limited to: local governments (e.g., planners, city council, public works), Federal/state/regional governments (e.g., FHWA, HUD, MDOT, SEMCOG), private developers, transit providers/agencies, and financial institutions. The deployment of these mechanisms requires significant intergovernmental cooperation at different levels.

The state of Michigan, the SEMCOG region, and the city governments represented by each of the two station areas selected are eligible for varying degrees of development incentives. For instance, although the city of Detroit has experienced a decrease in population over the past three decades, the city government, in cooperation with the Detroit Economic Growth Corporation (DEGC) has established well-defined mechanisms to promote developments expected to improve the quality of life for the remaining population.

The current federal administration has expressed a strong desire to incorporate smart growth, sustainability, and livability into new developments in the nation's communities. Federal monies are largely available through a competitive process, rewarding the most suitable projects with grants. The combination of local incentives, Federal incentives, and state and regional programs, may be highly attractive to stakeholders wishing to pursue sustainable development projects.

Table 12 shows a listing of different mechanisms available at the Federal & State level for implementing sustainable TOD programs. At the Federal level, the agencies offering these incentives are the FTA, EPA, and HUD; while the primary agency at the State level is MEDC [*71,72*].

7.1. Masonic Temple Site

There are various mechanisms available to stakeholders pursuing sustainable development within the Detroit city limits. There are a number of organizations that operate within the city who are empowered to execute these mechanisms in cooperation with the city.

Table 13 and 14 provides similar listings pertinent to the two TOD sites respectively, with specific reference to the cities of Detroit, Troy and Oakland County [*73*].

7.2. Troy-Birmingham Site

The cities of Troy and Birmingham enjoy the state and regional-wide distinction of having robust commercial districts and economies. Such distinction may serve as a proxy for a complex economic growth or planning organization, such as the Detroit DDA and DEGC.

An institutional mechanism was the driving force in the planning and development of the Troy-Birmingham MTC. A consent judgment (mutual agreement between the plaintiff and defendant) combined with intergovernmental collaboration enable the city of Troy to take ownership and control over a 77-acre parcel of land, located near the intersection of E. Maple Rd. and Coolidge Hwy.

Other mechanisms involving local, state, and Federal organizations/agencies that may be used for the implementation of sustainable TOD related projects in the cities of Troy and Birmingham have been listed in Table 14 [*74,75*].

Table 12. Mechanisms for Sustainable TOD: General

JURISDICTION	AGENCY	PROGRAM	APPLICATIONS	FINANCING (TYPE)
Federal	FHWA/FTA	Transportation Planning Capacity Program	Land use & scenario planning, TOD, non-motorized transportation, safety	Grants (Formula)
	FTA	Transit Investments for Greenhouse Gas & Energy Reduction (TIGGER) Program	Awarded to public transit agencies for implementation of new strategies for reducing GHG emissions or reducing energy consumptions from their operations.	Grants (Competitive)
	FHWA	Transportation Enhancement Program	Exp & transportation mode choices, safety programs, historic preservation, environmental mitigation, scenic beautification	Grants (Formula)
		Context Sensitive Solutions	Developing a transportation facility that 'fits' setting: scenic, aesthetic, historic preservation, & environmental mitigation.	
		Transportation, Community, & System Preservation Program	Projects to integrate transportation, community, & system preservation plans, with the intent of improving efficiency of the transportation system.	Discretionary funds (Congressional earmark)
		Congestion Mitigation & Air Quality (CMAQ) Program	Reduce pollution, transportation system efficiency, non-motorized transportation facilities, travel demand & management	General fund
	HUD	Sustainable Communities Initiative	Support linking integrated housing, transportation, economic development, & l& use planning; affordable & sustainable housing	Grant
		Energy Innovation Fund	Energy-efficient mortgage innovation (single-family & multi-family housing)	
	EPA	Smart Growth Implementation Assistance (SGIA) Program	Technical assistance for resolving transportation & parking issues, affordable housing, storm-water management, infill & redevelopment.	Grants (Competitive)

Table 12. Mechanisms for Sustainable TOD: General (cont.)

	JURISDICTION	AGENCY	PROGRAM	APPLICATIONS	FINANCING (TYPE)
10	Federal	EPA	Assessment Grant Program	Inventory, characterization, assessment, & planning for community involvement related to Brownfields. Hazardous materials and/or petroleum sites.	Grants (Competitive)
11			Revolving Load Fund Grant Program	Provide low, or no-interest loans & subgrants to site owners for cleanup activites for Brownfields.	Grants (Formula)
12			Cleanup Grant Program	Carry out cleanup activities at Brownfield sites, owned by recipient(s). Hazardous materials and/or petroleum.	Grants (Competitive)
13			Targeted Brownfields Assessments	Services that may be conducted by an EPA contractor: site assessment, cleanup options, cost estimates, & community outreach.	Grants (Formula)
14			Technical Assistance to Brownfields Program	Service provided to communities, regional entities, and non-profits in need of technical assistance in the mitigation of Brownfield contamination.	
15			Environmental Justice Small Grants Program	Financial assistance to building collaborative relationships, identify local environmental and/or health issues, develop solutions to empower communities.	Grants
18	Federal / State / Local		Energy Efficiency at the State & Local Levels	Technical assistance, analytical tools, & outreach support to state & local governments: clean energy initiatives, case studies, GHG inventory, etc.	Various
19	Federal		National Clean Diesel Campaign	Evaluation of performance & durability of retrofit technologies, case studies, cost studies, emission reduction.	Grants (Competitive)
20			SmartWay Transport Partnership	Web-based analytical tools, technical assistance, financing options, air quality planning, regional incentives for cleaner goods movement near communities.	Various
21		EPA	State Revolving Loan Funds	Federal/state parterships intended to finance costs for infrastructure improvements: drinking water, wastewater/storm-water management, wetlands restoration.	Grants, loans, ARRA
22			Green Infrastructure	Green roofs, rain gardens, green streets, storm-water management.	Various
23			Nonpoint Source Management Grants	Intended to reduce nonpoint source pollution through a variety of activities involving: agriculture, urban runoff, forestry, & physical modification of bodies of water.	Grants (Formula)

Table 12. Mechanisms for Sustainable TOD: General (cont.)

	JURISDICTION	AGENCY	PROGRAM	APPLICATIONS	FINANCING (TYPE)
24	State of Michigan	MEDC / MDNRE	Brownfield Tax Incentives	MBT credits, TIF, property tax abatements, mixed-use development, walkable neighborhoods,	Tax credits, abatements
25		MEDC	Commercial Rehabilitation Act	New construction, redvelopment & renovation of obsolete structures and/or properties. Changes should involve mixed-use developments and non-motorized transportation.	Tax abatements
26			Conditional Land Use Transfer	Transactions may be city-to-city, city-to-township, or township-to-township. May be used to support economic development.	
27			Corridor Improvement Authority	Designed to assist communities with funding to improve commercial corridors outside downtown areas. Mixed-use, first-floor retail, high-density residential, and walkability.	Various
28			Environmental Assistance Program	Brownfield redevelopment, compliance assistance, pollution prevention, wellhead protection, development/protection/conservation of geological resources.	
29			Historic Neighborhood TIF Authority	Fund residential & economic growth in local historic districts: parks, pedestrian mall/plaza, street beautification, parking facility.	Various
30			Neighborhood Improvement Authority	Fund residential & economic growth in neighborhoods. May be used for: parks, pedestrian mall/plaza, street beautification, parking facility.	

Table 13. Mechanisms for Sustainable TOD: City of Detroit

	JURISDICTION	AGENCY	PROGRAM	APPLICATIONS	FINANCING (TYPE)
1	Federal	HUD	HOPE VI	Elimination or reclamation of distressed public housing developments. Site acquisition, green building features.	Grants (Competitive)
2			Public Housing	Operating expenses & repairs. PHA's encouraged to use energy & water conservation measures; renewable energy systems.	
3			Section 108	Public entities eligible for loans for economic development, housing, & public facility projects.	Loans
4			Brownfields Economic Development Initiative (BEDI)	Used to return Brownfields to productive economic reuse, must be used with Section 108.	Grants (Competitive)
5			Community Development Block Grants (CDBG)	Used for most developments, when the following are met: benefit low-to-medium income persons, eliminate slum & blight, community development.	Grants (Formula)
6		EPA	Brownfields Job Training Grant Program	Funding for entities & non-profit(s) to create green jobs for the mitigation of Brownfield sites. Hazardous substances.	Grants (Competitive)
7			Community Action for a Renewed Environment (CARE)	Reduce toxic pollution in local environments, through technical and financial assistance.	
8			Lead Grants	Aimed at reducing childhood lead poisoning in communities with older housing units.	Grants (Competitive)
9	State of Michigan	MEDC	Obsolete Property Rehabilitation Act	Intended to encourage the redevelopment of obsolete buildings into vibrant, mixed-use projects.	Tax incentives
10			Core Communities	Spur private development in urban communities & centers of commerce: site assessment, property redevelopment, environmental remediation.	
11			Redevelopment Liquor Licenses	Issue of on-site licenses to businesses that have invested funds in rehabilitation or redevelopment of a structure they occupy.	
12	City of Detroit	DEGC	Detroit Brownfield Redevelopment Authority	Promote the revitalization of environmentally distressed & blighted areas within the city limits: site remediation, site prep, infrastructure improvements.	Tax incentives
13			Woodward Avenue Renaissance Zone	Approximately 2 acres of area intended for office, retail, or hotel land uses.	
14			Obsolete Property Rehabilitation	Intended to encourage the redevelopment of obsolete buildings into vibrant, mixed-use projects.	

Table 14. Mechanisms for Sustainable TOD: Cities of Troy and Birmingham

	JURISDICTION	AGENCY	PROGRAM	APPLICATIONS	FINANCING (TYPE)
1	Federal	FTA	Bus and Bus Facilities Discretionary Grant Program	Replacement buses, related equipment, facilities, and intermodal transit centers.	Grant (Competitive), Congressional earmarks
2	City of Troy	Economic Development	Brownfield Redevelopment Authority	Provide developers with financial incentives for environmental cleanup, and/or related activities.	Tax incentives
3		Planning Department	Various	Rezoning, overlay districts, planning, permitting, site plan review, ordinances.	
4	Oakland County	Planning & Economic Development	Brownfield Redevelopment Authority	Provide developers with incentives with financial incentives for environmental cleanup, and/or related activities.	Tax incentives
5			Community Planning & Consulting Group Services	Preparation & communication of information & plans to conserve natural environment. Sustainable economic growth & development.	

8. CONCLUSIONS

The term transit-oriented development (TOD) is being used increasingly in the literature, particularly in studies related to planning and design of urban rail-transit. TOD relates to the integration of diverse (but desirable) land uses with transit, both temporally and spatially, and is designed to increase transit ridership and to promote desirable land uses surrounding the station areas. Over the last decade, there has been increased interest in North American cities, to construct light-rail transit (LRT) systems to improve mobility. LRT stations appear to be ideal sites for TOD programs, primarily because of compatibility in their scale of operation. Currently, there are a number of transit initiatives in the Detroit metropolitan region that, if implemented, may significantly change the transportation characteristics in the southeast Michigan area. A number of studies are currently underway with the intent of exploring the feasibility of constructing an LRT system along Woodward Avenue, one of the most dominant travel corridors in Metropolitan Detroit.

The term "sustainability" is being used increasingly in policy debates about future transportation, and is known to evoke strong reactions among policy-makers, users, and experts. In a broad sense, sustainability implies the "capacity to endure over an extended period", and has become a wide-ranging concept. Sustainable development implies a conscientious use of resources to meet human needs, present and future, while ensuring the preservation of the natural environment. One of the earlier interpretations of the term is given in a 1987 United Nations report (often referred to as the Brundtland Commission), defining sustainable development as, "one that meets the needs of the present, without compromising the ability of future generations to meet their own needs".

The conceptual definition of sustainable transportation in meeting current mobility needs, and the lack of specificity in this regard has been addressed in literature. However, very little research is reported that incorporates environmental sustainability in TOD design related to LRT systems. While the U.S. lags behind many European countries in integrating sustainable development, a number of significant pieces of legislation have the potential to redefine collaborations by integrating transportation, land use, and environmental planning. The Clean Air Act Amendments of 1990 authorize sanctions (e.g. loss of funding for highway construction) for failure to meet reduction targets in urban smog. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, was mandated to develop transportation systems that are "economically efficient and environmentally 'sound'. Subsequent acts of Federal legislation commonly referred to as TEA-21 (1998) and SAFETE-LU (2005) increased the importance of environmental sustainability in the development of the nation's long-term transportation infrastructure. The aim of integrating transportation, land use and environmental planning combined with recent pieces of legislation provide the context to which a sustainability framework is ideally suited to achieve future objectives.

Recently, there has been a call to "adopt sustainability as a primary objective of transportation planning". While doing so, there is a need "to address transportation's unsustainable impacts, including depletion of nonrenewable fuels, climate change, air pollution, fatalities and injuries, congestion, noise pollution, low mobility, biological damage, and lack of equity". According to the 2004 World Energy Outlook of the International Energy Agency, transportation and the use

of petroleum-based fuels are non-sustainable as they account for more than 20 percent of greenhouse gas emissions. In addition to greenhouse gases, many pollutants produced as the result of transportation (sulfur dioxide, nitrogen oxides, particulate matter, ground-level ozone, etc.) significantly impact local air quality, thereby rendering current transportation programs as unsustainable. To counteract upward trends in energy use and greenhouse gas emissions, new transportation methods need to promote less driving, energy efficient, low-carbon modes of transportation, along with better integration of transportation and land use infrastructure [*25*], all of which can be categorized as benefits of TOD.

This report is the result of a study that may be considered as a continuation of an earlier study conducted jointly at Wayne State University (WSU) and the University of Detroit Mercy (UDM) with the objective of selecting two rail stations in the Detroit metropolitan area for TOD implementation. A total of four stations were initially identified following a preliminary network level analysis that included two stations in the city of Detroit, and two in two different suburban communities, based upon their land use, transportation, and other factors. Further analysis resulted in the selection of two stations.

The two sites are located in the cities of Detroit and Troy-Birmingham, representing typical urban and suburban development areas within the region. The proposed Detroit TOD is located at the intersection of Woodward Avenue and Temple St., east of the Masonic Temple Theater and just north of the Detroit CBD. The proposed Troy-Birmingham TOD is located approximately one-half mile east of the intersection of Woodward Avenue and 15 Mile / Maple Rd., along the Canadian National (CN) railroad tracks shared by both cities (Figure 3). The latter location is in Troy, proximate to an AMTRAK passenger boarding platform in Birmingham. Additionally, future plans call for a regional bus and para-transit services to be provided by the Suburban Mobility Authority for Regional Transportation (SMART) at this location.

This study explored the integration of environmental sustainability for the TOD programs proposed at the two stations in the earlier project. Environmental factors such as greenhouse gas emissions (GHG), pollutant loads, energy consumption, storm-water management, and beneficial uses of natural resources (e.g. rainwater capture) that may reduce the environmental impact of future TOD projects were explored in this study.

Environmentally sustainable design considerations are proposed for each of the TOD sites and planning, economic, and institutional mechanisms that may ease the implementation process are identified. Sustainable elements proposed at the two stations include among other things: (1) Green Roofing , (2) Permeable pavements, (3) Rain Gardens, (4) Greenspace, (5) Special Lighting, (6) Streetscape, (7) Energy Efficient Windows, (8) Low-Flow Plumbing, (8) Geothermal Heating/Cooling and (9) Brownfield Rehabilitation. Each of these treatments is discussed in the report along with any experience documented in the literature, and their applicability to the two sites. Following a general discussion of these elements, site-specific recommendations are made that can be integrated with the developments proposed at the two sites as a part of the original TOD program at the two sites. The study also recommends that LEED rating be pursued for both the stations to the extent possible. LEED is an emerging

program that stresses energy savings, water efficiency, reduction of carbon dioxide emission, higher standards for indoor environmental quality, and the overall livability concept.

Mechanisms that are expected to expedite the implementation process are identified. Examples of environmentally-sustainable design, planning and construction, are discussed, with the objective of fulfilling a set of sustainability criteria.

9. ACKNOWLEDGEMENTS

The research team would like to extend their gratitude to each of the following sponsors that have supported this study:

- United States Department of Transportation (US DOT)
- Michigan Ohio University Transportation Center (MIOH UTC)
- Michigan Department of Transportation (MDOT)
- Wayne State University
- University of Detroit Mercy

The research team also wishes to extend their gratitude to the following groups/organizations for their guidance in developing this study:

- City of Troy, Michigan
- City of Birmingham, Michigan
- Detroit Economic Growth Corporation (DEGC)
- Hamilton Anderson Associates (HAA)
- M1-Rail

Additionally, the following individuals provided significant assistance to the research team by providing their insight on the subject matter for this report:

- Mr. Korey A. Hall, Regional Manager for the Honorable Debbie Stabenow, U.S. Senator for the State of Michigan
- Dr. Robin M. Boyle, Chair and Professor of Urban Studies and Planning, WSU

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11. LIST OF ACRONYMS

ADT	Average Daily Traffic
BBCC	Birmingham Bloomfield Chamber of Commerce
BMP	best management practices
BRT	bus-rapid transit
CBD	central business district
CN	Canadian National Railway Company
CRT	commuter-rail transit
DDOT	City of Detroit Department of Transportation
DEGC	Detroit Economic Growth Corporation
EPA	United States Environmental Protection Agency
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GHG	greenhouse gas
GIS	geographic information system
HUD	United States Department of Housing and Urban Development
HRT	heavy-rail transit (see RRT)
ISTEA	The Intermodal Surface Transportation Efficiency Act (1991)
ITE	Institute for Transportation Engineers
JD	joint development
LEED	Leadership in Energy and Environmental Design
LID	low-impact development
LPA	locally-preferred alternative
LRT	light-rail transit
LRTV	light-rail transit vehicle
MBT	State of Michigan business tax
MDNRE	Michigan Department of Natural Resources and Environment
MDOT	Michigan Department of Transportation
MEDC	Michigan Economic Development Corporation
MIOH-UTC	Michigan Ohio University Transportation Center
MPO	metropolitan planning organization
MSA	metropolitan statistical area
MSU	Michigan State University
MTC	multi-modal transit center
NCHRP	National Cooperative Highway Research Program
NEPA	National Environmental Policy Act
NRHP	National Register of Historic Places
PD	planned development district
PHV	Peak Hour Volume
ROW	right-of-way
RRT	rapid-rail transit (see HRT)
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
SEMCOG	Southeast Michigan Council of Governments
SMART	Suburban Mobility Authority for Regional Transportation

TCOC	Troy Chamber of Commerce
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TIF	tax increment financing
TOD	transit-oriented development
UDM	University of Detroit Mercy
UM	University of Michigan
USDOT	United States Department of Transportation
USGBC	US Green Building Council
VPD	vehicles per day
WBC	World Business Council for Sustainable Development
WSU	Wayne State University