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National Consortium for Remote Sensing in Transportation

Streamlining Environmental and Planning Processes

MISSISSIPPI STATE UNIVERSITY

FINAL PROJECT REPORT TECHNICAL GUIDE

MARCH 2010

Validating Commercial Remote Sensing and Spatial Information (CRS&SI) Technologies for Streamlining Environmental and Planning Processes in Transportation Projects

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TABLE OF CONTENTS

1.0 US DOT CRS&SI ENVIRONMENTAL STREAMLINING PROJECT BACKGROUND

Introduction: The GeoSystems Research Institute (GRI) at Mississippi State University (MSU) proposed and was awarded a project to lead a consortium of research partners, which included Oak Ridge National Labs Center for Transportation Analysis (ORNL CTA) and Michigan Technology University Michigan Tech Research Institute (MTU MTRI). A consortium approach was developed and the project name "National Consortium for Remote Sensing in Transportation-Streamlining Environmental and Planning Processes (NCRST-SEPP)" was adopted for the project. Along with DOT partner agencies, the research team demonstrated new and innovative approaches that deliver streamlining benefits to transportation infrastructure planning and reduce uncertainties in related decision making processes. Researchers from GRI had previously led the National Consortium on Remote Sensing in Transportation – Environmental Assessment (NCRST-E), and delivered results that advanced awareness and acceptance of commercial remote sensing and spatial information (CRS&SI) technologies for transportation infrastructure corridor planning. An NCRST-E highlight, "Multi-Sensor Data Collection for Corridor Planning" was selected as a best practice by NCHRP 25-22(2) and featured in the NCHRP Research Results Digest 304.

Multi-Sensor Data Collection for Corridor Planning: Prior NCRST-E research projects focused efforts on multiple sources of remote sensing data collected early in the project life cycle (fig. 1.1). The collected data provided improved information for analysis and decision making. Analyses conducted demonstrated the utility of better information for planners, the public, environmental analysts, and engineers. The research program raised awareness as to how CRS&SI offers improved ability to plan, remove bottlenecks and shorten timelines in the environmental phases of transportation project development. Benefits of the approach include enhancing information available to practitioners, eliminating potential opposition, enhancing planning for field work, improving the ability to select among alternatives, screening potential environmental problems, and presenting multiple options to the public.

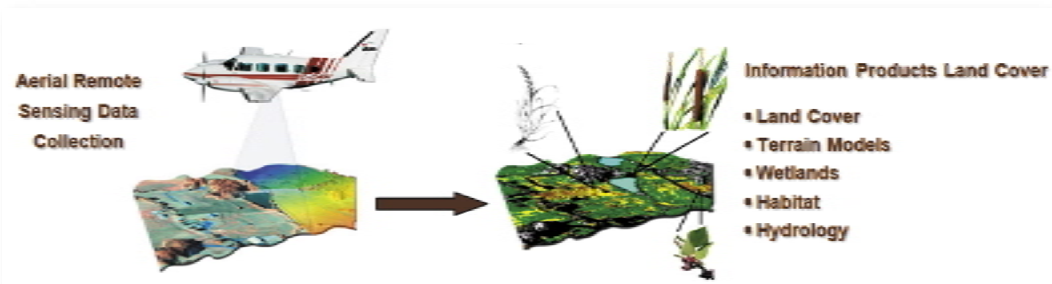


Figure 1.1. Multi-sensor data collection conducted early in the project life cycle are used to create products useful for environmental studies and provide useful feedback for planning. These data also may support early design activities subsequent to environmental studies and project decisions.

Useful Multi-Sensor Data Streams

- High-resolution multispectral satellite image data for land cover and land use analysis.
- High-resolution black and white, multispectral and CIR digital aerial orthorectified imagery.
- LIDAR elevation data for terrain analysis, hydrologic analysis, and early design work.
- Hyperspectral data for detailed land cover, wildlife habitat, and wetlands mapping.

Key Findings in Prior Research: Traditional approaches to black and white film photography and derived products are being replaced with digital image products. Digital high-quality, ortho-rectified images may be delivered quickly providing data useful to all project personnel across divisions and departments yielding improved maps and data for planning, design, environmental analysis, and public meetings.

New Project Directions: The NCRST-SEPP conducted research in transportation corridor planning and related EIS processes validating new and innovative uses of CRS&SI technologies. A recently completed EIS for I-69 traversing Memphis, TN, and Northwest Mississippi served as the research testbed within which research results of the project were developed and compared to the results of traditional approaches as documented in the EIS.

Relevance: NCRST-SEPP research results demonstrate the application of CRS&SI technologies in specific environmental and planning tasks and activities delivering outcomes of national significance. The participation and guidance of an advisory panel, comprising local and national representatives with competencies in both technical and policy aspects of transportation project development processes, ensured project relevance.

Project Deliverable: This Technical Guidelines document serves as the primary project deliverable providing results and outcomes that highlight a testbed case study of improved or enhanced processes illustrating a set of CRS&SI applications useful to practitioners.

Project Organization, Management, and Advisory Panel: The NCRST-SEPP research project, which was led by Mississippi State University, included Oak Ridge National Laboratory and Michigan Tech Research Institute. An advisory panel was proposed and was organized by FHWA that included participation and representation at both local and national levels. The advisory panel was designed to provide policy and technical support and direction to the research team in the following capacities:

Objectives of the Policy Representative on Advisory Panel

- Support the implementation of statutory and regulatory requirements, and FHWA policy, related to transportation planning, linking transportation planning and the environmental review process under NEPA, integrated planning, and environmental streamlining and stewardship.
- Facilitate the formation of working relationships and development of common understandings of different interests and needs among practitioners.

The technical members of the advisory panel represented the various geographic regions of the U.S. and contributed expertise highlighting the ability of DOTs adopting new remote sensing methods.

Objectives of the Technical Members of the Advisory Panel

- Evaluate data and technology to deliver useful and timely information for decision-making.
- Support implementation and demonstrate the use of natural resource conservation planning applications in the transportation decision-making process.
- Support transportation decision-making for multiple "what if" scenarios and trade-off analyses.
- Promote data sharing, delivery, and analysis to relevant conservation, transportation, internal and external entities.

1.1 CRS&SI in the Transportation Infrastructure Corridor Planning Process

Introduction: Transportation corridor-planning processes are well understood, and consensus exists among practitioners about common practices for stages and tasks included in traditional EIS approaches. However, traditional approaches do not typically employ full use of CRS&SI technologies. Case studies deploying best practices are needed to enable DOTs, practitioners, and consultants to effectively transition practices for enhanced use of CRS&SI technologies. As a guide to help plan and conduct case studies for deploying best practices for benefit to practitioners, this document presents research results relevant to developing, integrating, and deploying case studies needed to understand, document, and refine best practices in terms of requirements, definitions, characteristics, and specifications.

Problem Statement: Transportation corridor planning is a long-range program for developing and managing transportation systems that move people, goods, and services within a specific corridor, and has in the past made only limited use of CRS&SI technologies. DOTs have diligently sought to identify and refine planning processes that will result in the delivery of environmentally sound transportation projects that meet the long-term needs of the public. The planning process focuses on many stages and tasks that may benefit from CRS & SI technologies including the following:

- Develop a project scope and work plan for the corridor planning project.
- Develop a public participation plan.
- Develop early resource agency involvement.
- Develop a data and information sharing and exchange plan.
- Analyze current and future projected multimodal demand and performance.
- Document existing conditions of the transportation system.
- Document existing and projected environmental and land use conditions.
- Establish purpose and prioritize needs to meet goals.
- Generate alternatives that meet goals.
- Identify feasible alternatives by evaluating all alternatives that achieve goals.
- Compare alternatives to generate a list of preferred alternatives.
- Compile all results and components into a corridor plan document.

Scope and Objectives: A two-year project was proposed and conducted in which partners collaborated to refine requirements and develop a project-wide, data-enabled framework that supported research, developed technology deployments, and delivered results for selected tasks in the corridor project. The EIS for I-69 SIU 9 and the I-269 Corridor provided a basis for developing robust comparisons and quantification of benefits of new and innovative approaches.

The project applied CRS&SI technologies to streamline transportation corridor planning and environmental impact assessment processes. Transportation corridor planning processes are well understood, lengthy processes. The project's deployment of CRS&SI technologies targeted highlighting potential areas where best practices for this particular case study were identified for enhancing and speeding specific tasks offering significant payoffs to the project development process.

Methods: This research drew upon a carefully selected group of research and agency partners motivated to succeed in completing the project who are both stakeholders and have proven capabilities to succeed in activities that leverage these CRS & SI technologies. Research tasks identified were associated with specific stages of a typical EIS process. Each research project task had a similar set of milestones and deliverables that include a synthesis report, CRS & SI approach implementation, preliminary results, iteration and testing, verification and validation benchmarking, identification of key benefits, and inclusion of results in this final report. The synthesis report or presentation for each task documented traditional methods to conduct a particular component task of the EIS and laid out plans for use of CRS&SI technologies to enhance the component task. In many cases, this Technology Guide includes results summarized from full reports and presentations, which may be accessed via the links organized by chapter and provided in Appendix I. The methods used are summarized as follows:

Technologies: Leading-edge technologies and methods were applied to validate the use of CRS&SI technologies in transportation corridor-planning and impacts assessment processes.

Data: High quality and high resolution multi-sensor remotely sensed data acquired early in the project life cycle are fundamental to the project.

Products: Information products were derived from high-quality data products and validated for use by research and DOT partners.

Accessibility: Access to data and information products early in the corridor planning process enabled shared use and analytics in a plurality of tasks in the project.

Analysis Tool Development and Adaptation: Based on past research and development activities, tools were developed or adapted to use the enhanced data streams for analysis tasks.

Comparative Analysis: Comparisons of enhanced data products from analysis versus traditional methods characterized how new and innovative methods deliver comparable or enhanced results.

Validation of Results: Enhanced data and products were validated to quantify relative performance and streamlining benefits to highlight areas where improved data and technologies may best be used to enhance decision processes.

A specific area of project focus was the FHWA's *National Environmental Streamlining Initiatives,* which presented success factors and areas of greatest need for improved transportation decisions. This project delivers results that address areas of critical need identified by the FHWA including:

- Improved methods of multi-source data collection;
- Enhanced early data exchange and involvement of resources agencies;
- Improved delivery of quality information to public participation;
- Enhanced use of improved data in decision processes;
- Adaptation and improvement of analysis tools and methods for CRS&SI; and,
- Enhanced use of collaborative planning and evaluation tools.

Technology Payoffs: Speeding and enhancing corridor planning and EIS processes are expected payoffs of deploying project results for application by practitioners. Efficiencies, enhancements, and speedup may be accomplished through taking time out of specific tasks by providing enhanced access to and application of high quality data and information products while producing results similar to or closely approximating the results delivered by traditional approaches. The findings of this project are consistent with NCHRP Project 25-24, "*Monitoring, Analyzing, and Reporting on the Environmental Streamlining Pilot Projects*," sponsored by AASHTO which determined that –

> "The single biggest challenge to environmentally sound Federal-aid transportation project development is related to the amount of time it takes to advance a project through the project development process... It is common for major projects to take 10 years or more to advance from the planning phase to completion of construction and 20 years is a common time frame for complex, controversial projects." (NCHRP 25-24)

1.2 The NCRST-SEPP Project EIS Streamlining Approach

Introduction: The project relied and built upon insights from practitioners and partners to design a study that enhanced and refined aspects of the EIS approach, emphasizing early consensus building, exchange of values, and gathering and exchanging vital geospatial data. Additionally, data results gathered during the process were identified as valuable to provide vital feedback to planning in a process of project and program refinement.

Streamlining Approach: The National Consortium for Remote Sensing in Transportation – Streamlining Environmental and Planning Processes (NCRST-SEPP) project conducted research applied to a specific on-the-ground transportation project. NCRST-SEPP research demonstrated the application of Commercial Remote Sensing and Spatial Information (CRS&SI) technologies in specific environmental and planning tasks and activities, validating the use of those technologies by conducting rigorous comparison to traditional methods. A consortium of academic and agency partners conducted research tasks. Research directions focused on transportation project tasks and activities for delivering outcomes of national significance as ensured by the participation and guidance of a FHWA and RITA organized Advisory Panel (AP) that comprised local and national representatives with competencies that span both technical and policy aspects of transportation project development processes.

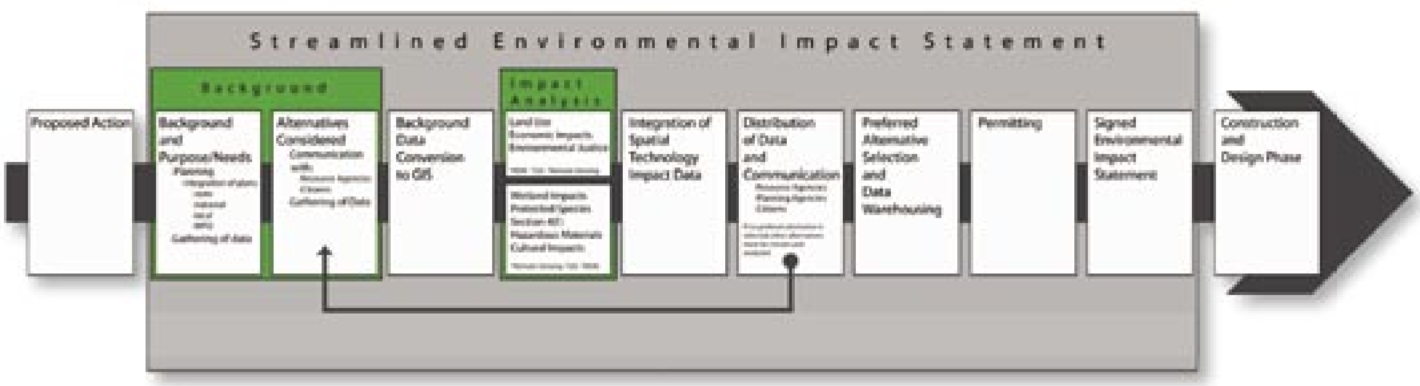


Figure 1.2. NCRST-SEPP streamlining process flowchart showing integration and feedback between planning and NEPA.

To document the foundational streamlined process, a flowchart was produced that shows the integration of planning and NEPA, the impact analysis section, and the output of data and results in a usable and transferable format. The concepts are more fully developed and supported in later chapters. Opportunities for feedback to planning, data exchange and use for more informed planning, and further detailed data and capabilities to inform pre-NEPA processes will be discussed. As one of the initial components, the integration of local planning information and community data is vital to effectively implementing spatial technologies that achieve streamlining benefits as well as provide linkages between planning and environmental studies.

1.3 Technical Guidelines Document Organization

This Technical Guidelines document is organized in a manner to deliver understanding to the transportation practitioner. It is intended to present materials in a useful, highly digestible form. The order of materials is intended to generally correspond within the document to the order that the subject matter is addressed in the typical transportation project development process.

The document organization embraces trends within DOTs to consider the linkages between planning and environment (PEL), the trends to combine these departmental units in state DOTs, and the opportunities that many practitioners are exploring to engage in "Pre-NEPA" consultation processes in a way that "gets ahead" of the NEPA and EIS process. In truth, the prevalent opinion expressed by members of the NCRST-SEPP Advisory Panel is that many of the geospatial data, spatial information technologies, analysis methods, and visualization capabilities deployed in this research could provide DOTs with enhanced capabilities. These enhanced capabilities offer more than simple project efficiency benefits:

> *What is promised are transformative capabilities to more effectively work as part of an ongoing process within which resource agencies, local government, and stakeholders would conduct exchanges, gather local values, identify vital concerns, and develop consensus-based directions that would substantially reduce opposition to and deliver streamlining benefits to transportation development processes.*

Organization: For sections of the Technical Guide addressing practices, a consistent approach presents materials along the following general outline:

- ***Introduction:*** Describe the particular task in the project development process being considered.
- ***Current Practice:*** Summarize how that task is addressed using traditional methods.
- ***CRS&SI Objectives:*** Identify opportunities for the application of CRS&SI technologies.
- ***Methods & Results:*** Present methods and compare results to EIS findings where possible.
- ***Key Benefits:*** Highlight and summarize key benefits of the CRS&SI approach.

1.4 The I-69 SIU 9 Testbed: Using the I-69/I-269 Environmental Impact Statement

The research project considered a selected segment of the nationally significant corridor I-69. Interstate 69 from Texas northeast to Michigan in its entirety is part of High Priority Corridor 18: The NAFTA Superhighway. I-69 is a nationally significant corridor, which will connect border crossings in Texas to border crossings in Michigan. The I-69 Corridor will comprise approximately 1600 miles of freeway while in areas such as Kentucky, Mississippi, and Texas, much of I-69 will be built as upgrades of existing four-lane highways to modern freeway standards (http://www.i69info.com/). The segments of I-69 in Mississippi and Tennessee are vital components of the overall I-69 plan.

The I-69 SIU 9 and I-269 Corridor EIS provided an ideal testbed for the proposed two-year study to quantify the benefits of multi-source remote sensing data and analysis. As partners on the project, MDOT and TDOT viewed the proposed study as viable, well designed, low risk for completion, and offering benefits of national significance.

The study is in an area with urban and rural settings, terrain and environmental challenges, and crosses state boundaries. The area will integrate thru-traffic along "Corridor 18" and will incorporate traffic and freight flows from the Memphis, TN, area and from Northern Mississippi areas.

The FEIS Testbed: The Final Environmental Impact Statement (FEIS) identified and assessed the environmental impacts associated with the construction of a segment of proposed Interstate 69 (I-69) that extends from Canada to Mexico across the United States. The segment of interest is Segment of Independent Utility 9 (SIU 9). The study corridor begins at the Interstate 55 (I-55) and Mississippi 304 (MS 304) Interchange in Hernando, Mississippi, and extends north

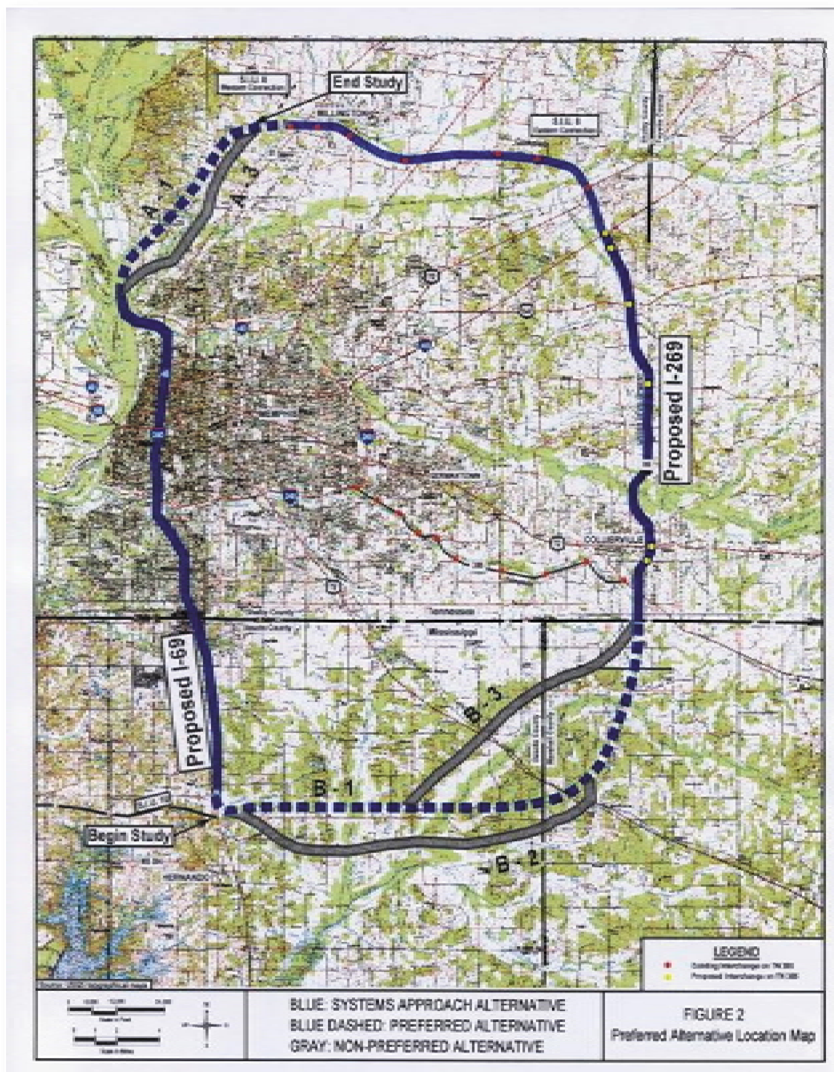


FIGURE 2
Preferred Alternative Location Map

through Memphis, Tennessee, to the intersection of US Highway 51 (US 51) and State Route 385 (SR 385) in Millington, Tennessee. The project is located in DeSoto and Marshall Counties in Northwest Mississippi and Shelby and Fayette Counties in Southwest Tennessee.

Project and Case Study Limitations: The EIS provided a baseline reference set of results against which results from new and innovative methods were compared. This required developing analysis techniques that could be directly compared against tabular or map-based results of the EIS. This project required understanding the nature of the EIS for this project and an important factor is the limitations of this study as compared to other studies for which different environmentally significant factors are relevant. Much of the focus in the EIS analysis and disclosure emphasizes hydrology, wetlands, existing and planned development. In this EIS, there were limited resource agency concerns for issues such as threatened or endangered species, habitat issues, or major cultural resource issues. As a result, this Technical Guide emphasizes the environmental aspects of analysis and disclosure emphasized in the subject FEIS so as to enable apt comparisons for this case study.

1.5 Environmental Features and Impacts Mapped in the I-69 / I-269 FEIS

Introduction: The EIS for I-69 / I-269 employed traditional approaches to mapping environmental features and estimating and mapping impacts. In Chapter 4 of the FEIS, the results of a comprehensive set of studies present cultural, environmental, economic, and ecological factors within communities affected and areas nearby the considered alternatives. In the EIS process, aerial photography was collected for the study area, and maps were prepared as exhibits upon which environmental and ecological features were delineated using manual techniques and quantified in tabular form in significant detail. Other map and visual aids were prepared that supported the tabulated summary of quantified impacts and environmental consequences.

Current Practice: The EIS considered Land Use Impacts [4.1], Farmland Impacts [4.2], Social Impacts [4.3], Relocation Impacts [4.4], Environmental Justice [4.5], Economic Impacts [4.6], Pedestrian Impacts [4.7], Ecological Impacts [4.8], Air Quality Impacts [4.9], Noise Impacts [4.10], Historical Impacts [4.11], Archaeological Assessment [4.12], Section 4(f) Impacts [4.13], Hazardous Materials Impacts [4.14], Visual Impacts [4.15], Energy Impacts [4.16], Construction Impacts [4.17], Indirect and Cumulative Impacts [4.18], addressed Short-Term Impacts versus Long-Term Benefits [4.19], and Irreversible and Irretrievable Commitment of Resources [4.20]. In the FEIS document, as well as accompanying appendices and constraints analysis map plates, there is an abundance of data presented and tabulated accompanied by lengthy discourse as to interpretations of results and findings.

Substantive Support for Tabular Data versus Data Driven Analysis and Modeling: The EIS describes use of data and methods for various impacts modeling and analyses. Absent from the EIS are implementations of data, methods, and analysis that offer enhanced capabilities to consider these factors in a CRS&SI enabled, data-driven framework. The use of photography as a base map upon which to scribe impacts, the use of topographic maps for floodplain depiction, air quality depictions, and noise pollution depictions are exhibits used to provide substantive support to tabulated results. Missing from the EIS are indications of 1) use of technologies for presenting information to planners and stakeholders for optimizing the preliminary planning process, 2) use of advanced data or methods employed for constraints analysis and environmental screening, and 3) use of approaches that gather stakeholder input about local values or commitments in arriving at potential alignments, 4) refining alignments via automated methods, or 5) use geospatial technologies in determining impacts of feasible alternatives.

<u>EIS I-269 Preferred Alternative:</u> Alternatives B-1, B-2, and B-3 for I-269 were selected for detailed study. Through the EIS process "Alternative Alignment B-1" was selected as the preferred alignment for the I-269 segment of the Systems Approach Alternative. The alternatives B-1, B-2, and B-3 were evaluated at length and the relative characteristics, merits, and impacts of each alternative were exhaustively documented. Although alternative B-3 was the shortest route and initially favored, there were significant factors favoring the ultimate selection of Alternative B-1.

Table 1.1. Summary of alternatives.

TABLE I

SUMMARY OF ALTERNATIVES

Alternatives	A-1	A-3	B-1	B-2	B-3	A-1/ B-1	A-1/ B-2	A-1/ B-3	A-3/ B-1	A-3/ B-2	A-3/ B-3
Project Length (miles)	15.2	15.3	28.6	30.6	26.6	43.8	45.8	41.8	43.9	45.9	41.9
New Right-of-Way (acres)	739	798	1479	1552	1406	2218	2291	2145	2277	2350	2204
Family Displacements	21	60	64	53	52*	85	74	73*	117	113	112*
Business Displacements	2	5	6	6	1	8	8	3	11	11	6
Non-Profit Displacements	0	0	0	0	0	0	0	0	0	0	0
Farmland (acres)	128	95	435	497	253	563	625	381	530	592	348
Stream Crossings	21	20	39	46	37	60	67	58	59	66	57
Potential Linear Feet of Stream Impacts (feet)	9,590	8,620	15,780	20,980	13,850	25,370	30,570	23,440	24,400	29,600	22,470
Wetlands (acres)	48	53	69	51	6	117	99	54	122	104	59
Historic Properties Impacted	0	0	0	0	0	0	0	0	0	0	0
Recorded Archaeological Sites	11	9	20	22	15	31	33	26	29	31	24
Hazardous Waste Sites	0	1	0	0	0	0	0	0	1	1	1
Landfill Sites	3	4	0	0	0	3	3	3	4	4	4
Impacted Noise Receptors	3	29	70	68	43†	73	71	46†	99	97	72†
Construction Cost ($ million)	233.4	264.9	416.5	462.0	368.8	649.9	695.4	602.2	681.4	726.9	633.7
Right-of-Way Cost ($ million)	38.4	43.6	68.6	76.1	60.7	107.0	114.5	99.2	112.2	119.7	104.4
Utility Cost ($ million)	2.8	3.1	4.9	5.4	4.3	7.7	8.2	7.1	8.0	8.6	7.5
Total Cost ($ million)	274.6	311.6	490.0	543.5	433.8	764.6	818.1	708.5	801.6	855.2	745.6

Impacts are based on a 300-foot wide corridor.
Cost data has been updated since the Draft EIS to reflect the most recent cost estimates.
* Because of the recent residential development along this alignment, B-3 has the potential to displace several hundred new homes in the Forest Hill Community subdivision.
† Does not include future noise impacted residences in the Forest Hill Community subdivision that is currently under construction.

<u>Discussion of Key Factors in Selection of the Preferred Alternative:</u> Although alternative B-3 created a lesser amount of wetland and stream impacts, these same factors influenced the plans for significant future developments in the vicinity of B-3. According to the EIS, "The I-269 corridor is presently experiencing a significant increase in residential development and other infrastructure construction. Many new homes have been constructed since the beginning of this study which is directly related to the availability of developable land and the economic growth in this region."

Of the alternatives considered, B-3 is the shortest route; it follows the edge of the Coldwater River floodplain, but is above the floodplain and generally does not include extensive wetlands that are more frequent in the lower lying areas of the floodplains. In the course of conducting the EIS, in the vicinity of B-3 and B-2, the following issues arose which contributed to significant opposition to B3, required numerous iterations, and in the end led to the selection of alternative B1:

> "A 1,600 lot planned residential community has developed and a new elementary school and fire station have been constructed. Some alignment adjustments were made adding time and effort to the project; however, alignment adjustments separated the school from the community served. Furthermore, rapid development in the community places many of the new homes in the path of the B-3 alignment. Planned developments in the community will likely be well underway before construction for I-269 and will result in hundreds of

additional residential displacements, significantly increasing the cost of the project and resulting in major community opposition. Shifting the alignment in the other direction would result in increased impacts on the Coldwater River floodplain and wetlands.

Alternative alignment B-3 was opposed by a large majority of the public attending the Corridor Public Hearing, as well as local elected officials in the area; for these reasons B-3 was not selected. Alternative B-2, the longest of the three alignments, has the highest estimated cost, has the potential to adversely impact new residential development in the area, passes a new subdivision (estimated to be 100± lots) currently under construction on Getwell Road, and passes just south of a new subdivision (estimated to be 50± lots) under development on Fairview East Road. These new housing developments will be complete before the construction of this segment of I-269 begins. B-2 would displace many of these new homes and subject those left adjacent to the interstate to traffic noise impacts. For these reasons, B-2 was not selected."

In consideration of the ongoing development in this region and the impacts associated with each alternative, along with public comments made at the Corridor Public Hearings and support of local officials, Alternative Alignment B-1 was selected as the preferred alignment. B-1 closely follows MDOT's previously proposed MS-304 alignment that was presented at local public meetings.

KEY FACTORS NOTED IN THE EIS FOR ALIGNMENT GENERATION AND SELECTION

- The three alignments proposed for the I-269 route were field located in an attempt to avoid as many existing environmentally sensitive areas, houses, businesses, churches, and other infrastructure as possible, thus minimizing the impact of this project.
- The alignments were manually shifted "iteratively" during the course of this study to avoid new developments as they were identified. Although Alternative B-1 was initially estimated to displace 64 families (slightly higher the Alternatives B-2 and B-3), no new subdivisions are currently under development in the path of B-1.
- Alignment B-1 was supported by local elected officials who have the authority to approve land use zoning to control future residential development in this area.
- Alternatives B-2 and B-3, due to the previously discussed ongoing development, will displace more houses and other infrastructure than the B-1 preferred alignment.
- Alternative B-1 will displace more wetlands than Alternative B-3.
- A new 1,600+ lot planned residential community is currently under construction in the path of Alternative B-3.
- Alternative Alignment B-3 has the potential to displace several hundred of these new homes. It would split the community and be very close to a recently constructed elementary school.
- Alternative B-1 is more economically beneficial to the City of Byhalia and Marshall County. It will provide access to more land for local development.
- Alternative B-1 will increase the tax base and improve the quality of life and will provide better traffic service to existing industrial and residential development in the area.
- Alternative B-1 was endorsed by the Northern Mississippi Industrial Development Association, Marshall County Industrial Development Authority, Marshall County Board of Supervisors, the Byhalia Chamber of Commerce, and the town of Byhalia. It will provide very much needed economic relief to this area.

OBJECTIVES FOR AND KEY BENEFITS OF INSERTING CRS&SI IN THIS EIS PROCESS

Of the factors described as key to the definition of alternatives B-1, B-2, and B-3, there are several opportunities, enhancements, and key benefits that could be achieved by the appropriate insertion of CRS&SI technologies. These opportunities and key benefits include:

- Collecting geospatial data from local, county, MPO, planning development districts, and other agencies with vital basemap information for the project area. (Chapter 2)
- Identifying key data layers needed for the entire project area, including environmental layers such as high-resolution image data, digitized wetlands, soils data, land cover land use data, hydrology and streams, terrain data, as well as environmentally sensitive features. (Chapter 2)
- Gathering land use, zoning and planning map information from all agencies and integration of the data into the planning process. (Chapter 2)
- Delivering data and insights for ongoing planning (Chapter 3) as well as for land use and characteristics and conditions of the transportation system (Chapter 4).
- Developing and sharing maps of alternatives that could enable early and effective exchange of data and plans for development. (Chapter 5)
- Delivering understanding about social conditions for the project and areas served (Chapter 6).
- Developing GIS data-driven constraint maps as well as screening analyses of features that could be potentially impacted. (Chapter 7)
- Developing GIS data-driven approaches for generating, refining, and analyzing alignments and impacts generated. (Chapter 8)
- Developing and implementing a geospatial technologies checklist for enhancing transportation planning and environmental studies. (Chapter 9)

Subsequent chapters of this technology guide will address the deployed insertion of CRS&SI technologies, discuss key benefits and enhancements delivered, and address key factors of implementation in the transportation project development process. Chapters 7 and 8 deal with environmental features and multi-criteria decision support, respectively. Because Chapter 7 presents methods and results for extracting baseline spatial data from the EIS for making rigorous comparison of performance metrics and Chapter 8 presents methods and results for corridor, alignment, and alternatives generation and refinement, these chapters are presented in greater detail than other segments of the report. Chapters 7 and 8 present maps, methods, and results as well as in-depth comparisons between the results of traditional approaches and the new and innovative methods presented.

2.0 GATHERING COMMERCIAL REMOTE SENSING AND SPATIAL INFORMATION

The team grappled with the difficulty of gathering, organizing, documenting, managing, and utilizing data from multiple sources (including federal, state, county, and local data). A highlight of this is the excellent high resolution image data, LIDAR data, planning data, zoning data and other spatial data provided by Desoto County, MS. The availability of these local data enabled advanced analyses where present. However, matching geospatial data type, accuracy, resolution, scale, and freshness with requirements for geospatial analysis applications in transportation planning is normally a big challenge.

To streamline environmental and planning processes as proposed in this project, three “topics” must be covered in terms of CRS&SI: 1) understanding needs for project-wide and area-specific; 2) developing a multi-source and multi-scale geodata catalog; and 3) structuring data for multi-scale analysis. A summary of these tasks is presented.

2.1 Understanding Needs for Project-Wide and Area-Specific CRS&SI Data Layers

A significant variety of CRS&SI data layers are required for conducting a large-area NEPA study. As a process of disclosure, the environmental study touches on aspects of the proposed project at both the project-wide large area (small scale) focus and localized areas (large scale) of focus for developing understanding about specific alignment alternatives and the local features potentially impacted. Whether for developing generalized plan views of the proposed project for public participation processes or for advanced mapping applications such as environmental features analysis, constraints analysis, and environmental screening for estimation of impacts, spatial data of appropriate coverage, accuracy, consistency and freshness are required. Identifying the existence of these data, arranging data for early data exchange, gathering together the data and necessary metadata and organizing the collected data for use in the project are significant tasks. Moreover, using the data consistently and in a manner appropriate to different tasks is singularly important to producing reliable results.

Current Practice: For developing large area base map data to depict the project-wide transportation corridor, gathering CRS&SI today is not a difficult task. Federal and State geodata are normally well stored and catalogued. However, when moving into moderate-scale map data—typically a limiting factor for a local NEPA study—more accurate information is required for area-specific analysis.

Unfortunately, gathering large scale geodata can be tedious and sometime fruitless work. In general, the higher the mapscale, the more difficult to compile and organize the data especially if they are from disparate sources. This is often compounded by “organizational resistance” to sharing local data. Whether due to stovepipe practices, lack of funding, or internal-only viewpoints, local organizations frequently guard their data and do not readily share data in collaborative efforts. General lack of data documentation or metadata support can make the use of local data difficult as well. Figure 2.1 illustrates the level of geodata detail compared to metadata detail and availability at scales that span from local to federal. Understanding geodata based on “data ownership” hierarchy plays a significant role in comprehending the usage of the data for the project and the rationale employed in conducting project analysis with local emphasis for areas where high quality geodata was provided by local partners such as was the case for Desoto County, Mississippi, a ready and willing partner to the project.

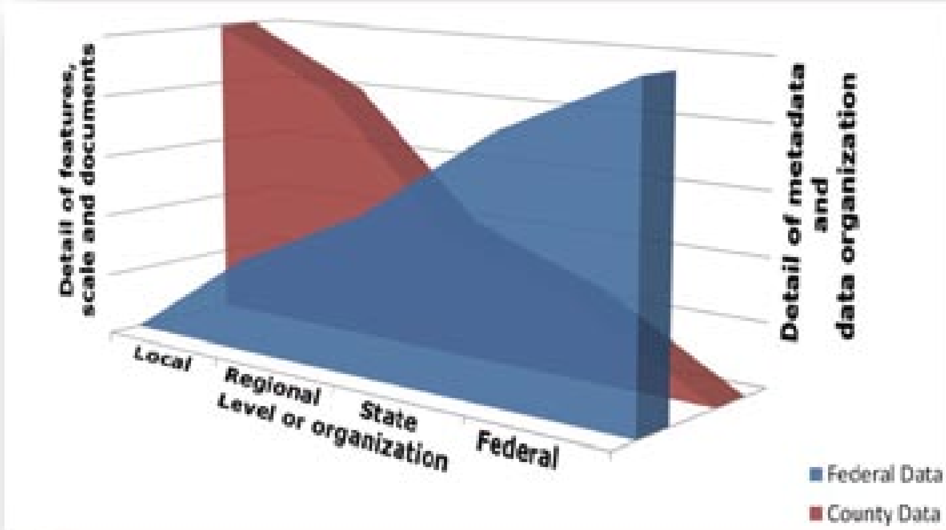


Figure 2.1. Data hierarchy and quality showing the high contrast in level of geospatial data detail versus metadata detail.

Problem Statement: For geospatial data from federal sources, resolution, freshness, and relevance of data to local issues can be moderate to low depending on the data source, whereas the level of metadata documentation is high. For data from local sources, where data is acquired and used for local purposes, the resolution, freshness, and relevance of data to local issues is very high; however, the level of metadata documentation, naming conventions, degree of organization and consistency of the data may be moderate to low. The uncertainty of using federal data for local issues lies in the geospatial data, whereas the uncertainty of using local data for local issues lies in the lack of corporate knowledge and documentation of the geospatial data and lack of clear understanding of how it may be applied.

As a picture of the current practices, remote sensing and spatial information are being successfully used in transportation planning and environmental analysis as well. The past efforts of GIS-T have contributed to clarify and disseminate geospatial technologies among transportation practitioners. However, the demand for geoinformation-based analysis goes beyond traditional environmental and engineering practices. Today, a large number of factors and attributes must be covered in a modern decision making process in both project-wide and area-specific analysis. Currently, the effective use of the state of the art of CRS&SI remains a gap in transportation planning.

CRS&SI Objectives

- Eliminate gaps caused by missing geodata necessary to supply the project needs
- Provide compatibility between the project requirements and the geodata across map-scales

Methods: CRS&SI technologies are evaluated in the context of modern planning process and environmental study approaches in transportation to benchmark the capabilities to deliver timely, cost effective, and accurate results as well as enhanced understanding when compared to traditional methods. Gathering the best-available data and exploring methods of streamlining environmental analysis remains a challenge in today's transportation planning. The NCRST-SEPP approach focuses attention on three initial geodata factors that must be considered to overcome this impasse:

Growth of geodata and associated challenges: The growing range of available geodata in digital forms and the rapidly increasing need for their combined use highlighted two rising problems associated with the application of automated spatial data handling technologies: 1) a rigidity and narrowness in range of applications and data types; 2) unacceptable storage and speed efficiency for current and anticipated data volumes. Despite all the advances in informatics, those issues still remain valid in some applications, with a significant application area being transportation planning and environmental studies.

Efficient Use vs. Stockpiling/Stovepipes: Tendency toward sustainable development, globalization, environment conservation, political disputes, human rights, and economic issues has emphasized the necessity for imminent access to and better management of geodata. The efficient use of the geodata behind sustainable land management and environmental applications depends upon how well the data are managed because in many private and public organizations, data are stockpiled or organized according to stovepipe organizational and process-related structures. Efficient and reliable access to geo-information infrastructure at global, regional, national and local levels has profound value in data management.

Best Available Data: In transportation, the environmental needs and cost implications associated with corridor are strongly correlated. It is imperative to identify and work with the best available geodata to minimize potential risks and to predict realistic cost estimates prior to engineering construction. The analysis extends across different map-scales to cover top-down (macro) and bottom-up (ground level) perspectives. Furthermore, the geodata must support time-series analysis, so multi-temporal geodata are targeted.

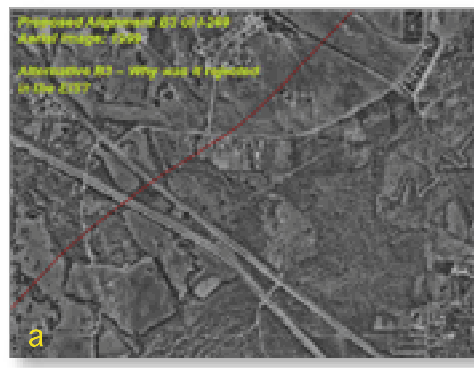
Results

Geographic Data Hierarchy and Quality: Most geographical information used in transportation planning does not cover all aspects and requirements of planning and environmental studies. Ideally, projects in transportation planning should be supported by accurate and up to date geodata that provide information about biophysical, socio-economical, and cultural issues to streamline the process.

Multi-Temporal and Long-Term Planning Data: For transportation planning, multi-temporal data are important because they can supply information about the past and provide a basis for long-term planning analysis along the corridor and adjacent areas. The analyses of geographic data through time enable qualifying and quantifying differences in land use and land cover, which play an important role for environmental management. One of the well known uses of multi-temporal data is change detection, which is the key to understanding and managing the dynamics of land cover and land use. New man-made features, such as open areas, roads, buildings, ponds, and agriculture fields can be easily detected by comparing time-series commercial remote sensing images.

I-269 B3 Alternative Example: An alternative that was initially favored for a part of the I-269 project, B3 (red line traversing the 3 images), provided an option that avoided low-lying areas, had minimal wetland impacts, and was initially thought to impact a low number of existing housing units. However, when put forth as an alternative, this option was met with significant criticism as it was located in areas with significant numbers of planned developments.

In reviewing 1999 image data (figure 2.2 a), these areas are undeveloped. When reviewing 2004 image data (figure 2.2 b), a significant amount of clearing, preparation, and initial construction was apparent, which can be seen in conjunction with the planning layers that were provided by the Desoto county planning and GIS department. In 2007 image data (figure 2.2 c), the new developments are clearly visible as recent and ongoing development areas.



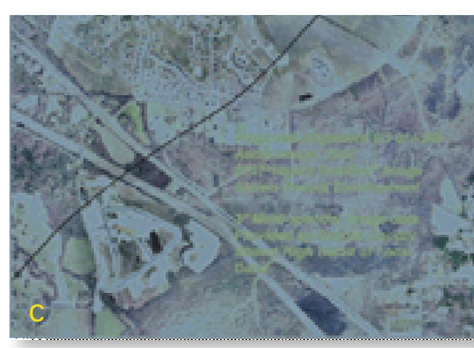


Figure 2.2. Integration of local planned development.

This "B-3 Alternative Example" highlights the need for 1) high quality recent image data, 2) possible recapture of temporal image data as the project progresses, 3) sharing of planning and zoning data with local planning and GIS organizations, and 4) effective integration of multi-temporal and long-term planning data into environmental and planning analyses.

Multi-Scale Data: As a linear engineering project to connect different locations (cities, counties, states and countries), transportation corridors involve data analysis in different scales. The interaction among different levels (as shown in figure 2.3) in terms of data and policies are vital to the success of the project.

In defining initial boundaries for a planning or environmental study, depending on the size of the study area, it is likely that low resolution data and generalized information provide good perspective for setting initial boundaries. From this standpoint, a wide corridor (several miles wide) may be defined based upon the logical termination sites to be connected as well as the macro areas or barriers to avoid (national parks, mountains, lakes, etc.).

The transportation project is largely directed in this phase by the positive long-term impacts on economy and development. Necessary geodata are commonly provided by federal agencies while analyses are, in general, dependent on predictive models and state and federal long-term plans.

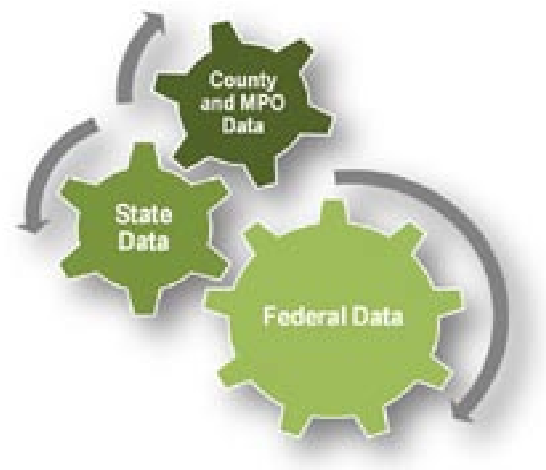


Figure 2.3. Multi-scale data.

As the planning process moves to a regional point of view, a new level of information is required for streamlining the project. A new set of cost-benefit analyses are conducted within the wide corridor limits. Thus, one of the most relevant target sets is sustainability, which involves environmental, socio-economic, and risk assessment. Focusing in on needs for local analysis, geodata from municipalities, counties, and planning organization should be integrated as it has the fidelity of detail to deliver insights key to the decision-making process. Local data such as zoning, current and future plans, population, developments as well as topographic, hydrographic and land cover data provide inputs needed for detailed refinements that may be automated in conjunction with structured environmental screening.

A balanced combination of multi-source, multi-temporal, multi-scale data environment is vital to arriving at concurrency points of decisions in any well conceived, "data driven" streamlined environmental assessment process. The more complete the data to compute and rank the corridor alternatives, the less dependent the EIA process is on "front-end loaded" field work. This is not to say that field work is eliminated, because, even considering the best-available data and methods employing CRS&SI for streamlining, the final EIA report and permitting activities always require certain levels or types of data and information be collected or validated through field work and ground surveying.

2.2 Developing a Multi-Source, Multi-Scale Project GeoData Catalog

The term GeoData Catalog is applied since users found the term "GIS Data Dictionary" awkward and suggested that the project adopt more apt terminology. The GeoData Catalog is a structured database that contains, in an organized fashion, sufficient information for the informed use, access, understanding, and application of geodata that have been assembled. The document compiled by SEPP team includes the source and provenance of geodata, location of online storage, web links where appropriate, and details as to special processing, or other data modifications that have been incorporated into the geodata. The most significant effort developed for the GeoData Catalog is the multi-source and multi-scale implementation. The GeoData Catalog offers the practitioner a selection of material that can be ranked according to criteria such as accuracy, availability, scale, and completeness. The opportunity is to provide a solid compendium of geoinformation useful for transportation projects. The Geodata Catalog's purpose is not merely to define a collection of data; it also provides an organizational and structural framework that exposes data useful and transparent for applications in the transportation planning process.

Current Practice: Positive and negative impacts are often conflicting and must be balanced within the planning phase. The context of transportation corridors often transcends local to regional interest levels. Transportation planning requires information that range from federal and state domain to ground surveying. Thus, a multi-scale data structure plays an important role in understanding, classifying and delivering appropriate geographic data according to the different contexts from local to federal levels.

CRS&SI Objectives: The SEPP GeoData Catalog builds upon GIS-T practices in developing standard data dictionaries and extends this concept by acknowledging the complexity and challenges of pulling together from disparate sources data that are useful to the project development process. This approach is an important step toward developing a unifying compendium that meets the needs of DOT practitioners, the FHWA, stakeholders, and resource agencies in identifying and utilizing geodata with characteristics and policies needed to modernize and improve the efficiency and reduce the costs of the transportation planning processes.

KEY BENEFITS

- Enhance the applied uses of best available spatial data.
- Inform organizations as to best practices and usage of available geodata resources.
- Strengthen linkages between geodata cataloging and multi-criteria decision making.
- Encourage practitioners / users to maintain documented geodata catalogs and resources.

Methods: Methods presented divide the development of a multi-scale and multi-source catalog into two segments focusing on design and implementation which follow.

<u>Designing availability, purposes and needs:</u> The GeoData Catalog comprises structured geodata gathered from disparate sources which serve as primary layers of information useful for tasks that range from basemap development to environmental screening and constraints analysis, which ultimately lend themselves to the implementation of a Multi-Criteria Decision Making framework. The overall use of GeoData and the GeoData Catalog focuses on the EIS process of disclosure, documenting efforts to avoid adverse impacts, and where avoidance is not possible, showing analysis-based approaches taken to minimize negative or adverse environmental implications.

<u>Assessing, understanding and organizing geodata:</u> Documenting the content of the geo-information, data mining processes and data organization plays a vital role that delivers understanding and precedes information as to the whereabouts of storage and publishing. The outcome is a complete inventory of all essential information available for use in a transportation planning and environmental study that rises above the limited standpoint of traditional metadata. Compiling the GeoData Catalog is an ongoing process that starts with the analysis of available metadata and is subject to ongoing refinement.

Results

<u>The workflow:</u> Handling information to build and populate the GeoData Catalog is a continuous process. A workflow of gathering, analyzing and inputting geodata into the Geodata Catalog is vital to the maintenance of the system. Figure 2.4 highlights the workflow of populating the GeoData Catalog.

Figure 2.4. Stages of developing and populating the SEPP GeoData Catalog.

The main steps of the GeoData Catalog workflow are explained in the following sequence:

1. <u>Planning</u>: Data requirements of the project are considered.
2. <u>Collection</u>: Geodata are gathered from various sources in varying formats. Preliminary analyses are performed to ascertain and document accuracy, completeness and integrity.
3. <u>Data storage</u>: Geodata are classified and stored in assigned data pools.
4. <u>Data modification</u>: Initial processing is implemented for filtering, redesigning, reprojecting, de-noising, cleaning, etc, to assure compatibility with established standards.
5. <u>Data appraisal and data classified</u>: Geodata are analyzed according to specific criteria of use for the scope of the project.
6. <u>Documentation</u>: Knowledge management is vital and requires continued upkeep to maintain a useful GeoData Catalog. This makes for an intelligent, re-useable and transferable approach for geodata management and application in similar projects.

<u>The layout</u>: Because transportation planning always involves a large amount of data, the information reported in a GeoData Catalog must describe technical aspects geodata gathered for the project and provide descriptive content at different levels expressed in clear technical language. When accessed for specific applications, the GeoData Catalog must present data and metadata in clear, consistent, and unambiguous terms.

KEY BENEFITS

Following these steps regarding the geospatial data needs in corridor planning resulted in a NCRST-SEPP GeoData Catalog. The catalog played a vital role in the project management of the USDOT-RITA project and delivered insight as to geodata content that responds to geographically dynamic requirements. The catalog includes not only the information about the data themselves, but also the classification as per the nature of data, and information concerning the use of the data on transportation and environmental tasks conducted in the research project.

2.3 Structuring Data for Multi-Scale Analysis

Transportation corridors are typically engineering projects designed to traverse area which, in many cases, cross different counties, states and even countries. Despite formal engineering standards to design transportation corridors, the project must be flexible to adapt to local policies when passing through different administrative boundaries. The geographic scope of the transportation project may dictate different levels of analysis for various areas traversed, hence, one of the needs to subdivide a major project like I-69 into segments of independent utility. Geodata and policies change according the scale of the analysis. The multi-scale capability of the GeoData Catalog enabled NCRST-SEPP to cover both macro-level and local perspectives.

Current Practice: Transportation practitioners utilize modern computational packages to design highways and handle NEPA's resolution. The EIS is intended to disclose, through identification and assessment processes, the environmental impacts associated with the development of a transportation project.

The current transportation planning process shows a lack of coordination and data integration in pre-NEPA stages. In current practice, project-wide geoinformation are analyzed and used to develop, adjust, and evaluate concurrent alternatives (Figure 2.5). In the EIS process, biophysical, socio-economic and cultural characteristics are considered to predict negative and positive impacts. Many aspects of the EIA are surveyed based on mandatory requirements.

The intent of NEPA is to disclose all feasible alternatives of project construction, resulting in the elimination of some and the selection of a subset of feasible alternatives for which impacts are analyzed and compared in the process of selecting a preferred alternative.

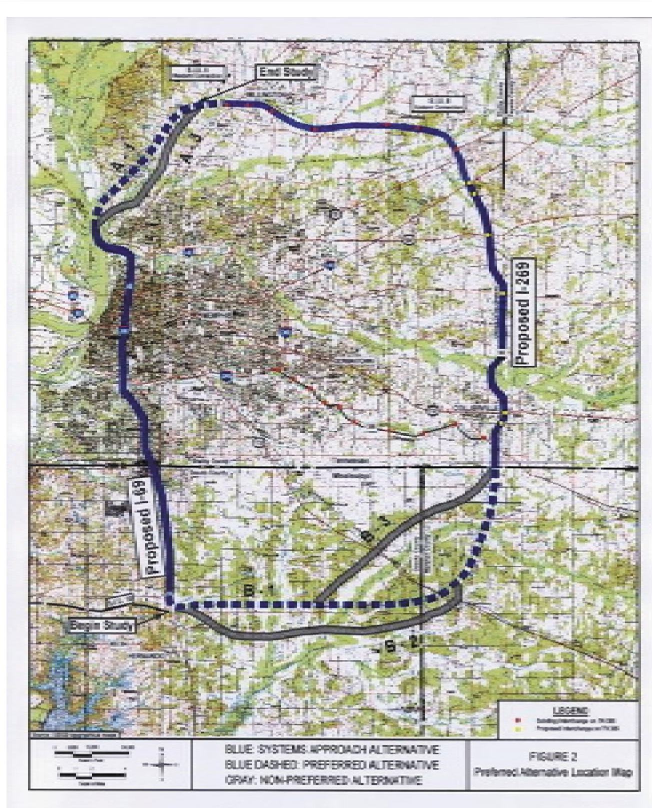


Figure 2.5. Preferred alternative location map as per Final EIS document.

CRS&SI Objectives

- Provide mechanisms to assimilate geodata into the scope of the transportation planning process.
- Establish a foundational basis for the GIS-based Multi-Criteria Decision Making process.
- Stimulate the concept of continuous planning when thinking about project and map scales.

Methods: The NCRST-SEPP team developed a multi-scale approach to compute a set of hierarchical corridors from project-wide (small scale) to area-specific perspectives (large scale) with incremental refinements applied in a structured process. The refinement process begins with federal and widely available data and ends with local data to estimate environmental impacts. Figure 2.6 shows the top-down corridor, narrowing approach by using geodata changing from national to local perspectives.

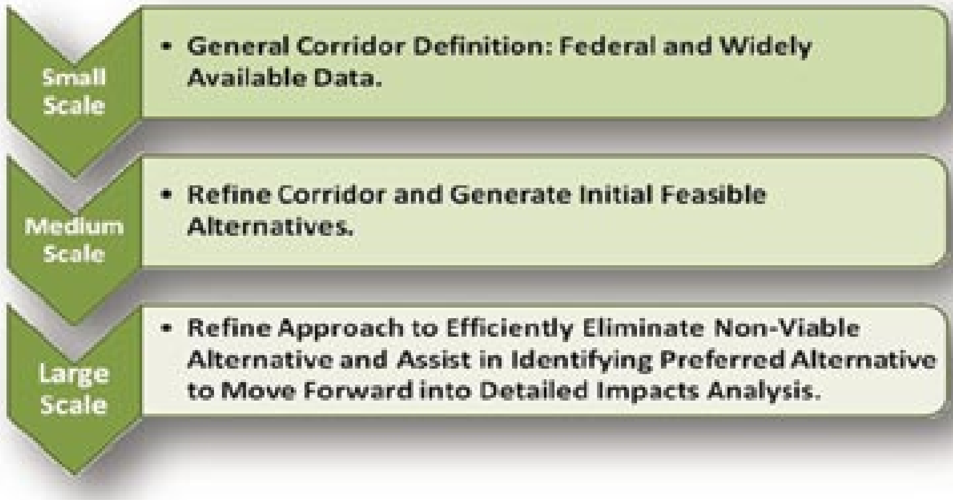


Figure 2.6. The top down scale approach proposed by NCRST-SEPP.

Projects with extended areas, such as the I-69 Corridor, are segmented into smaller SIUs (Segments of Independent Utility). This configuration enables enhanced coordination among Federal and State DOTs (Figure 2.7). Thus, the small scale analysis uses the extent of the particular SIU as testbed for gathering geodata. The small scale geodata are used to define a project-wide corridor. Subsequently, medium scale geodata are used to refine the wide-corridor and generate initial feasible alternatives. Medium scale geodata normally comprise accurate federal and regional data. The large scale analysis is the final step in refining the feasible alternatives, considering the usual 1000-foot right-of-way corridor to quantify the environmentally impacted features as expressed in area-specific geodata.

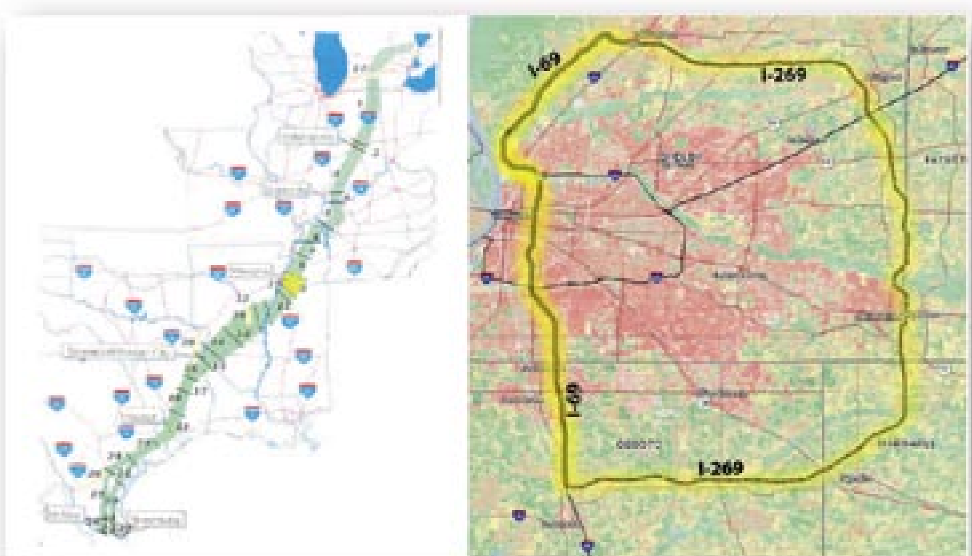


Figure 2.7. The overall proposed I-69 (left) and the segment of utility 9 (right).

Results: The structured geodata for multi-scale analysis serves as basis for progressively considering and refining alignments. The multi-scale structure starts from nationwide and regional data and ends up using county and local data to ensure enhanced fidelity, accuracy, and continuity in moving toward decisions at the local scale. Figure 2.8 illustrates the SEPP results obtained using the multi-scale approach.

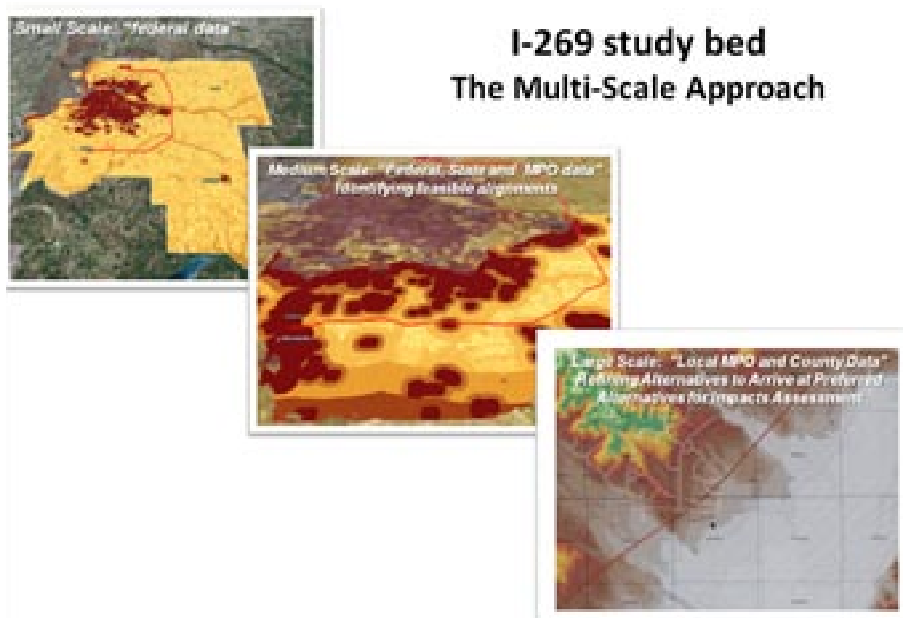


Figure 2.8. Cumulative cost surfaces in different scales as result of the GIS-based MCDM.

Key Benefits of 2.1, 2.2 and 2.3

Understanding project needs from macro to local perspectives is imperative when selecting CRS&SI data and methods. Transportation corridor studies demand geospatial analysis across different fields and across different map scales. Today, the large availability of commercial remote sensing data and geospatial datasets can support the planning processes by providing a systematic basis to estimate early positive and negative impacts in a smart automated way prior to intensive NEPA ground efforts and local community involvement. The addition of appropriate geodata and methods as proposed by the NCRST-SEPP project results in an innovative approach to support corridor planning, including the design of the alternative alignments. Others key benefits associated with the use of CRS&SI technologies are savings in cost and time.

KEY BENEFITS

- GeoData Catalog prevents the duplication of data collection and storage.
- Support cross-agency coordination and collaboration.
- Supports effective data sharing.
- Provides coherent terminology across data collections.
- Provides coherent information management practices.
- Streamlines geodata exploration across different scales.
- Offers continuity for data processing across scales.
- Delivers support for geographic intelligent analysis.

Transportation project background and planning is traditionally limited to the review of the project description, location map, concept reports, air and noise report, traffic, and accident data. This information is provided to the project team of specialists and from there given to the resource agencies and the public (Public Information Meeting). However, if done differently and supported by CRS&SI technologies, this stage of the process could be much more robust and provide a strong link between the collection of the social, economic, and environmental data and the public.

3.1 Social, Economic, and Environmental Data (SEE) and Planning and Environmental Linkages (PEL): Resource Agency Involvement & Data Exchange

Linking data, planning and NEPA is functionally challenging. Resource agencies, planning organizations, and departments of transportation have different primary missions. Bringing them together for a common cause requires their respective actors to behave in a way that is often contrary to their original missions. CRS&SI technologies can assist in creating an environment where collaboration, not conflict, is possible.

Current Practice: According to the FHWA, "Corridor planning can be an effective tool to connect systems-level and project-level decision-making and support stakeholder involvement. Corridor planning studies are used when the long-range plan leaves open the possibility of multiple approaches to fulfill goals and objectives, and they occur prior to project planning. These studies may include scoping, alternatives analyses, preliminary identification of environmental impacts and mitigation opportunities." Furthermore, the FHWA indicates that linking Planning and NEPA is an integral part of Planning and Environment Linkages (PEL). The term PEL is used when agencies include environmental considerations in transportation planning and carry activities or decisions into the NEPA process.

CRS&SI Objectives: CRS&SI provide the opportunity to use data, methods, and technologies to tighten task descriptions and objectives to avoid scope creep.

Methods: The research team asked each partner agency to provide all geo-coded data that related to the corridor area. This was the base layer from which all other geo-coded data could be built upon.

Results: For final corridor alignment decisions, Least Environmentally Damaging Practicable Alternative (LEDPA) doesn't adequately meet transportation needs today, but with better data / tools, perhaps a successful alternative that closely matches LEDPA can be devised. Better data will deliver improved ability to more rapidly identify alternatives, eliminate non-viable alternatives, and present mitigation strategies that improve the process and decrease impacts. In developing quantitative measures of impacts, the project has the opportunity to consider technologies that provide matrices of impacts that not only quantify environmental impacts, but also qualitatively rank the ability of the alternative to meet purpose and need.

3.2 Planning Investigation for Counties and Local Organizations in the Study Area

Counties and local organizations vary widely in personnel capability, organizational capacity, and regular collection of geo-coded data. Therefore, each attempt at merging county and local plans with corridor selection presents new and different challenges. However, advantages are great and more and more local communities are investing in CRS&SI technologies with increasing emphasis on interoperability.

Current Practice: Many planners and planning organizations do not emphasize a direct connection between transportation planning and environmental and land use condition. An analysis of nine planning documents from local governments within the I-269 region highlights a need to connect transportation planning and land use development. Most importantly, the current practice in this case study indicates a fragmented planning process that underutilizes the Metropolitan Planning Organization (MPO) as a convener that can help broker the complexity of transportation decision making (Campany, 2008).

CRS&SI Objectives: Using CRS&SI applications, a data exchange meeting was held between the Memphis MPO and local governments. Vital mapping and geospatial information provided a wealth of data. This data include high resolution image data, LIDAR data, planning zoning and future developments as spatial layers.

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Methods: In the early phases of the project, the research team contacted all of the counties in the area, gathered electronic copies of Comprehensive Plans, and determined to what extent the counties or organization utilized geospatial technologies. Once completed, the research team conducted focus group meetings and on-site visits with personnel from the Desoto County and with the Shelby County MPO. In addition, phone interviews were conducted with other local governments.

Results: Exchanging and providing geodata in the early stages of the planning process in a visual format, and integrating this data in Multi Criteria Decision Making (MCDM) enables practitioners and project stakeholders to adjust the build and no-build scenarios to account for changes in growth patterns. This in turn allows local and regional planners, working through the MPO, to adjust long-term development plans accordingly.

3.3 Context Sensitive Solutions & Capturing Local Values

With safety and the efficient movement of people and goods as a tenet for most transportation projects, it is possible to understand how community and quality of life become secondary aspects of the transportation planning process. With escalating construction and fuel cost, it is becoming more important that new corridor developments respect and integrate the surrounding community context.

> "Context sensitive solutions (CSS) is a collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility. CSS is an approach that considers the total context within which a transportation improvement project will exist." (FHWA)

Current Practice: At this point, CSS applications are rare, and most State Departments of Transportation (DOTs) are exploring ways to incorporate CSS. As part of a larger USDOT Research and Innovative Technology Administration (RITA) project, alternatives were explored for the detection of community, land-use, historical and culturally significant features using spatial technologies so these features can be evaluated and integrated into the planning process.

CRS&SI Objectives: With the advent of geospatial technologies, diverse data, and an increase in the acceptance and use of these technologies, the integration of context sensitive solutions into the transportation planning process is becoming a reality. This is due in part to the inventory and analysis capabilities associated with a GIS. With current GIS technology, community features can be quickly located and incorporated into the process.

Methods: Key components identified for the research project included investigating streamlining opportunities that exist for tasks and activities typical of a transportation corridor planning and environmental assessment process. Each activity identified considered how CRS&SI technologies may add efficiencies, reduce costs, and/or improve the quality and outcomes of the task or activity.

Site reconnaissance and inventorying visits are useful tools and should continue to be employed. However, in order to make the planning process more integrated and streamlined, it proved useful to employ validated remote sensing and geospatial technologies.

Tools, data and technologies are important; however, one must know how to utilize and query the information to get meaningful results. Coupled with innovative data and tools, a CSS inventory matrix and feature recognition tools presented powerful methods to integrate built and natural features into a data rich environment so that analysis and alterative corridor developments can occur in a way that respects the built and natural context.

Results: To help bridge the gap, this project sought methods of community feature and land use recognition using standard GIS software. Furthermore, this project sought ways to incorporate proven smart-growth elements so that the community features and land use could be evaluated using the smart growth elements with the goal of 1) Providing a variety of transportation choices; 2) Directing development toward existing communities; 3) Mixing land uses; 4) Taking advantage of compact building design; 5) Preserving open space, farmland, natural beauty, and critical environmental areas; 6) Creating a range of housing opportunities; 7) Creating "walkable" neighborhoods; and, 8) Creating distinctive, attractive communities with a strong sense of place.

Google Earth was used extensively in the project, not for analysis, but rather for presentation of the results in the context of a highly useful tool and a set of Geodata interfaces that are almost universally available. Google Earth is not suggested as a substitute for detailed geospatial analytical tools, but is stated as being highly useful for exchange and visualization of results. The use of Google Earth and the ease of KML integration with the process is later demonstrated to show the close relation between EIS alignments and the alignments generated by the project. The use of KML and Google Earth to provide easy exchange of alignment options is an area that is discussed and—as a map distribution mechanism—is a practical and low-cost technology that could certainly be more fully used in transportation planning.

Limited recent geospatial data was available at usable scales, therefore site visits and physical surveys were the methods employed to gather data during the inventory process. The objectives of the visits were to observe and document land use types and other contextual characteristics of the corridor, including significant cultural and historical sites, the extent and nature of development along the corridor, and the characteristics of individual towns and urban nodes intersected by the corridor.

Key Benefits of 3.1, 3.2 and 3.3

For each of the potential alignments considered, there were social, economic, and environmental impacts; however, both impacts and benefits were efficiently and effectively analyzed and described utilizing segmented parts of each alternative to provide a geographic basis for presenting and describing the impacts and benefits of the alternatives. By providing this data at the early stages of the planning process in a visual format and integrating this data in a multi-criteria decision matrix, it allows project stakeholders to adjust the build and no-build scenarios to account for changes in growth patterns. This utilization of CRS&SI in the early planning stages resulted in highlighting community features and land use recognitions that would not have available through traditional fragmenting planning processes. This in turn allows local and regional planners, working through the MPO, to adjust long-term development plans accordingly. The MPO is able to evaluate regional impacts of localized decisions on the region's transportation infrastructure and air quality.

DISCUSSION OF KEY BENEFITS

- In its role as collector and synthesizer of information, the MPO is able to evaluate regional impacts of localized decisions on the region's transportation infrastructure and air quality. In this role, it has the potential not only to serve as a one-stop-shop for information from throughout the region related to multiple facets of transportation, but to develop information products that add value to the information collected. These products can be used to help inform public authorities and the general public about the impact of their policy values and outcomes.

- To help bridge the gap between environmental and land-use planning, this utilization of CRS&SI in the early planning stages resulted in highlighting community features and land use recognitions that would not have available through traditional fragmenting planning processes.

- Transportation planners and those DOT employees tasked with developing alternatives for new corridor development as well as analyzing the environment impacts of those corridors, all utilize some form of GIS during the process. Given the integration of community features that reflect the various elements of smart growth and CSS into usable spatial data sets and layers, it is now possible to incorporate these data layers that respect and promote high qualities of life throughout the community.

- The streamlined EIS process is based on early data collection and the integration of existing plans with high quality data. With the early integration of plans, it is possible to begin the process with a sound understanding and reflection of long-range transportation plans, comprehensive plans, economic development plans and other plans that are in place to help guide development for the area.

- Transportation improvement projects as well as new corridor developments provide development energies and pressures that must be accounted for outside of the corridor ROW. Not only is land use affected, but all infrastructures of the area experience increased pressures. The pressures and development frameworks are considered and planned for in the local and regional comprehensive, transportation, and economic development plans and currently, these plans are not being utilized to help frame and guide transportation projects. CSS, spatial technologies, and the smart growth matrix all provide a mechanism for this integration.

4.0 CHARACTERISTICS AND CONDITIONS OF THE TRANSPORTATION SYSTEM

Over the years, the context of highway development has changed dramatically. Shifting from a silo perspective that contrasted and designed roads to a systematic, seamless component of a transportation system, highways have emerged as an economic stimuli that link the elements of the global marketplace. The section provides a brief description of the current purpose and needs of I-69 and highlights how CRS&SI can benefit this early stage of the planning process.

4.1 Purpose, Prioritized Needs, and Perspectives in the I-69 SIU 9 FEIS

Introduction: Traditionally, highway developments focused on building a nation's basic transportation system. However, the National Transportation Policy shifted America "from building the nation's basic transportation system to adapting and modernizing transportation facilities and services to support economic growth, meet the competitive demands of the international marketplace, contribute to our national security, and improve the quality of life for all Americans." In early 1987, in response to that Futures Group task force a transformation to "...taking a strategic look at issues, trends, technologies, and program options that would ultimately impact highways" became a high priority in transportation policy.

Current Practice: Today's transportation system faces safety issues, traffic congestion, freight movement constraints, the lack of intermodal connectivity, and environmental concerns. SAFETEA-LU attempts to addresses these issues, and it tries to promote groundwork for addressing future challenges. Although SAFETEA-LU is the most recent transportation bill, it builds off the ideas of its predecessor legislation, the Transportation Equity Act for the 21st Century (TEA-21). "Section 1309 of the Transportation Equity Act for the 21st Century (TEA-21) directs the U. S. Department of Transportation (USDOT) to develop and implement a *coordinated* environmental review process for highway and transit construction projects" (FHWA, 2008, p.2). This mandate of coordination has manifested into Environmental Streamlining. Environmental Streamlining requires transportation and natural, cultural, and historic resource agencies to develop timeframes for transportation projects, and then to work collectively to accomplish those timeframes. A key to Environmental Streamlining is collecting and disseminating input information from the public and stakeholders and developing an iterative process that capitalizes on communication between all pertinent parties.

CRS&SI Objectives: Utilizing CRS&SI technologies, the research team attempted to identify project alignments. This effort concentrated on examining and analyzing data before conducting field observations in an attempt to reduce costs and time and predict early estimates of project impacts.

Results: Initial identification of feasible alignments and subsequent "field location" of the alignments did not take advantage (in the early stages) of current photography collected by the MPO or by Desoto County Planning and GIS. Given these data, a simple overlay of potential alignment with image data would have clearly depicted potential and existing conflicts due to development. The further incorporation of GIS layers for planned developments would have significantly simplified and perhaps streamlined the process, certainly avoiding needless manual adjustments and iterative minor modification of alignment alternatives hopelessly conflicting with long-term development plans. Similarly, overlay analysis of feasible alternatives over environmental feature layers would have delivered significant insights as to possible environmental impacts and could have helped to direct and manage field activities to field locate and refine maps for the quantification and analysis of potential for impacts.

4.2 Multi-Modal Demand, Performance and Level of Service

As the purpose and needs of a transportation system develop, planners are tasked with identifying traffic patterns and investigating mode demand that may be effected in a potential development area. This section highlights how CRS&SI technologies can provide enhanced geodata for input to models, improved data processing methods for allocating O/D splits required by models, enhanced methods for depicting model results to visualize model results for build and no-build options, as well as imagery for visualizing multi-modal demand and performance and alteration in level of service.

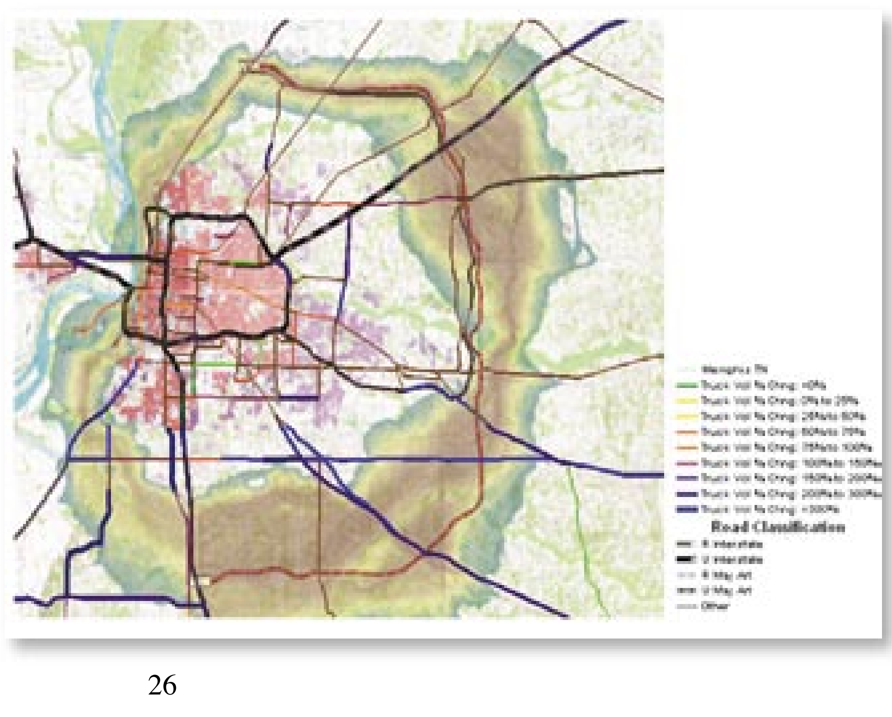
Current Practice: The traffic investigation is one of the most important parts of an Environmental Impact Statement of projects involving the construction of new roadway facilities and/or the improvement of existing ones. In general, it focuses on the determination of anticipated traffic flow characteristics of the proposed project by performing traffic analysis methodologies that can be grouped under the umbrella of *capacity analysis*. The main traffic parameter used in EISs to describe the quality of traffic flow is the Level of Service (LOS).

CRS&SI Objectives: With the assistance of CRS&SI technologies, the results of these analyses can be expanded to all the roadways in the affected area and not be restricted to just the road segments directly affected. Hence, CRS&SI technologies can help deliver a much better understanding of the impacts of the different alternatives not only in terms of the quality and relevance of the information but also in terms of coverage. Additional information (e.g., freight volumes) not generally included in the EIS can be explicitly conveyed to facilitate a better decision-making process.

Methods

- Conceptualize a comprehensive approach for the use of remote sensing and geospatial technologies for the characterization of transportation networks for environmental assessments;
- Develop an analytical transportation network, which includes regular traffic and freight flows for the selected transportation corridor (I-69 SIU 9);
- Provide enhanced understanding of the current and future conditions of the transportation system

Results: The "Purpose and Needs" graphic to the right shows the juxtaposition of the general "corridor definition area" as an output from MCDM, colored truck freight flow volumes, and road classifications with an overlay of the design of I-269 symbolized by mobility LOS. Modeling and GIS integration would benefit the FHWA by incorporating the I-69 system into the national freight modeling systems to determine how much new freight would be attracted by this system. Of local importance, this integration of modeling and GIS can deliver policy as well as operational insight that may be applied to the use of the system. These technologies can enable planning for operations and decisions about use so that freight flows traveling through the system may be routed away from segments of greatest congestion and rerouted along I-269 or via other segments with ideal traffic and level of service conditions.



There are, however, some associated costs. The main one is the institutional barrier. In many cases, the travel demand models used in the analyses are stand-alone models that have been reliably performing their task over many years. Therefore, there is an understandable reluctance to change these models/software utilities. However, as described above, there are many two-way interfaces with GIS platforms that have been developed for the most used travel demand models that can help in this regard by making these connections transparent to the transportation analyst. The other option, switching to the new models that have integrated GIS capabilities, has a material cost associated with the software itself, and in some cases, with the training of the technical personnel that runs these models. The latter could be important, especially if the transition is to a different model than is currently being used; but these software utilities also bring many new capabilities that can be used in many other projects besides EISs.

Key Benefits of 4.1 and 4.2

Utilizing CRS&SI technologies provides significant benefits to planners during this stage of the process. As shown in 4.1, these technologies provide additional enhancement regarding feasible alignments and identify early estimations of project impacts. In addition, 4.2 resulted in CRS&SI technologies linking the gap in the project analysis. These linkages can enhance project planning by aiding in the decision-making process by highlighting local, regional, and national purpose and needs through integrated visualizations. Utilizing geodata to provide guidance for alignment generation and optimization, screening impacts, and providing automated capabilities to provide early estimates of impacts would add optimization benefits that could potentially offer improvement over "field location" methods traditionally employed to "avoid as many existing environmentally sensitive areas, houses, businesses, churches, and other infrastructure as possible, to minimize the impact of this project."

KEY BENEFITS

- Bridge the gap of analysis and depiction of results.
- Incorporate additional information (e.g., freight volumes) not generally included in the EIS.
- Deliver enhanced understanding of the traffic conditions impacts of the different alternatives.
- Aid in the decision-making process.
- Costs of deployment are expected to be low since additional data required (i.e., freight information) are publicly available from FHWA.

The U.S. Department of Transportation's Federal Highway Administration has compiled a citizen involvement best practices document for state transportation agencies entitled, "Public Involvement Techniques for Transportation Decision-Making." The document has four chapters: "Informing People Through Organization and Outreach," "Involving People Face-to-Face Through Meetings," "Getting Feedback from Participants," and "Using Special Techniques to Enhance Participation." Though each of these chapters is subdivided into several subsections, the document is not designed to be a step-by-step guide. FHWA states that it does not expect any agency to use all of these public involvement techniques, but instead, to use a "careful variety" of the techniques discussed (FHWA Link, 2002). However, because it is a reference tool created by FHWA to specifically assist practitioners in coordinating a full public involvement program, it is an appropriate measuring tool for an involvement program.

5.1 Use of Enabling Tools for Sharing Maps and Spatial Information

Some state DOT's involvement plans are legally compliant and, in fact, encourage public involvement beyond what is legally required. Unfortunately, some plans are not geared for two-way communication and leave the reader of the plan—and no doubt the citizens involved in the process—to wonder exactly why the agency wants public involvement, and what the agency does with that involvement. This is a clear example of where the traditional and even the dual hearing formats were formulated at the top and then translated into instructions for state DOT employees to implement at the bottom. However, the implementation of this policy is not achieving the desired effect ISTEA, TEA-21 and SAFETEA-LU was meant to address—namely citizen *involvement* in transportation planning.

Current Practice: Hearing formats have been the traditional approach to public participation and planning. The USDOT identifies three types: traditional format, dual-hearings or combined format, and open format.

First, USDOT notes the "traditional format was developed at a time when hearings usually afforded the sole opportunity for citizen involvement" (USDOT, 1991). The traditional format or "town meeting" is the one used by most local governments (O'Leary, Arnold, Kyte, and Perfater, 1999). This format has two major drawbacks. The question and answer period is of little substantive value, and the hearing format does not offer the public the opportunity to discuss the project on a one-on-one basis with the project team members, nor inspect the graphic display during the hearing (USDOT, 1991). It is a top-down approach designed by USDOT and disseminated as part of a NEPA training policy for the states. Policy implementation strategy is formulated at the top (USDOT) and translated into instructions for those who will implement at the bottom (states and localities).

Second, the dual hearing is made up of both a formal and informal hearing. It has several advantages over the traditional format because it:

- Eliminates the pretense of two-way communication in the testimony room.
- Reduces the possibility of having a hearing disintegrate into a prolonged debate between members of the public and agency personnel.
- Allows the public to inspect graphic materials and technical documents and to discuss the project freely without disturbing or interrupting those giving testimony (USDOT, 1991).

Third, the open forum format is the most recent innovation in public hearing techniques, dating back to the 1980s, when citizens and administrators became increasingly unhappy with the traditional format.

Georgia was the first state to use this format and needed FHWA approval prior to changing from the traditional to the open format. Now, using the open format is a common and acceptable way to engage citizenry. USDOT explains the open format as the following:

> "Members of the public are free to interact informally with agency staff one-on-one and view the exhibits which may include a slide show or video presentation. As appropriate, agency specialists such as cultural resource or wetlands specialists are available at tables in the center of the room. There is no formal agency presentation at a set time and the public may submit written comments, speak to a court reporter or recorder at any time. Consequently, this format has been found to be much more convenient to persons who may not be available in the evening (e.g. shift workers or the elderly) or may not have the time to sit through an agency presentation and numerous public speakers until their turn comes. The format also makes commenting easier for people who are uncomfortable speaking before a group (USDOT, 1991, p. 64)."

CRS&SI Objectives: Multiple Criteria Decision Making utilizing new CRS&SI technologies was developed to address problems associated with the use of current GIS technologies for agency coordination and public participation. Sadagopan (2000) states the integration of interactive maps, audio, text, video and other forms of community or city related data with analytical tools could help the public access and understand information.

> "Such integration could also aid gathering opinions of the masses on related city or community issues. Most planning information has a spatial orientation. For example, social, economic and environmental data are related to their corresponding spatial location such as county or city. The spatial feature of planning information is essential for acquiring knowledge necessary for public participation in the planning process. GIS are also referred to as "intelligent mapping" systems, since it can integrate map (graphic) data with attribute (tabular) data using different matching methods. The ability to integrate information through spatial links aids in decision making for government and private organizations for a wide range of applications. GIS are very powerful tools that enable analysis of enormous amount of information and create new records, which is not feasible to do manually (Sadagopan, 2000, p. 7-8)."

Methods: MCDM's methods for collaborative involvement, scenario evaluation, and comparative analysis can deliver decision makers and stakeholders valuable insight into the relative strengths and weaknesses of different solutions and the degree to which solutions achieve intended purposes and conform to prioritized goals. As spatial technologies have evolved and expanded, two areas that are receiving greater attention are the availability of social, economic, and environmental (SEE) data much earlier in the planning process, and the development of visualization techniques that enhance both the public's and the agencies' review of project alignments and designs. This early introduction of pertinent SEE data into the planning process has allowed the linking of planning and NEPA to be an effective initiative for the development and prioritization of transportation infrastructure. Visualization is a natural and effective tool in not only the development of better transportation solutions, but in their acceptance by the public and reviewing agencies.

Results: Our research highlights new forms of map documents that not only show proposed highway projects, potential alignments, and aspects of projects, but also provide the ability to turn on and off specific map layers for easily viewing aspects of interest. These new forms also give users the ability to add comments and mark up the map. These capabilities are available in GeoPDF files, and the participatory process can benefit greatly by the use of new and enabling technologies. GeoPDF technology provides the capability to interact with GeoData used in the project mapping process. This open, accessible, and enabling technology presents a potentially enormous step forward for public participation in transportation project development processes. By utilizing the GeoPDF technologies, transportation planners can efficiently and effectively communicate project impacts through visualization which can connect the community and transportation project plans resulting in two-way communication and information flow.

To address the concerns expressed by FHWA, state DOT employees, and citizens that transportation plans are too abstract and long term or to incomprehensible for the public, the attached flow chart has been created to simplify the process (See Appendix B). It is our hope that by having the charts like these readily available at public meetings or hearings, citizens will better understand the process by which state DOTs builds roadways and when and where their input can be most useful to the agency. Another useful tool is an outline discussing the major elements of the road building process, some of which occur concurrently.

Marketing is a buzzword government agencies often use when working to improve communication effectiveness as it relates to public involvement. The marketing paradigm may have advantages in sharing and targeting information, yet it is important to remember that it cannot replace real public participation. Marketing and citizen involvement are two distinct types of communication with different yet complementary goals. Marketing can be characterized as one-way communication or education while citizen involvement can be characterized as two-way communication. This is not to say that agencies cannot benefit from marketing-based programs and initiatives as they may serve to reinforce the issue as it relates to trust and competence on behalf of public perception. Marketing-structured communication, coupled with visualization can serve to raise awareness—key to education—and can facilitate enhanced input through MCDM.

> ***In complex and dynamic social environments, no single actor, public or private, has all the information needed for a successful planning effort.***

At the most basic level, public participation is based on the notion that hearing and discussing all sides of an issue results in better decision making. The fact that decision makers must be willing to share decision-making powers with the public undergirds this notion of improved decisions that serve the needs of both the agency and the public. It is paramount to the success of any public involvement effort to remember the goals of the agency in determining what mix of participation techniques best fits the particular situation and circumstances. The specific public participation goals for an agency, and its specific planning and project initiatives, must serve as the guide for technique selection in order to facilitate shared decision making with the public. We submit that the process of learning about and then acknowledging the community values and priorities at work in any transportation area under discussion is key to an agency's ability to identify and implement appropriate techniques for the specific situation. On this level, MCDM is of some value but should not be considered a replacement for citizen-to-citizen or citizen-to-transportation-official interaction.

Failure to include diverse perspectives in the comprehensive planning process can present itself as an obstacle to effective decision making and implementation of comprehensive plans. In complex and dynamic social environments, no single actor, public or private, has all the information needed for a successful planning effort. The basic premise behind facilitation of deliberative engagements in the comprehensive planning process is inclusion of diverse local perspectives and information that can add substance to the planning efforts, but which otherwise may be unavailable to government bureaucracies.

Furthermore, building community networks as a long-term commitment eases future implementation of comprehensive plans and strengthens the communities' resilience to respond to potential catastrophic events. Therefore, facilitating deliberative processes can contribute to the planning process and to strengthening community resilience by:

- Including diverse local perspectives and information in the planning processes
- Engaging citizens in identification of strengths, weaknesses, opportunities, and threats
- Strengthening the quality of decisions in the planning efforts
- Enhancing community awareness of the planning process
- Building community networks and public-private partnerships involved in the planning processes
- Developing community and institutional structures for implementation of plans
- Opening channels of communication between government institutions and communities that can improve the community resilience and can be critical for effective planning
- Enhancing flexibility of the planning processes to adapt to unanticipated situations

5.2 Multiple Criteria Decision Making for Top-Down and Bottom-Up Process

Traditional top-down approaches to mapping and roadway planning can be displayed and supported using regional geodata frameworks. However, local data that include planning, zoning, development, high resolution image data and others are needed to fully consider local values as well as features that would otherwise create opposition in the public participation process. Utilizing MCDM enables a stakeholder equilibrium implementation that incorporates and embraces both top-down purpose as well as bottom-up priorities.

Current Practice: Over the past decades, national transportation policy has guided the principles and practices of the decision making process. Since the shift of the "Interstate Era," national policy has promoted highway systems to "support the economic vitality of the metropolitan area, especially by enabling global competiveness, productivity, and efficiency" ***(USDOT, 2008).***

CRS&SI Objective: Utilizing CRS&SI technologies, the research team attempted to merge the national policy agenda with the local perspective to develop an integrating planning process that benefited both the global objective of transportation policy as well as maintaining the local continuity within a region.

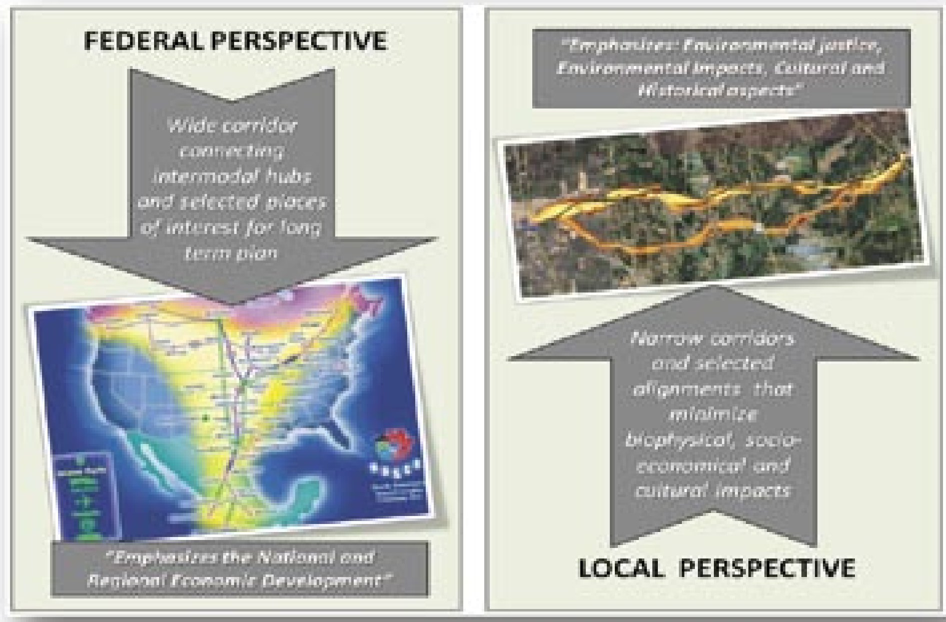


Figure 5.1. Top-down and bottom-up transportation planning approaches.

Methods: Multi-Criteria Decision Making enabling collaborative input of diverse stakeholders enabled within a GIS framework comprises the primary methods for implementing top-down and bottom-up decision making.

<u>The MCDM-based project</u>: GIS is capable of handling massive amounts of data. When coupled with physical or economic models, GIS may be employed to manipulate spatial and attribute data as needed to express values for evaluation criteria. Similarly, advances in informatics provide a wide range of core solutions for multi-criteria decision, where the Analytical Hierarchy Process (AHP) is becoming one of the most important methods to couple decision-making processes and geospatial analysis.

AHP is a method for MCDM that employs decision analysis mathematics to determine the priorities among alternatives using pair-wise comparisons of different decision elements. Aiming to connect the theoretical AHP-GIS models within real demands from transportation planners, the NCRST-SEPP team implemented novel modifications of AHP and a spatial implementation that delivers interactive and collaborative MCDM to transportation practitioners through the following:

- Direct ranking from decision makers and stakeholders to prevent stakeholder from having to think in terms of pair-wise comparisons;

- A scale-adaptive MCDM approach, which brings the opportunity to combine factors and criteria at different levels within the decision-making process.

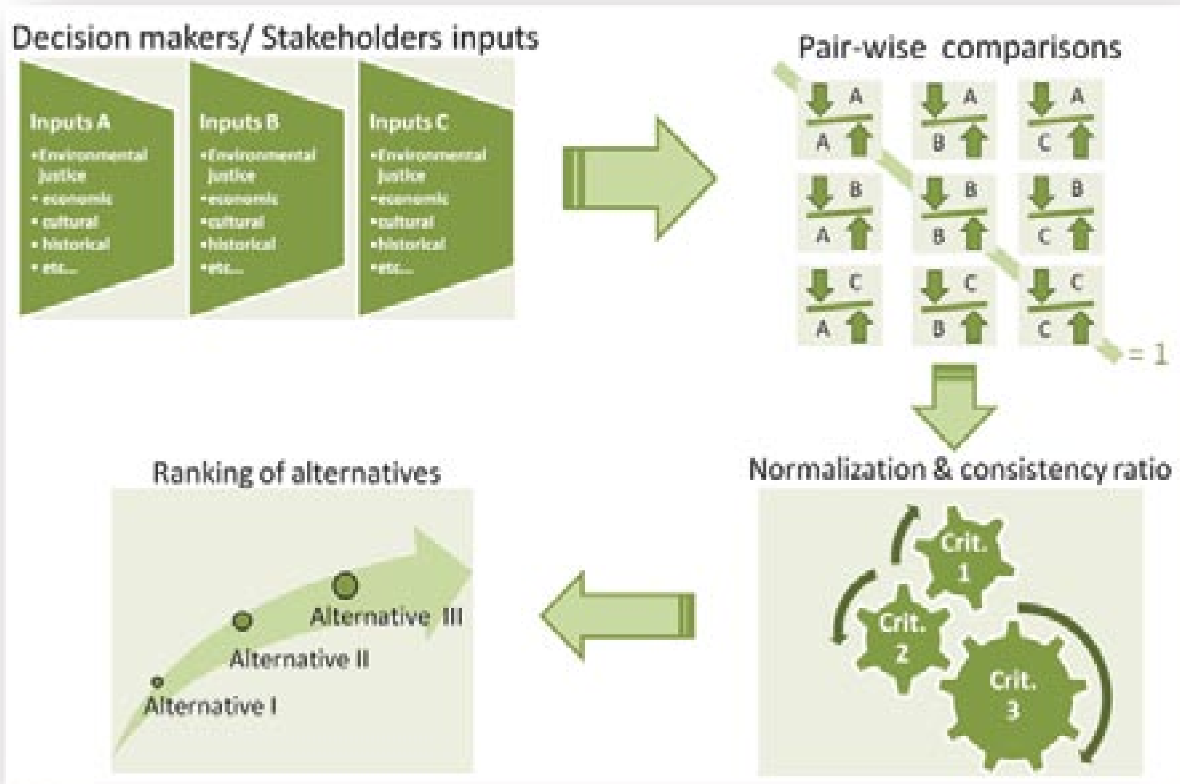


Figure 5.2. The modified form of AHP as a spatially enabled MCDM for transportation planning.

The Top-Down Viewpoint: I-69 is a national highway project that will connect Canada and Mexico. The highway includes eight states from the Gulf of Mexico and Texas's Golden Triangle, through the Mississippi Delta, the Midwest, to the industrial north and finally to Canada. The states included in the entire project are Arkansas, Indiana, Kentucky, Louisiana, Michigan, Mississippi, Tennessee, and Texas. The proposed I-69 highway, which was ..."designed by Congress in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) to connect major cites and enhance economic development" (FEIS, p.1), is a significant transportation project that potentially will alter the trade flow within North America. After the enactment of the North American Free Trade Agreement of 1992 (NAFTA), the trade community projected a significant increase in trade flow from Mexico to the U.S. and from Canada to the U.S. With these projections, the Transportation Equity Act for the 21st Century (TEA 21), which was signed into law June 9, 1999, officially authorized and prioritized I-69 as a national highway project.

The Bottom-Up Viewpoint: As transportation policy reaches the local level, stakeholders identify their position regarding the implementation of a transportation investment. For example, economic developers and businesspersons highlight the potential economic impacts associated with the improvement or construction of a highway project. Conversely, environmental and cultural resources agencies identify the need to investigate and identify the impacts that may result from developing a highway. As this process develops, the conflicts and contention emerge because ultimately some stakeholders may have something to gain or lose when the highway is constructed.

Because these local actors, whether at local, regional, or state levels, may have an intimate knowledge of the alignment or political landscapes, their influence into the process may hinder certain initiatives and policies.

FACTOR	Ranking
MPO urban limits	9 *criteria: dist from 0 – 7 Km*
Wetlands	5 *avoidance*
Forest	5 *avoidance*
Agriculture	3 *High cost*
Hydrography	2 *criteria: dist from 0 – 300 m*
Roads	1 *Reuse existing roads*
Slope	1 *0- 20% , >20%*

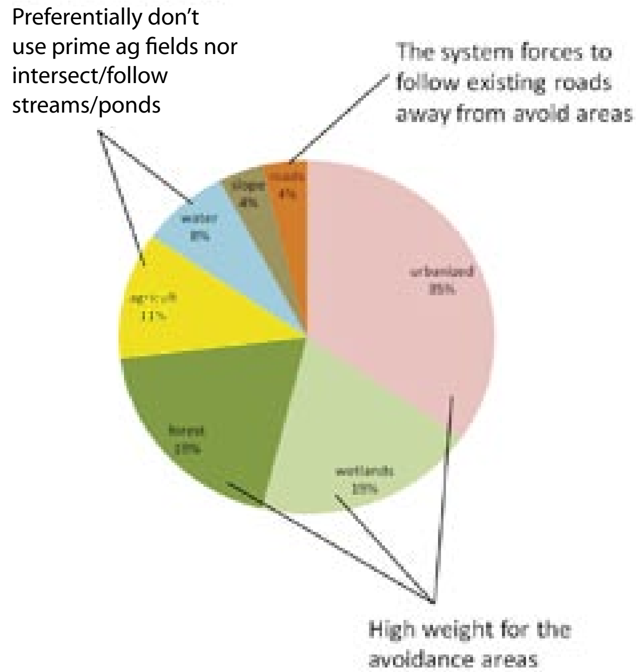


Figure 5.3. Sample of factors and ranking used as input in the decision-making process in a wide-corridor scale.

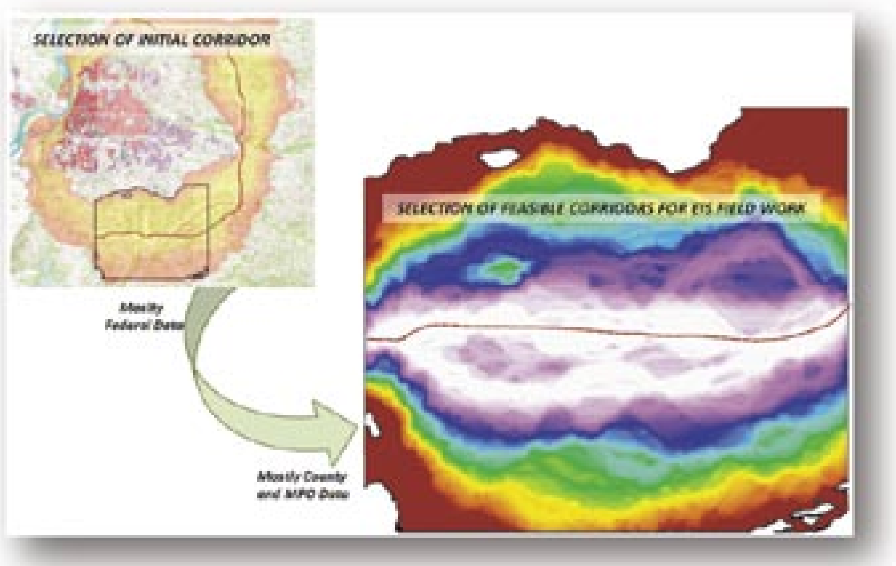


Figure 5.4. Moving from a top-down federal perspective of the I-69 / I-269 corridor project boundary to a local analysis that shows paths that reflect local values and priorities for alignment pathways that create the least amount of environmental adverse impact.

Although the national perspective of this corridor emphasizes the enhancement of potential economic development opportunities and potential traffic efficiencies, as the implementation of the project develops, transportation planners are faced with difficult decisions. Because transportation projects can potentially have dramatic effects on the local community, planners are tasked with identifying a community's values. These highlighted community values may affect the alignment patterns of a corridor. For example, in the I-269 case, transportation planners analyzed the potential impacts of the implementation of the I-269 corridor by conducting public involvement meetings, which are standard for public works projects.

In the I-269 EIS process, transportation officials conducted eight “early” public involvement meetings and four “public meetings” that were held around the study area. The meetings highlighted the purpose and needs of I-269. In addition, transportation planners probed for feedback regarding local concerns and issues that transpired from the implementation of I-269. As identified by the EIS,

> “Concerns expressed by the public included increased air and noise pollution, impacts to neighborhoods and schools, wetlands, and archeological sites and historical resources, safety, loss of property, amplified urban sprawl, lower property values, the transportation of hazardous materials, and the creation of a drug traffic corridor.” (p.241).

Over all, 1180 individuals attended the four public hearing. The analysis indicates that local citizens were overwhelmingly concerned about the potential economic benefits associated with I-269. According to the EIS, at the public hearing in Southaven, MS, “there were several comments made about the overall positive economic impact of the project.”

In addition to public hearing, 456 responses were received by the transportation planners that addressed concerns. The major concerns were impacts to neighborhoods and schools, loss of property values, air pollution, noise pollution, economic benefits, safety, transporting of hazardous materials, increased crime, creating a drug corridor, urban sprawl, an increase in flooding, loss of wetlands, and loss of farmland. (p. 247).

The authors of this paper are not suggesting that local citizens are concerned with the potential economic impacts associated to I-269. However, the data suggest that local citizens are concerned with more value-based issues, at least compared to national transportation agenda setters. The disparity in values and concerns related to the implementation of a transportation corridor can develop into a contention impasse that requires significant resources for resolution. Since the project was directed to be an “ex post” project, the team was not able to bring technologies to an active project process as was originally proposed. The remainder of this paper highlights one decision making tool that can assist transportation planners prioritize the values between national and local actors and is addressed as a feature that should be part of future studies highlighting best studies.

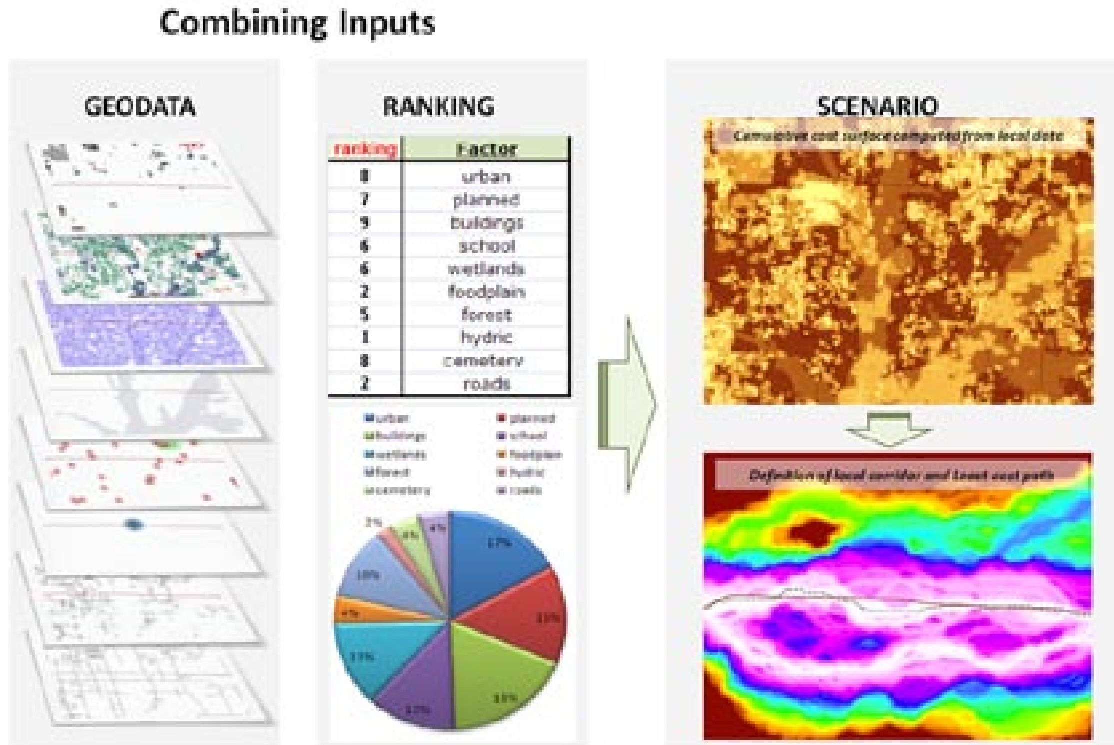


Figure 5.5. Local implications scenario and hypothetical rankings.

Results: The findings suggest the use and integration of existing data from remote sensing technologies, GIS, and economic modeling can result in a visual Multiple Criteria Decision Making (MCDM) model that can aid in streamlining and enhancing the NEPA process, agency coordination and public participation. The interoperability of the REMI and GIS applications as well as background remote sensing data enable researchers and practitioners the ability to produce high quality visualizations that can enhance the communication between and among transportation professionals, resource agency personnel and local stakeholders.

Example Technologies: NEPAssist Web Tech for Environmental Screening

NEPAssist provides a powerful web-based tool for enhanced environmental screening that provides detailed feedback about environmental concerns. Trends in technology to expose spatial information to web-based mapping and query tools are being extended to support tasks such as environmental screening. With the NEPAssist tool, users can define areas of interest by utilizing a polygon tool to outline an area of interest and query databases for information regarding transportation project development. NEPAssist raises important environmental issues at the early stages of project development, enhances collaboration with other agencies for review of NEPA documents, provides easy access to region-specific geodata, customizes regional assessments, and streamlines the review process.

Probabilistic modeling and resource identification were incorporated into GIS and provide a basis for MCDM integration. When evaluating a number of transportation alternatives over a very large area, extensive surveys would be both costly and time consuming. An archaeological predictive model can help focus attention on alternatives that minimize the risk of encountering significant cultural resources. Such models also allow designers to make relatively minor modifications in alignments to avoid high risk areas. When the number of transportation choices has been reduced, models can be used to target survey areas efficiently. By eliminating surface surveys from areas where archaeological sites are not likely to be found, more resources are available to evaluate any sites found in the targeted, higher-risk areas surveyed. Finally, accurate mapping of cultural features enables better assessment of impact and development of measures to mitigate and minimize those impacts.

Key Benefits of 5.1 and 5.2

By developing new and innovative methods for collecting and displaying impact data regarding the affects of transportation projects, researchers and practitioners will have better information and tools that can enhance decision making, which will improve the efficiency and effectiveness of the efforts regarding the NEPA development processes.

KEY BENEFITS

- A lack of DOT, MPO and local collaborative approach demonstrably results in failure to exchange vital data that could otherwise be useful in streamlining.
- CRS&SI technologies and commercial GIS are capable of handling massive amounts of data. When coupled with physical or economic models, GIS may be employed to transform and manipulate spatial and attribute data as needed to express values for evaluation criteria (e.g. the cost of different alternatives, the population exposure to different levels of health risk, and the distribution of road network concentrations in different areas of a city). Conceptually, MCDM can be implemented based on different approaches.
- MCDM and visualization techniques can make this collaboration easier for the practitioner while enhancing communication among hearing participants.
- Integrating local, regional, and national issues and concerns into one decision-making tool offers potential for transformative streamlining conflict avoidance benefits.
- Prioritizing various impacts to determine the preferred alternative.
- Can provide a powerful web-based tool for enhanced environmental screening that provides detailed feedback about environmental concerns. Trends in technology to expose spatial information to web-based mapping and query tools are being extended to support tasks such as environmental screening.

6.0 SOCIAL CONDITIONS

The utilization of social, economic, and environmental (SEE) data early in project life-cycle can prove to be an effective method of planning in the NEPA process. By utilizing tools that integrate environmental and land-use conditions with various other social data, transportation planners can engage in a significantly and sufficiently enhanced process that provides a more comprehensive understanding of social conditions. As CRS&SI tools have evolved, the inclusion of SEE data allows the linking of planning and NEPA to prioritize elements within the decision-making process. The Arkansas State Highway and Transportation Department has made progress using this strategy to deliver improved transportation solutions **(ASHTD Link)**. For each of the potential alignments considered, there were social, economic and environmental impacts; however, both impacts and benefits were efficiently and effectively analyzed and described utilizing segmented parts of each alternative to provide a geographic basis for presenting and describing the impacts and benefits. This segmented methodological approach effectively allows practitioners to connect the systems-level and project-level initiatives as well as support stakeholders' interest and involvement.

6.1 Economic Impact and Land Use Conditions

Current Practice: According to transportation legislation, transportation projects should "support the economic vitality of the metropolitan area, especially by enabling global competitiveness, productivity, and efficiency" (USDOT, 2008, p.3). As the nation continues to engage the global marketplace, transportation officials must also account for how the transportation system will influence the economic development and growth of a region. Understanding the direct, indirect, and induced economic impacts of a transportation system is an important component of completing the NEPA process. Traditionally, a Benefits-Cost Analysis (BCA) only measures the direct impacts regarding economic impacts. The BCA does not track the second and third order effects of highway improvement projects.

CRS&SI Objectives: Employing the Regional Economic Modeling, Inc. (REMI) application provides analysts with a technological tool that enhances the economic impact analysis process and streamlines the data collection efforts. The REMI model is capable of integrating travel demand data with economic and demographic data to simulate project impacts. Moreover, with the utilization of REMI, economic impact output can be extrapolated to "known" growth patterns and mapped in visualization tools such as GIS.

Methods: To examine the economic impacts associated with the I-269 project, the research team collected data from interviews, documents, and physical artifacts. First, face to face and telephone interviews were conducted with 21 individuals whom were executives or staffers from the Federal Highway Administration (FHWA), Mississippi Department of Transportation (MDOT), Regional Economic Modeling, INC., (REMI), economic consulting firm, local governmental official, or the Memphis Metropolitan Planning Organization (MPO). Second, through document analysis, the research team analyzed all documents collected, including planning reports, the I-269 EIS, state and local comprehensive plans, the Mississippi and Tennessee long-range transportation plan, supportive documents from MDOT, FHWA, and the Memphis Metropolitan Planning Organization's planning documents.

Using a four-step methodological approach, the research team compared a control EIA with an innovative EIA process that utilized REMI. The first step was to analyze the control economic impact analysis (EIA) process. By utilizing an EIA Framework, the researcher team developed a list of "process codes" as guidance during the analysis. In step two, the team analyzed previous EIA processes that utilized REMI.

The intent of the effort was to establish "best practices" for conducting the test EIA. In step three, appropriate input data were collected for the economic model. This included travel demand and cost estimations. In step four, the research team compared the control EIA with the test EIA, which enabled the team to determine the outcomes of the process change.

Results: This effort found that the utilization of IT did streamline the EIA, which is a component of an EIS and required through NEPA. With the utilization of REMI, the scope of the EIA broadened, the data collection efforts decreased, and capacity to analyze economic impacts was enhanced. In addition, by comparing the control EIA with the test EIA, which utilized REMI, the direction of the economic impacts changed. In other words, the control EIA projected positive economic impacts associated with the construction of I-269, but the test EIA projected negative economic impacts.

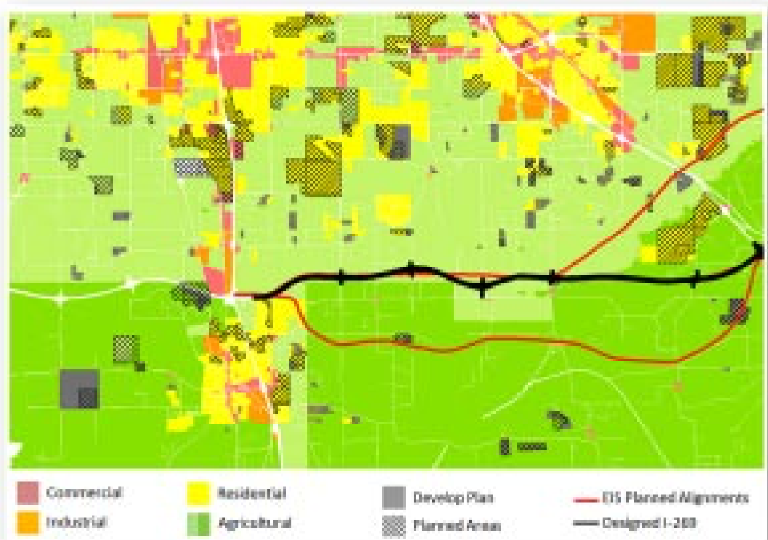


Figure 6.1. Alignments and final design overlaying current land use conditions.

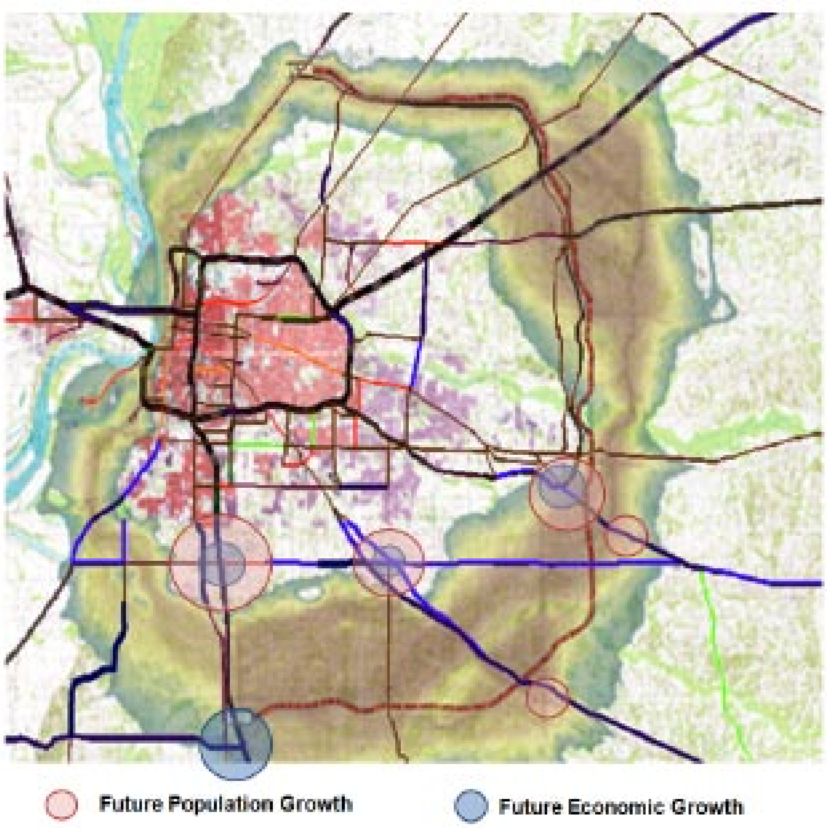


Figure 6.2. Areas of future expected growth in population and economy.

Although the REMI model altered the EIA, this study highlights limitations that are associated with utilizing IT in the NEPA process. First, the lack of "grout knowledge" may negatively affect the decision-making process. Second, the cost of the software may limit DOTs from utilizing the tool. Third, the REMI model is not capable of analyzing sub-county level data, which is a limitation for transportation planners. Fourth, the model is essentially a black box and works only within the parameters that are built within the model and there are additional economic models utilized in transportation policy. For example, the MEPLAN, TRANUS, METROSIM, and TELUS models have been used to measure three-way relationships between transportation, land use, and economy. Finally, REMI is not remote sensing software, but does provide for modeling regions of impact. These regions are geographically defined and provide a basis for economic, policy, and transportation impacts modeling and analysis. The use of REMI is this project was to spatially extend the results in which REMI delivers to provide a spatial content that provides estimated economic impacts.

6.2 Environmental Justice

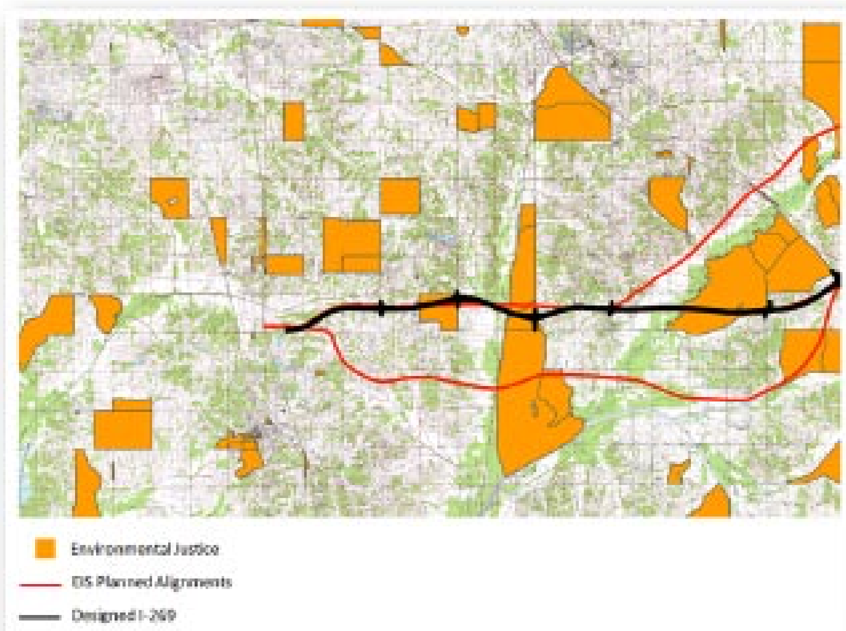
Under Title VI and related statutes, federal agencies are required to ensure that no person is excluded from participation in, denied the benefit of, or subjected to discrimination under any program or activity receiving federal financial assistance on the basis of race, color, national origin, age, sex, disability or religion. In 1994, President William Clinton signed Executive Order 12898: Federal; Actions to Address Environmental Justice in Minority populations and Low-Income Populations. The Executive Order requires that each Federal agency shall, to the greatest extent allowed by law, administer and implement its programs, policies, and activities that affect human health or the environment so as to identify and avoid “disproportionately high and adverse” effects on minority and low-income populations.

Current Practice: There are three keys to approaching Environmental Justice concerns: 1) To avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations; 2) To ensure the full and fair participation by all potentially affected communities in the transportation decision-making process; and, 3) To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority and low-income populations. This is traditionally accomplished by reviewing U.S. Census tracks for these populations along the project corridor. If minority or low-income populations are found, efforts are made to achieve the three objectives listed and data is presented in tabular form.

CRS&SI Objectives: U.S. Census track information is geo-coded and can be used as a geodata layers on a project corridor map though use of GIS.

Methods: The project base map is highlighted with potential alternatives. As shown in the graphic to the right, census track information for areas with minority or low-income populations may be selected for visualization and analysis.

Results: The project was able to locate and consider minority and low-income population locations. These areas could then be included into MCDM with a ranking for avoidance.



6.3 Historical and Archeological Impacts

A review of cultural resources is required by the National Historic Preservation Act of 1966 (particularly section 106) and 36CFR800: Procedures for the Protection of Historic and Cultural Properties. Section 106 requires the identification of all national register eligible resources within a project corridor, the determination of the project’s effects upon identified resources, and the avoidance, minimization or mitigation of these adverse effects.

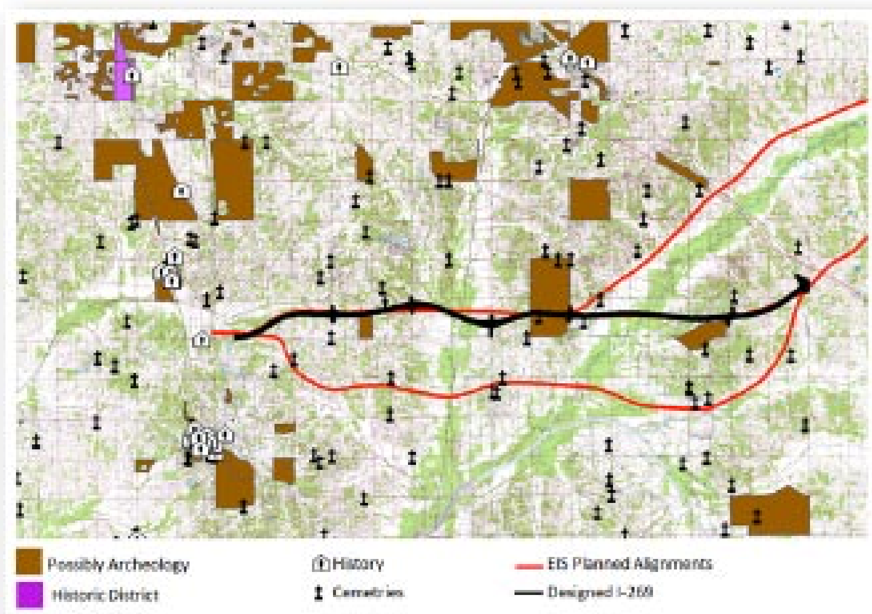
Introduction: Perhaps more than any other area, early coordination is key when dealing with cultural resources. A resource could be associated with a significant event or person, have significant architecture, or contain important information. Further, a suitable boundary around a resource needs to be determined. For this determination, the involvement of multiple parties is necessary. This could include a field inspector, property owner, court house documents, local regional development centers, historical societies, local governments, and other knowledgeable professionals. These surveys and coordination meetings can lead to lengthy delays and costly field studies if not done properly in early coordination.

Current Practice: The useful application of spatial information technologies for historical and archaeological cultural features is practiced at varying levels by different DOTs. Few high resolution GIS-based archaeological predictive models have been created for very large areas.

Mn/Model, the statewide archaeological predictive model developed by the Minnesota (USA) Department of Transportation, is perhaps the first of its kind. Twenty regional models were developed using multiple stepwise logistic regression to create a composite statewide model. Models of archaeological survey bias were developed to help compensate for the lack of probabilistic data. Overall, the predictive model has met project goals and performs well for its intended purpose. By incorporating models into the earliest stages of transportation planning, the Department has been able to avoid potential impacts on archaeological resources and make cultural resource reviews more efficient.

CRS&SI Objectives: Using CRS&SI, the research team identified multiple models that utilize CRS&SI and attempted to incorporate the models into the I-269 project.

Methods: The research team conducted interviews with DOT personnel and conducted a meta-analysis, which provided knowledge regarding various models that provided assistance in streamlining the NEPA process.



Results: Probabilistic modeling and resource identification were incorporated into GIS and provide a basis for MCDM integration. When evaluating a number of transportation alternatives over a very large area, extensive surveys would be both costly and time-consuming.

An archaeological predictive model (such as the MN Model) can help focus attention on alternatives that minimize the risk of encountering significant cultural resources. Such models also allow designers to make relatively minor modifications in alignments to avoid high risk areas. When the number of transportation choices has been reduced, models can be used to target survey areas efficiently. By eliminating surface surveys from areas where archaeological sites are not likely to be found, more resources are available to evaluate any sites found in the targeted, higher risk areas surveyed. Finally, accurate mapping of cultural features enables better assessment of impact and development of measures to mitigate and minimize those impacts.

However, expansive development of geospatial databases for cultural resources will require cooperation with State Historic Preservation Offices, local Historic Preservation Commissions, National Forests and National Parks, and other agencies that may maintain files of archaeological sites or historic properties. More exploration into the capabilities of this predictive modeling integration, appropriate buffer distances per site, and protection scenarios of identified resources is necessary.

Key Benefits for 6.1, 6.2 and 6.3

For each of the potential alignments considered, there were social, economic, and environmental impacts; however, both impacts and benefits were analyzed and described utilizing segmented parts of each impact that could be streamlined by CRS&SI. In addition, this segmentation method enabled the research team to organize comments and feedback from stakeholders as well as resource agencies. This methodology is noted as an excellent practice that lends itself well to perhaps "pinpoint" analysis of potential causes of concern for social conditions in cases where impacts can be localized.

KEY BENEFITS

- REMI did streamline the EIA process.
- REMI provided a broader scope in the analysis and provided more variables and outputs for analysts to observe.
- REMI reduced time associated with the data collection process.
- REMI enabled the analysts to represent the data in graphics and tables as well as cross-sectional, longitudinal, and time-series analyses.
- REMI provides baseline data outputs that can be produced in visualization format.
- Providing this data in a visual format and integrating this data in MCDM allows project stakeholders to adjust the build and no-build scenarios to account for changes in growth patterns. This, in turn, allows local and regional planners, working through the MPO, to adjust long-term development plans accordingly.
- By showing the information visually instead of tabular, the project planners are able to easily evaluate each possible alternative. If no alternative is available, the engineer is able to clearly see where and how realignment should be created.
- Mn/Model, the statewide archaeological predictive model developed by the Minnesota (USA) Department of Transportation, is perhaps the first of its kind. Twenty regional models were developed using multiple stepwise logistic regression to create a composite statewide model.
- By incorporating probabilistic models into the earliest stages of transportation planning, DOTS can avoid potential impacts on archaeological resources and make cultural resource reviews more efficient.
- Results from REMI may be exported to be utilized for simple visualization or may be integrated with other GIS data for more in-depth analysis of impacts. So, while not remote sensing software or data, REMI provides "spatial information technologies" relevant to transportation project planning and environmental impact studies.

A recently completed EIS performed for I-69 SIU #9 provides an ideal testbed for comparing the results delivered by the application of new and innovative uses of commercial remote sensing and spatial information technologies (CRS&SI) against the results delivered via traditional approaches. To develop apt comparisons of results, rigorous methods were developed to convert EIS materials from basic map plates of impacts to geodata sets useful for comparative analysis. The subject EIS contained a series of map plates with base map photography on top of which were mapped streams, ponds, and wetland features as well as alignment features. In order to perform detailed analysis of these features, the images were converted to tiff images, georeferenced, and all of the environmental features on the maps were digitized from the surfaces and saved as geodata layers. After conversion to geodata layers, the environmental features were utilized in geospatial analyses that included buffering and intersection to quantify the amount of feature(s) within the 300-foot and the 1000-foot buffer zones considered in the EIS for impacts analysis relative to each alignment considered. This method of data and feature manipulation and extraction was needed to provide appropriate data to conduct the detailed comparisons needed to achieve the objectives of the research project. This demonstrated not only enhanced capabilities to map, analyze, and quantify impacts, but also the capability to efficiently adjust alignment and repeat analyses using the geodata layers and automated buffering and intersection processing to update impact analysis results.

Traditional Methods Versus CRS&SI Technologies: The EIS process followed in the I-69 SIU 9 project employed standard black and white photography as a base image layer for mapping environmental features and for compilation of results of field mapping activity. These maps were compiled in what can be regarded as a GIS/CAD environment. Later in the project life-cycle, with the circulation of a Draft EIS, conflicts in planned developments arose that resulted in reassessment of alternatives B1, B-2, and B-3 in terms of planned developments, number of existing residential units impacted, and number of planned units impacted. These analyses and the results played a significant role in rejecting the B-3 alternative and selecting B-1 as the preferred alternative. The traditional approach responded to these changes and adjustments in an iterative manner and provided an ideal opportunity to present aspects of the mapping performed in the EIS and methods developed by the team to make useful GIS applications from the data provided. It can be noted that the EIS made little or no use of geospatial analyses, such as buffering or intersection to add meaningful and beneficial analysis streamlining to the process, and only adopted the use of new photography and planning data when conflicts arose. The apt use of CRS&SI technologies will be shown to offer enhancements to the overall process as well as an opportunity to get ahead of EIS conflicts by conducting meaningful analysis during pre-NEPA consultation phases of project development.

The apt use of CRS&SI technologies will be shown to offer enhancements to the overall process as well as an opportunity to get ahead of EIS conflicts by conducting meaningful analysis during pre-NEPA consultation phases of project development.

Figure 7.1. Benchmarking results of CRS&SI approaches required compilation of EIS constraints maps into georeferenced map plates of the study area. From each of these georeferenced map plates, GIS data layers were extracted for streams, waterbodies, wetlands, and other features mapped. These features identified on constraint maps produced via traditional methods were key in the comparison of features extracted and quantified using CRS&SI technologies.

Benchmarking CRS&SI Results Against Results Delivered by Traditional Methods: To facilitate comparison between the results of the EIS study and new and innovative methods, it was necessary to compile "benchmark" geodata layers to faithfully represent the features found and quantified in the EIS. A series of map plates were converted to tiff, georeferenced, and used to digitize environmental features. The features from the EIS were treated as "reference" layers against which the new and innovative methods were evaluated as part of the research process. Through use of overlay, buffering, and intersection technologies, these benchmark geodata layers were readily compared to the results of the NCRST-SEPP research project, which are presented in later sections of this chapter. Furthermore, this chapter will serve to illustrate the use of geodata and processing methods to deliver approximations consistent with traditional methods, and to ascertain whether these data and methods are capable of delivering systematic, conservative, and consistent results in identifying possible environmental features that would be potentially adversely impacted by a transportation project.

7.1 USE OF STANDARD GEODATA AND FEATURES EXTRACTION FOR EIS MAP ANALYSIS

The EIS process is intended to disclose through identification and assessment processes the environmental impacts associated with the development of a transportation project. In the EIS process, biophysical, socio-economic, and cultural characteristics are considered to predict negative and positive impacts.

Current Practice: The intent of NEPA is that all feasible alternatives are considered, resulting in the elimination of some and the selection of a subset of feasible alternatives for which impacts are normally analyzed and quantitative aspects of the alternatives are compared in the process of selecting a preferred alternative. The objective of this aspect of the research project is straightforward and entails comparative methods and geodata analysis for streamlining transportation corridor environmental analysis.

CRS&SI Objectives: Whether for pre-NEPA consultation, planning, or for analysis as part of environmental studies, spatial data and analysis methods offer significant benefits for delivering quantitative capabilities for the estimation of environmental impacts in the transportation development process. Available to the analyst are standard data sets, screening methods, and specific areas where remote sensing data and spatial information technologies provide enabling capabilities to the transportation practitioner. Commercial remote sensing and spatial information (CRS&SI) technologies provide environmental analysis capabilities that are available to transportation practitioners for application to the development of highway projects. From standard geodata to advanced data products and processing methods, geospatial data and environmental analysis applications of commercial remote sensing and spatial information technologies offer valuable tools for enhancing and streamlining environmental and planning processes in transportation project development.

Hypothesis: Commercial remote sensing and spatial information (CRS&SI) technologies offer enhancements through reduction in time and cost for early analysis as well as potential for improved quality for environmental screening and constraints analysis. It should be clearly stated that the use of CRS&SI technologies is suggested herein as a methods for early screening and estimation of impacts. It is not intended to assert in any fashion that necessary field and ground work are eliminated from the rigorous EIS project process. However, it does make a strong case for enhanced early screening of project alternatives for rapid elimination of non-viable alternatives, early identification of key environmental features of concern to resource agencies, informed decision making, conservative estimation of impacts and enhanced capabilities to plan field work and areas to be surveyed for quantifying final impacts, conducting permitting activities, and working through the mitigation planning process.

Methods: The NCRST-SEPP effort demonstrated enhanced methods for environmental feature identification, extraction, screening, and quantification that offer benefits for EIS streamlining by extraction of reference data from the EIS, employing standard GIS and CRS data layers for alternative inputs, and conducting standardized methods of buffering and intersection analysis to deliver quantified results. These methods were developed based on observations from experts in the community of practitioners who believe that in EIS studies, such as in the case study EIS for I-69 SIU #9, the state of the practice can be said to be typified by the following summary statements:

- Best existing available or acquirable geospatial datasets are not often employed to define preliminary alternative corridors or to conduct preliminary constraints or screening analyses.
- Complementary data derived from new RS/GIS data acquisition and feature extraction techniques are rarely employed to update EIS information.
- The evaluation of impacted features is typically based on extensive ground survey work that is often guided and directed by manual image interpretation.

Results: Developing Reference and Comparison Data Sets for Benchmarking Results of CRS&SI

For the benchmarking and comparative analysis activities identified in the introduction, the FEIS was used to provide a baseline for extracting quantities from tabular results and converting maps to geodata to extract spatial feature of mapped impacts. These data from tables and map components of the FEIS were treated as "truth" layers and provided a source of reference data used to benchmark—through comparative analysis—the quality of results, limitations of usefulness, and the quantitative aspects of employing new and innovative geospatial methods.

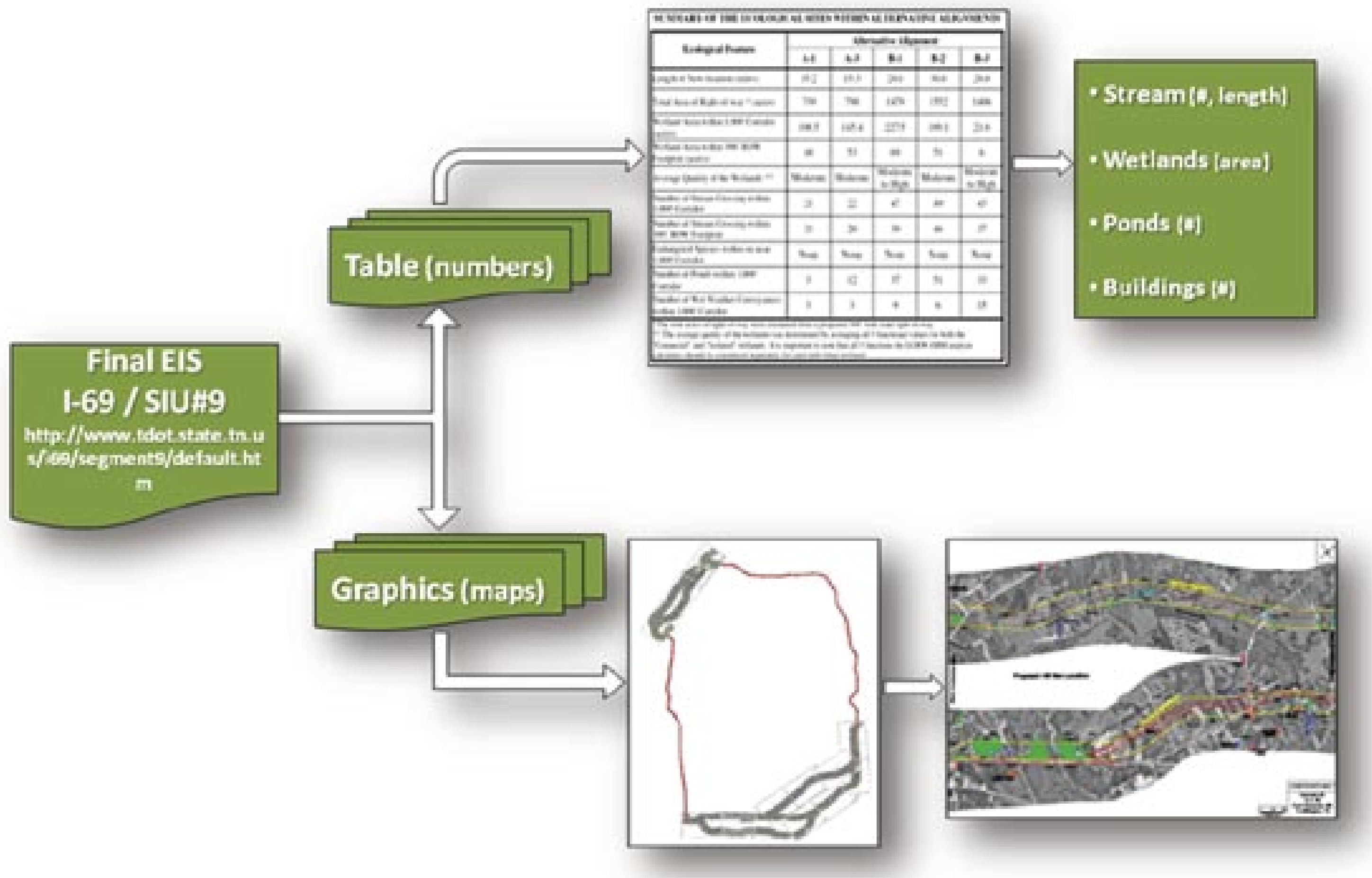


Figure 7.2. Sequence of activities for extracting reference baseline data from EIS documents for use in benchmark analysis to quantify the performance of new and innovative CRS&SI technologies and approaches.

In completing the extraction of reference baseline data from the EIS, a standardized set of methods were employed for the georeferencing of maps, extraction of features, and quantification of features within EIS specified distances from alignment alternatives being considered. As shown in figure 7.3, the following steps summarize the processing methods that were employed:

Georeferencing FEIS Constraints Maps
Extracting Mapped Features: 1000 Foot Corridor
Extracting Mapped Features: 300 Foot Corridor
Loading Existing Geospatial Datasets
Intersecting Features and Corridor Boundaries

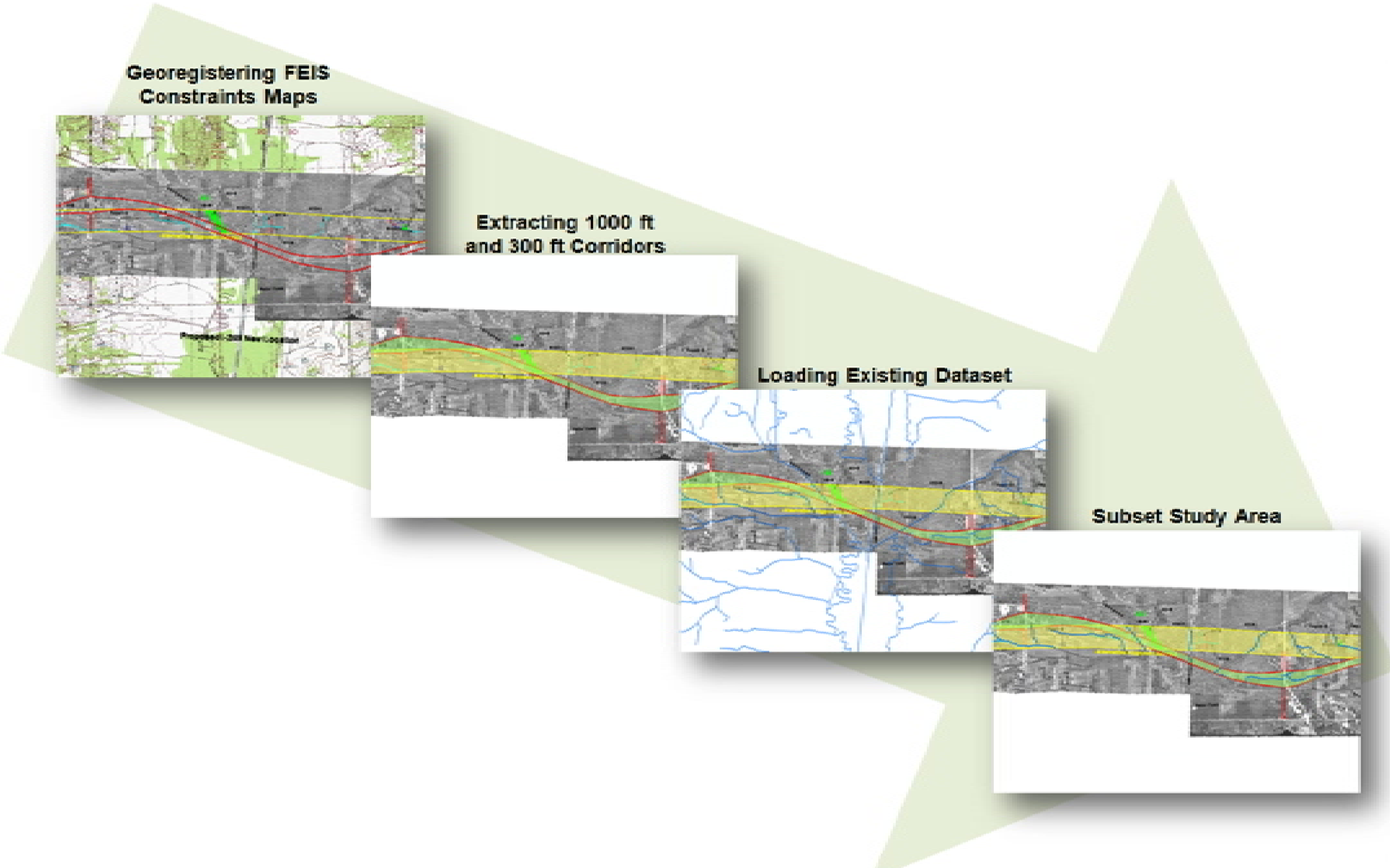


Figure 7.3. Sequence of activities performed to facilitate development of reference baseline layers and quantify results of spatial screening of environmental features identified in EIS maps.

For each of the 25 constraints maps provided with the FEIS, the map plates were georeferenced, mapped corridor boundaries and environmental features were digitized from the maps, and geospatial data layers were created from the digitized features. After the corridor boundaries were captured, standard geodata layers depicting environmental layers were loaded and intersected with corridor boundaries to select a subset of the features for the study area. These steps were performed in a uniform manner for all environmental constraint maps to facilitate spatial screening of environmental features.

Identification and Use of Best Available CRS&SI "Geospatial" Data: To conduct a comparison of methods and results, data were extracted from constraints maps created using manual photo identification procedures in the EIS process. These map products were converted to tiff images, georeferenced, and environmental features were digitized. To conduct appropriate comparisons, the areas with the 1000-foot and 300-foot corridor boundaries were used to select and quantify features. Features mapped in the EIS were compared to features tabulated in the EIS and against standard geospatial data layers.

Gathering the "Best Available Data" for geospatial analysis can be challenging. As previously documented in Chapter 2, gathering multi-source data and building a geodata catalog for analysis was a primary task in the research project. To enable comparative analyses for screening of environmental features, several data sets were selected, including the National Hydrography Dataset (NHD) to evaluate stream crossing impacts, the National Agricultural Imagery Program (NAIP) to provide the most recent image data to extract water bodies and buildings for impacts analysis, and a combination of National Wetlands Inventory (NWI) and the National Land Cover Dataset (NLCD) to estimate wetlands impacts. These existing data sets were intersected with the corridor boundaries to create a subset of the data against which the features from the EIS were to be compared to benchmark the effectiveness of the use of these standard data sets, providing early conservative estimation of potential environmental impact associated with the alternative being studied.

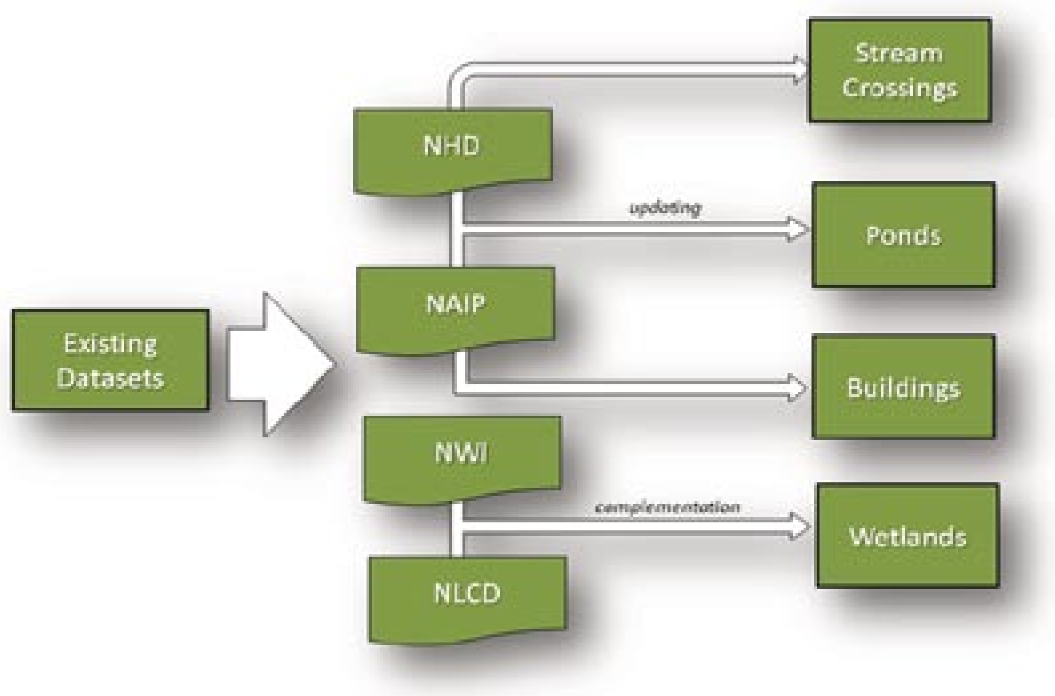


Figure 7.4. Geospatial data for environmental feature extraction and quantification to enable comparison against EIS reference data and to benchmark performance.

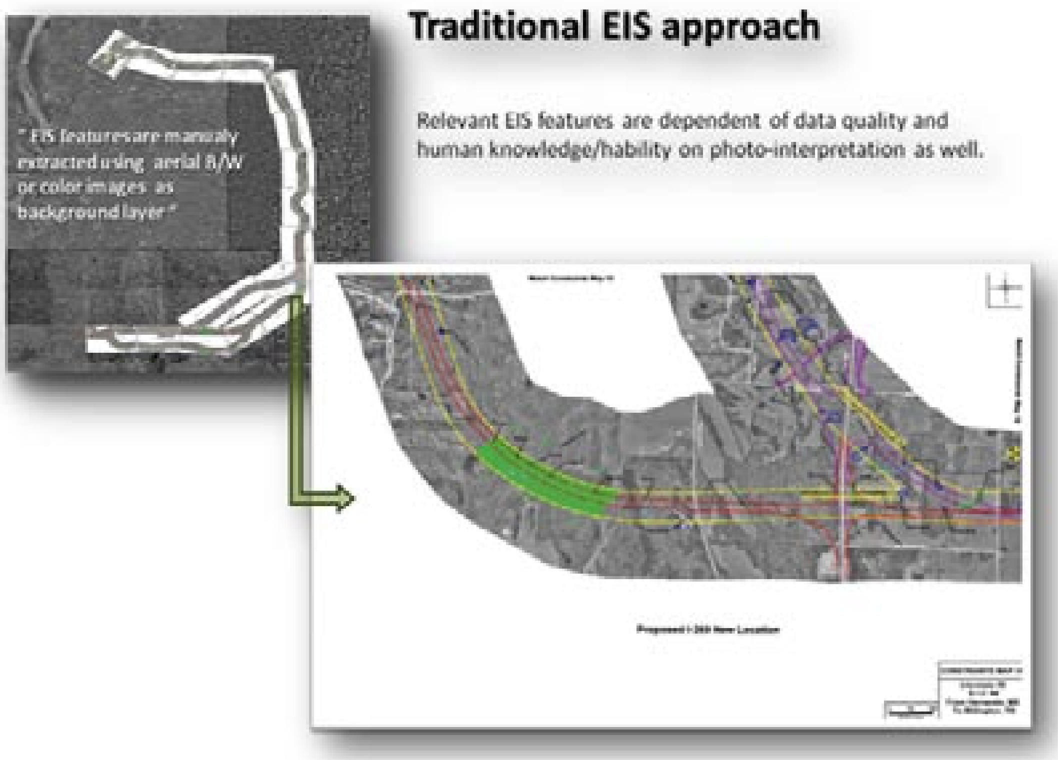


Figure 7.5. Stream crossing and impacts mapped via traditional approach

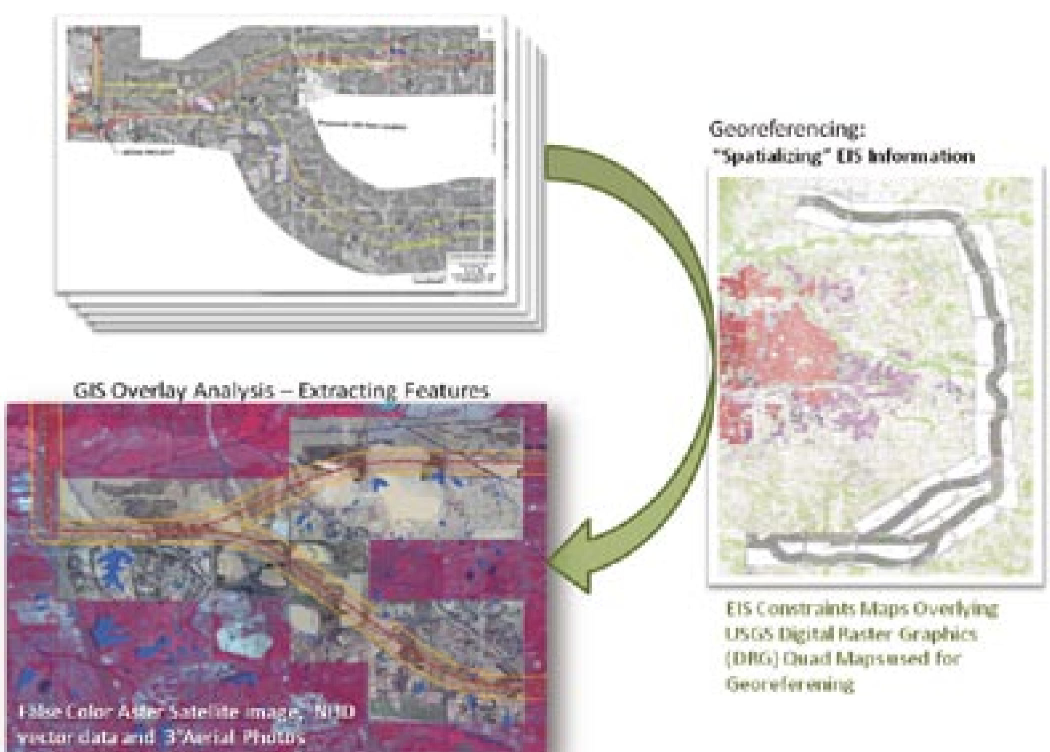


Figure 7.6. Stream crossings and impacts mapped via GIS approach

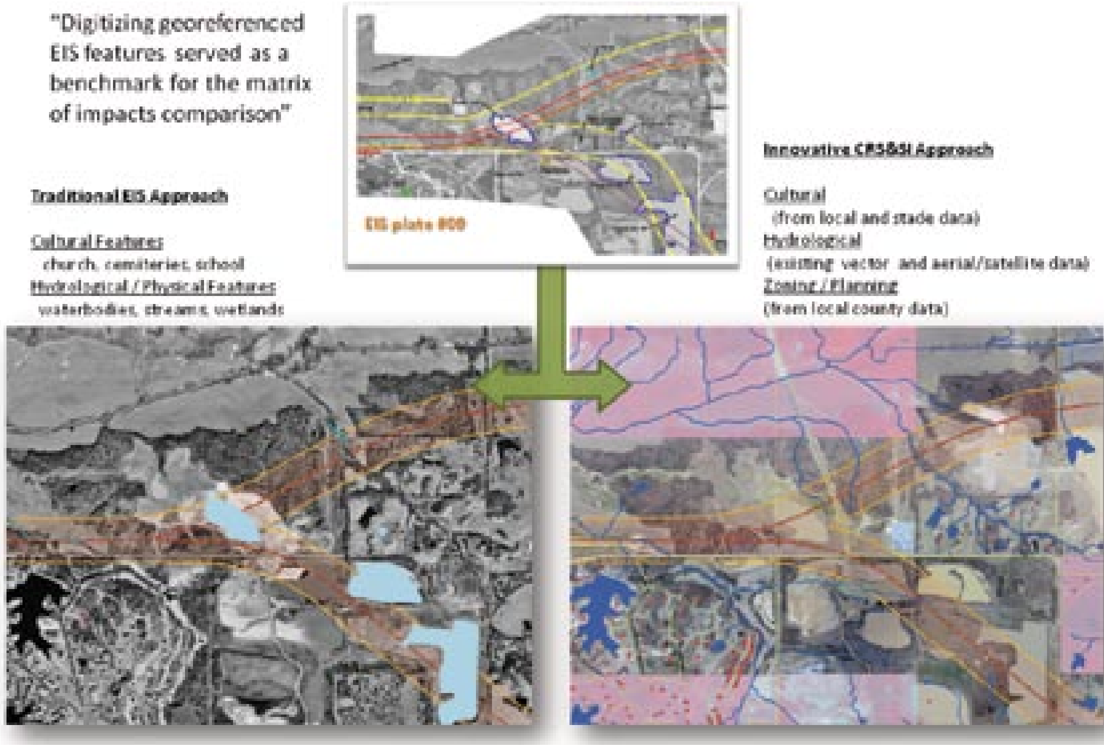


Figure 7.7. Comparing processes for extracting cultural, hydrological and zoning features.

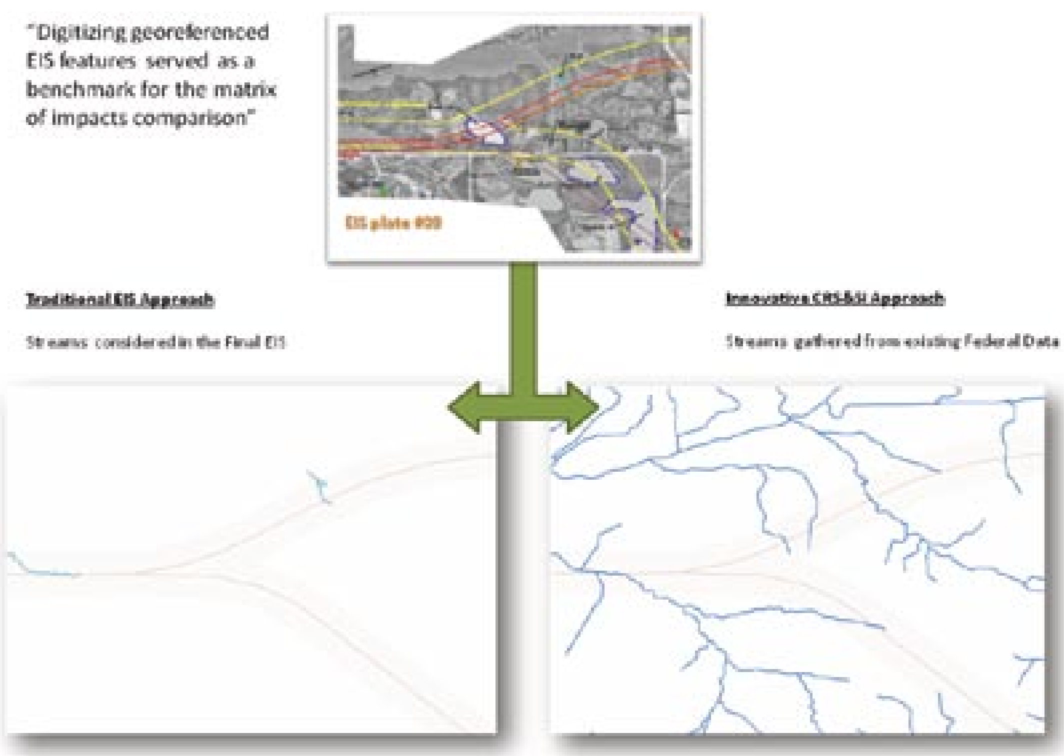


Figure 7.8. Comparing traditional and GIS approaches for extracting stream crossings.

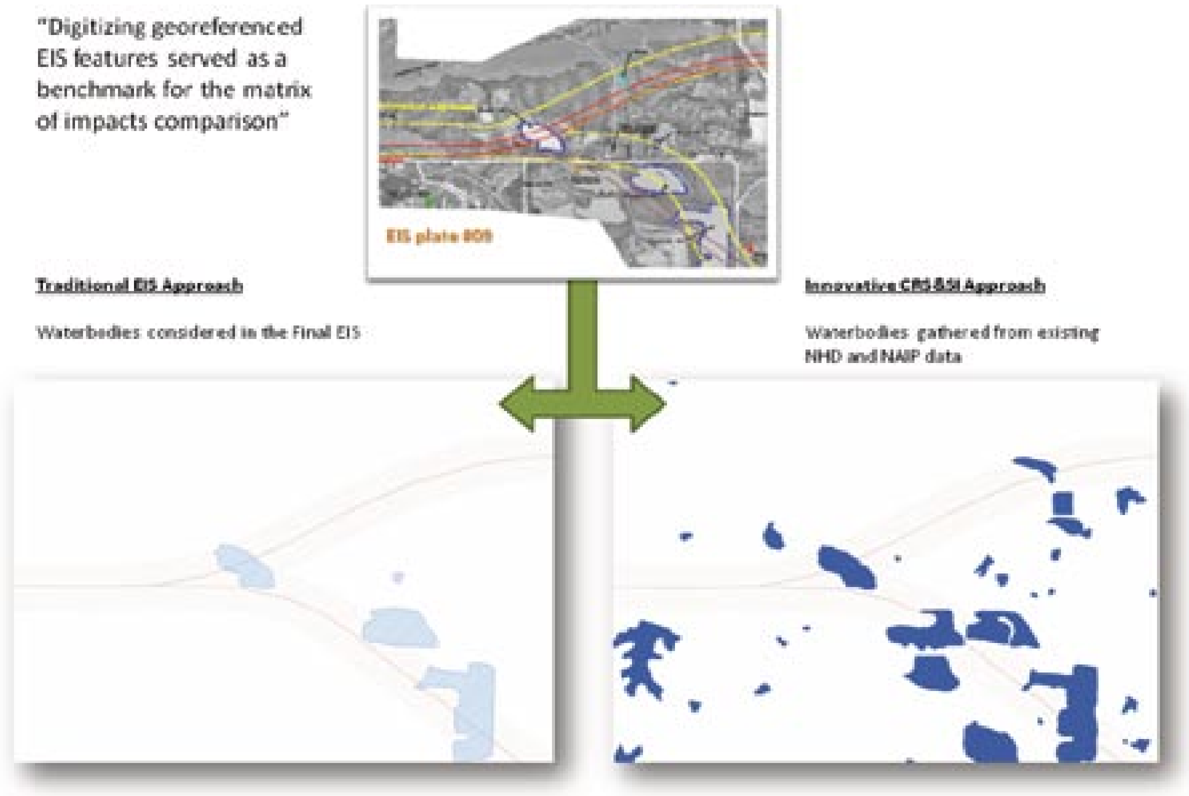
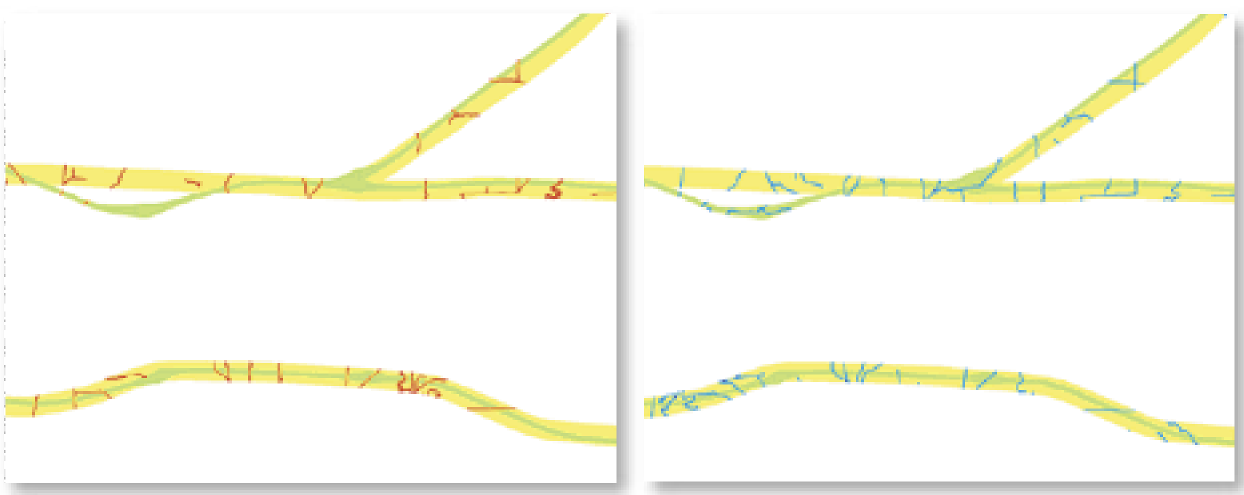


Figure 7.9. Comparing traditional and GIS approaches for extracting water bodies.

Stream Crossings

Streams from Final EIS　　　　Streams from NHD

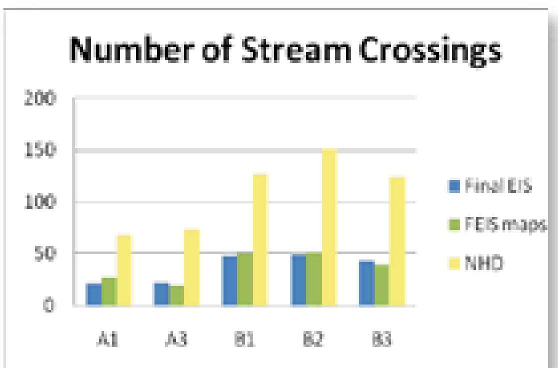


Yellow Corridor = 1000-foot; Green Corridor = 300-foot

Figure 7.10. Comparing EIS and NHD stream features extracted using corridor buffers.

Table 7.1. Quantification of stream features within the 1000 ft buffer

Streams Within 1000-ft Buffer						
Segments	Reported in Final EIS		Showed in FEIS maps		Extracted from NHD	
	# streams	*Total Legth (feet)*	*# streams*	*Total Legth (feet)*	*# streams*	*Total Legth (feet)*
A1	21	21970	27	29768	68	50433
A3	22	21220	19	20795	73	50953
B1	47	58125	50	67550	127	105614
B2	49	73320	51	79596	151	111909
B3	43	48705	39	43300	124	102176
	182	**223340**	**186**	**241009**	**543**	**421085**



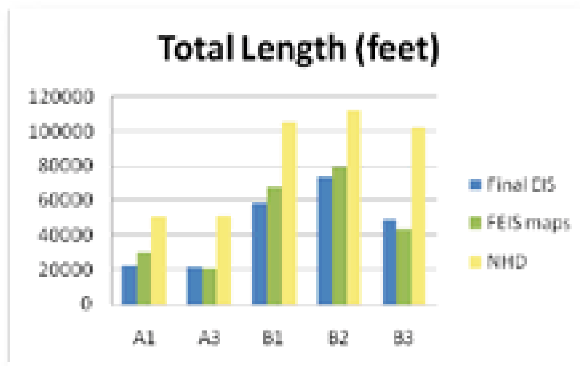
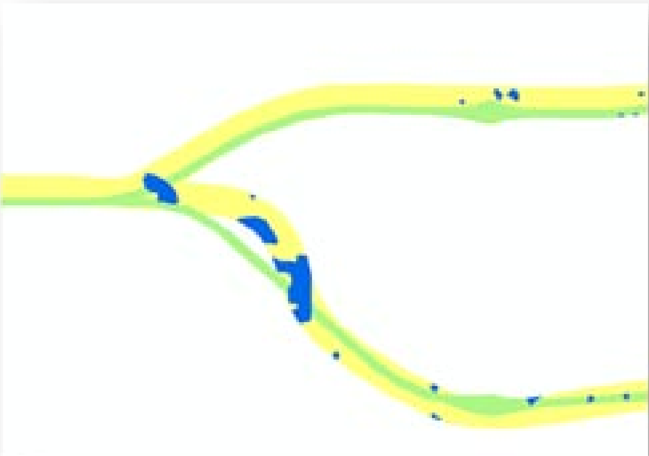


Figure 7.11. Bar charts depicting the number and length of stream crossings for each of the alternatives considered showing data results reported in FEIS tabulation (blue), extracted from maps layers created from FEIS maps (green), and extracted using GIS buffering and intersection analysis from NHD (yellow).

Ponds

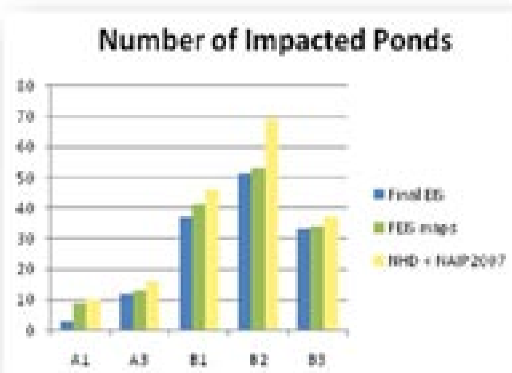
Ponds from Final EIS



Ponds from NHD and NAIP 2007

Yellow Corridor = 1000-foot; Green Corridor = 300-foot

(NHD ⋃ NAIP 2007) ⋂ Buffer



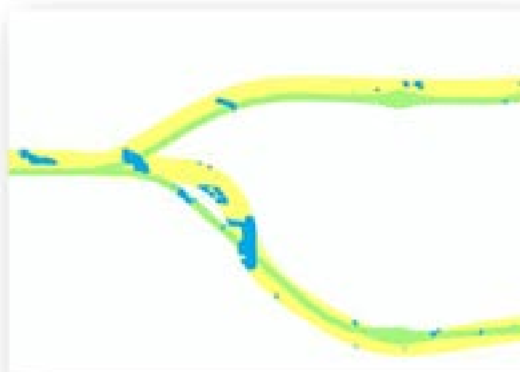


Figure 7.12. Analysis of water bodies with maps showing ponds mapped in the EIS (upper left), ponds from the NHD combined with NAIP-derived water bodies (upper right), and the NHD + NAIP ponds intersected by corridor boundaries along alternative alignments (lower right); numerical quantification of the number of ponds is shown in the bar chart (lower left) presenting results for each alternative from EIS tabulation (blue), extracted from EIS maps (green), and extracted from geospatial data for features within the corridor buffered alignments (yellow).

Table 7.2. Quantification of water bodies within the 1000 ft buffer.

Ponds Within 1000-ft Buffer			
Segments	**Reported in FEIS** ***# ponds***	**Showed in FEIS maps** ***# ponds***	**Extracted from NHD⋃NAIP** ***# ponds***
A1	3	9	10
A3	12	13	16
B1	37	41	46
B2	51	53	69
B3	33	34	37
	136	**150**	**178**

Stream and Pond Impacts: Among the geodata layers with national value, the National Hydrography Dataset is available across the country and provides a geographic depiction of stream and water bodies across the US. The NHD was developed from data within USGS quadrangle maps and include all of the stream features mapped, some of which represent ditches, intermittent streams, or features that do not flow. For these reasons, it is likely that the presence of streams in the NHD and the number of crossings and length of streams impacted will likely be overestimated when using the NHD. This conservative estimation, in fact, provides a good mechanism to direct field mapping and verification of stream location and flow conditions.

For ponds, lakes, and water bodies, there are many cases in which recently constructed manmade water bodies occur that are not represented in the NHD. In these cases, the locations of ponds in the NHD may be readily combined with water bodies detected in NAIP image data to provide a complete and up-to-date geodata layer for ponds / waterbodies.

Conservative Basis of Initial Estimation for Screening Alternatives: For streams and ponds, what has been demonstrated for this study area is that the combination of NHD plus water bodies from recent multispectral image data can be used to provide data to establish a conservative basis for estimation of occurrence. In comparing the number of stream segments, it should be noted that sinuosity of the stream can lead to a stream being counted more than once when a stream crosses a planned alignment more than one time. This leads to higher counts for the stream crossings, while lengths of intermittent streams or non-flowing streams also add to both the crossings and to the length estimations for impacted streams.

KEY BENEFITS

There is a general need for improved availability of standard federal geodata for all areas and improved map quality of data products. In addition to availability of nationwide datasets, there is a significant need for improved standardization of local and MPO data provided through education, standards-based directions, and structured out reach for developing useful cross-purpose datasets that are consistent and adequately documented. Finally, there is a need for basic tools that can conduct screening and reporting of results for easily used analysis and reporting.

It should be noted that the NAIP imagery used to supplement the NHD for waterbodies is a 1m resolution multispectral aerial image data product. For most DOT projects, pre-EIS data collection should include project-wide very high resolution digital multispectral image data including the color infrared band. In addition to image data, LIDAR data at dense postings should be collected. The combination of aerial multi-spectral image data and LIDAR would enable extraction of features with far greater precision than using the standard geospatial data sets described herein. Furthermore, high resolution image + LIDAR would enable highly accurate elevation, slope, drainage, and topography maps that would dramatically improve abilities to provide early horizontal and vertical refinement of alternatives. Finally, these layers would significantly enhance automated approaches to extracting cultural and land use features of interest in the impacts assessment and condition reporting aspects of the project. This general usefulness of high resolution image data is supported by the use of data provide by Desoto County. As a local partner to the project, the county provided their 3-inch resolution multispectral image data which the county had acquired for enhancing their asset, infrastructure, land use, and other maps. This very high resolution commercially acquired digital aerial remote sensing image data was highly useful in identifying cultural features, existing buildings, and urbanization, and its use is further addressed in Chapter 8 where the generation, refinement, and selection of alternative alignments is addressed.

7.2 Spatial Screening of Wetland Environmental Features

Highlighted in this section are two examples of the use of geospatial data to screen for the probable occurrence of wetlands in evaluating probable environmental impacts of potential alignment and for developing avoidance and mitigation strategies.

Current Practice: A variety of methods exist for screening potential wetlands in developing transportation projects. Many states have compiled data sets that include wetland data from a variety of sources. None of these screening methods preclude permitting activities that must be undertaken for quantifying final wetland impacts and determining appropriate mitigation measures that must be taken to offset the determined impacts. However, these methods do provide a basis for screening and developing an estimation of the general amount of wetlands likely to be impacted by alignment alternatives. These layers also provide insight for planning field studies as well as for planning potential mitigation in the vicinity of the project area. For the subject EIS, Mississippi DOT has implemented wetland land banking that provided an effective measure to develop DOT and resource agreement concurrence as to acceptable mitigation for determined impacts.

CRS&SI Objectives: To use existing GIS data or commercial remote sensing data to screen for the probable occurrence of wetlands in evaluating probable environmental impacts of potential alignments and for developing avoidance and mitigation strategies.

Methods: Highlighted in this section are two examples. The first example highlights the need for standard datasets and illustrates the useful application and limitations of National Wetlands Inventory (NWI) data, the integrated use of NWI and National Land Cover Database (NLCD) information on Wetlands, and shows results of use of space borne RADAR to aid in mapping the likely occurrence of forested wetlands. Another use case highlighted has been provided by Patti Caswell, the Wetlands Program Coordinator for Oregon DOT, and illustrates a merger of conservation datasets and the application of spatial screening tools to consider a collection of geospatial wetlands data.

Results: The use of National Wetland Inventory data as a screening layer for the existence of wetlands is limited by the areas where NWI maps provide coverage. In many areas the NRCS County Soils data (SSURGO Soils) are also absent preventing the effective mapping of hydric soils for the area. The presence of hydric soils is information vital to estimating areas of wetland likelihood. In the area of the case study, NWI data are scarce and hydric soils only partially mapped for Desoto County.

In figure 7.13, blue depicts areas mapped as hydric soils which are apparently not well mapped in Desoto County. The lack of quality soils maps is further complicated by the lack of NWI maps for the 7.5 minute quadrangle maps shown on figure 7.14 for areas in Desoto and Marshall Counties.

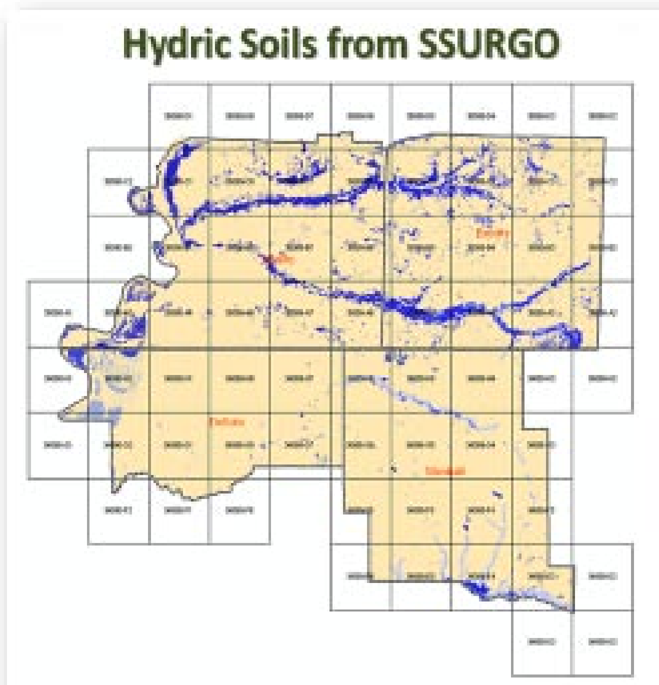


Figure 7.13. USDA NRCS SSURGO Soils data showing hydric soils mapped for the project study area. Lack of hydric soils mapped for Desoto County indicate incomplete maps for the project area and difficulty in screening likely wetland impacts.

The basic need for continuous data across the study area means that decisions must be made about use of best available data. In the case of absent NWI data for the study area, an inspection of the areas classified as wetlands in the USGS NLCD showed close agreement with the NWI data for the majority of the study area. Since the NLCD is a nationwide dataset produced using consistent methods for the entire U.S., the availability of this data should not be a problem.

For the purposes of environmental screening and for estimating wetland impacts across the study area, wetlands from NWI were used where available and wetlands from the NLCD were added for areas where NWI data were absent.

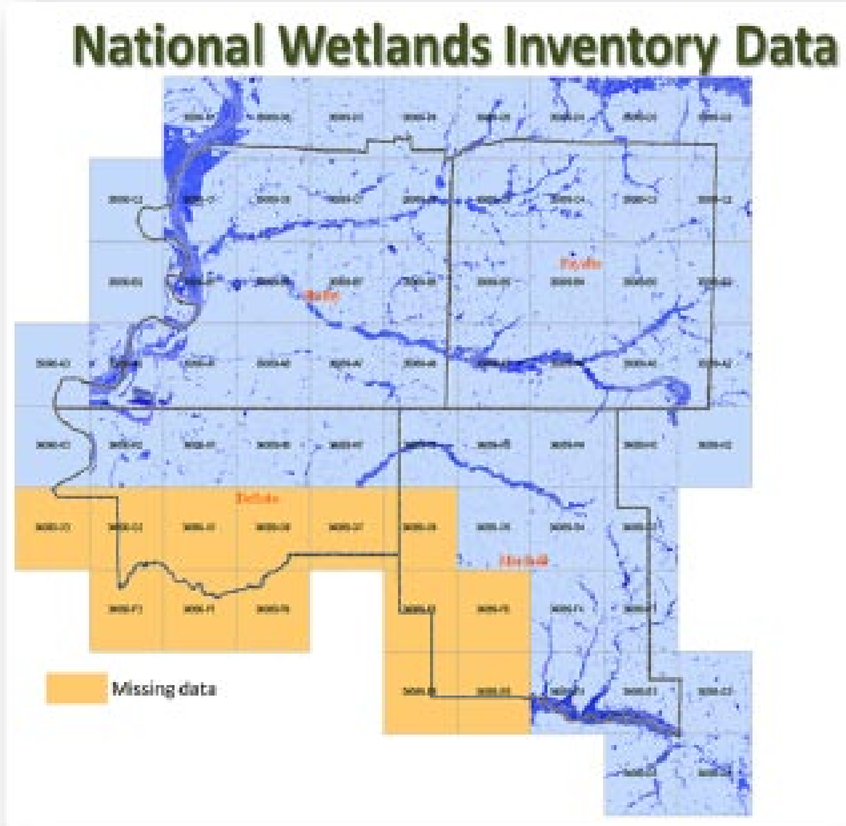


Figure 7.14. National Wetlands Inventory data showing areas where NWI quadrangle maps are not available in the national database. Lack of complete coverage for NWI is a problem as is lack of consistent detail and "breaks" where data are not continuous across quad maps.

Figure 7.15. Depictions of the NWI (left image in blue), wetlands from the USGS National Land Cover Dataset (NLCD) is shown in green (middle image) , and areas estimated to be forested wetlands based on MTRI's combination of satellite radar, land sat, and NLCD are shown in light brown tones (right image).

<u>Oregon Case Study Example:</u> The Salmon Resource and Sensitive Areas Mapping (SRSAM) inventory and maps of sensitive areas near transportation features were used to provide geodata useful for mapping wetlands in the vicinity of existing highways, which is beneficial for planning new facilities. In addition, this provides an excellent basis for comparing mapped wetlands.

Building off of the overall priorities from the merged conservation portfolio, wetland priority areas were identified, assuring that priority wetlands occur within each EPA 4th field Watershed. These priority sites must be vetted with wetland regulators. They become the sites where mitigation and banking needs to occur. This assures that wetlands mitigation and restoration occurs in the best places.

Figure 7.16. Wetland Inventory features in green fill area, Wetland Reserve program in dotted yellow black and Oregon DOT surveyed wetlands in blue outlines. Wetland Inventory features (green fill area), Wetland Reserve Program (outlined in yellow-black dashed lines), and Oregon DOT surveyed wetlands (blue outlines) may be accessed in an integrated manner. This may be effective in showing how active wetland restoration sites need to be included in maintenance of a wetlands database and how subsequent surveys (ODOT) should extend NWI.

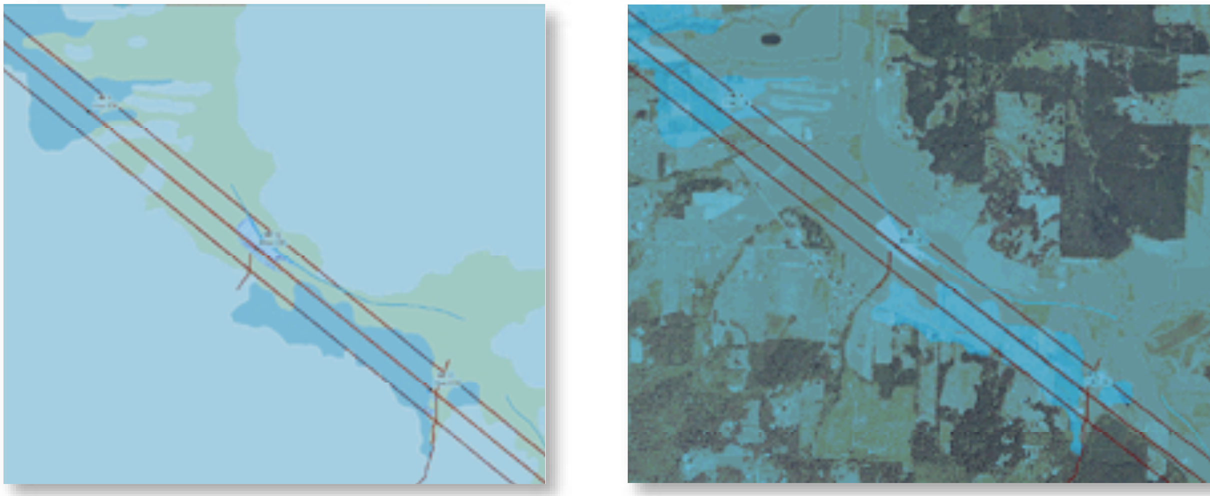


Figure 7.17. Oregon DOT Wetland Screening tool used to identify hydric soils

The Oregon DOT Wetland Screening tool is shown with a 500 foot buffer of HWY 22 used to identify areas of all hydric soils (tan), area partially hydric (light blue fill), and area that are wetland in either NWI or the SRSAM databases (dashed blue). These data enable effective analysis of management and operational activities and how specific areas require special care and consideration in operation. Similarly, these data may also be useful for screening possible impacts along planning new highway facilities.

KEY BENEFITS FOR 7.1, 7.2 AND 7.3

Rigorous comparison of stream impacts as well as ponds as depicted in the EIS to features in readily available geodata layers indicate that use of geodata for screening can provide valuable inputs to the EIS process. The project validated results by georegistering constraint maps and extracting features of interest from EIS map documents. This demonstrated that geospatial analysis of geodata layers using buffering, and intersection methods can provide results that enhance the EIS process.

For the NCRST-SEPP project, the lack of continuous geospatial data of appropriate scale and resolution for wetlands mapping precluded the rigorous comparison of CRS&SI methods and results against traditional methods and results reported in the EIS. The lack of consistent or continuous maps in geodata format for wetlands is a national issue. Mapping efforts at national, regional, and state levels target mapping wetland features from satellite data, aerial photography, or via related features such as hydric soils. In many areas, incomplete or inconsistent mapping of the National Wetlands Inventory (NWI), lack of GIS county soils map data (NRCS SSURGO Soils), lack of ancillary data, such as Wetland Reserve Program (WRP) data, or wetlands layers from conservation agencies, may dictate the use of National Landcover Dataset a general screening of areas likely to contain wetlands. Although the NLDC is a low resolution dataset, for this case study, in areas where NWI was mapped and available, the NWI corresponded well with NLDC areas classified as wetlands.

Past studies have shown that high resolution aerial multispectral or hyperspectral image data and LIDAR data can enhance the ability to identify the likely presence of wetlands and can be useful in identifying wetland mitigation sites in the vicinity of the project area—finding sites which provide similar hydrologic and wetland function as the wetland features impacted.

8.0 "MAKING EVERY DAY COUNT": ENVIRONMENTAL CORRIDOR OPTIMIZATION AND PLANNING ALIGNMENTS (ECO-PAL)TOOLKIT

Introduction: Validating CRS&SI technologies to approximate or enhance results presented in the FEIS for identifying the project corridor boundary, highlighting potential alignments, selecting a preferred alignment, and generating a final optimal alignment were major tasks in the NCRST-SEPP project plan. Furthermore, based on early feedback from the Advisory Panel, developing systematic and readily reproducible methods to automate the alignment generation and optimization process, and exposing those methods for collaborative input would deliver significant value due to capabilities to readily incorporate stakeholder input, manage conflicts, and consider all alternatives.

The needs for such automation and collaborative participation in decision-making are many. Roadway planning can become a contentious and lengthy process. Delays to projects are frequent due to opposition, conflicting interests, and differing opinions from stakeholders, resource agencies, planning organizations, and others. With many factors affecting the decision-making process and the lack of a unique solution and the plurality of opinions, computational tools offer support to resolve potential conflicts and resources that aid decision making. Methods for collaborative involvement, scenario evaluation, and comparative analysis can deliver decision makers and stakeholders valuable insight into the relative strengths and weaknesses of different solutions and the degree to which solutions achieve intended purposes and conform to prioritized goals. Taken together, if these methods were implemented in a GIS-based decision making framework focusing on environmental and early planning needs, the benefits will prove to be significant in the transportation corridors project development process.

Current Practice: The identification of the corridor boundary for the I-269 project was conducted through a "Systems Approach" which determined that an I-69 segment and a separate bypass loop designated as I-269 were needed to adequately handle the long-term needs of the system. The general boundary for the bypass loop for I-269 was manually aligned. The alignments B-1, B-2, and B-3 in the southern part of the study area were likewise manually aligned and subject to subsequent "field location" of the alignments. In the course of the EIS, alignment B-3 was initially favored because the alignment was obviously above nearby floodplains and avoided obvious features of concern such as wetlands and stream impacts. However, when initial plans were presented to local decision makers and shareholders, there was significant opposition and rejection of the B-3 alternative. Supporting this rejection, local planning organization presented the EIS team with extensive plans for new developments, schools, and other features in stark juxtaposition with the B-3 alignment. It seemed that the same features that led to B-3 being favored for the initial preferred I-269 alignment also contributed to plans to develop those areas the alignment was planned to traverse. Early efforts to make manual modifications of the B-3 alignment likewise met with unwavering opposition resulting in the selection of alignment B-1.

CRS&SI Objectives: The efforts of SEPP team converged into a cutting edge methodology to optimize the planning process by using solid expertise in geospatial analysis, NEPA resolution, socio-economic and cultural issues, and policy implications. The Environmental Corridor Optimization and Planning ALignments (ECO-PAL) toolkit was designed to perform accurate and efficient corridor analysis across different scales in the transportation planning. ECO-PAL may be used to capture value-based inputs and opinions from decision makers, stakeholders and public participation about issues that range from project-wide considerations to area-specific perspectives. Using ECO-PAL, inputs and opinions may be captured and converted to numerical values. The numerical values are assigned as relative ranking and are allocated to criteria based on a spatial data layer. Multiple spatial data layers, each employed as a factor in the analysis, may be considered and allocated weights that influence how much influence each factor contributes to a given cumulative scenario in the multi-scale GIS-based MCDM.

Methods: Opinions from subject-matter experts, decision makers, and stakeholders are organized into scenarios that may each be explored in a systematic and comprehensive manner. For each scenario, subjectively ranked criteria are converted into pair-wise comparisons of criteria, and give rise to relative ranking of criteria. For each factor, a numerical weight assigning relative priority in the decision process is computed. The weighted factors are then combined resulting in a cumulative cost surface. This cost surface is used to generate a least-cost path between selected locations on the surface.

Results: ECO-PAL provides a scalable and comprehensible framework that delivers a series of top-down, least-cost corridors that are progressively narrowed to least-cost pathways that constitute potential alignments according the bottom-up requirements. ECO-PAL enables eliminating non-viable alternatives, considering exclusion or avoidance areas, considering local values when generating alignments, and simulating feasible alignments among different scenarios all of which arise from inputs provided by the differing stakeholder or decision maker opinions.

Key Benefits: ECO-PAL was designed not only to speed up the environmental analysis by using CRS&SI technologies, but also to increase the capabilities of the planning process to consider factors largely absent or not fully used in transportation planning (such as policy implications and public participation). This innovative methodology brings significant advantages in comparison with the approaches currently available. *ECO-PAL considers subjective values of features that range from cultural to social to economical to environmental. It is not a computational solution for an engineering least-cost path, rather it is a tool that enables planning and environmental linkages (PEL) by exposing data-driven alignment generation to value-based opinions, each of which may result in a unique alignment that fully captures the values and opinions expressed. ECO-PAL provides the capabilities to effectively capture differing values to generate alignments, to modify approaches or create compromise scenarios that contain aspects of multiple opinions, and enable participants to visualize alignments generated in the context of the environment so that apt comparison may be made and further adjustments and refinements may be incorporated.*

KEY BENEFITS

- Automated generation of general corridor boundaries based on generally available geodata.
- Automated generation of refined subcorridors based on refined geodata with enhanced content.
- Rapid elimination of non-viable alignments.
- Progressive refinement of scenarios resulting in feasible alignments.
- Adaptive scenarios that blend in aspects favored by stakeholders or public participants.
- Use of local data and evolution of ECO-PAL scenarios for generation of preferred alternative.
- Efficiently evolve the scenarios as desired based on new or improved input geodata.
- Refinement of preferred alternative to provide geometric smoothing to remove pixilation.
- Capabilities to efficiently generate alignments that closely match roadway designs

8.1 Exploring the Use of ECO-PAL Toolkit – Example Test Cases

Developing an improved understanding of the ECO-PAL toolkit requires exposing the basic underlying logic and exploring aspects of how the application has been adapted to create environmentally directed potential roadway alignments.

- Test Case 1: Understanding the GIS-based MCDM approach for corridor design
- Test Case 2: Understanding the multi-scale approach for corridor design
- Test Case 3: Using ECO-PAL to produce alternative alignment scenarios
- Test Case 4: Evaluating the accuracy of ECO-PAL designed corridors

Test Case 1: Understanding the GIS-Based MCDM Approach for Corridor Design: Presents a practical overview of Multi-Criteria Decision Making process coupled with GIS.

The ECO-PAL's methodology is proposed as an equitable system for generating concurrent corridors for quantification of environmental impacts of selected pathways, or to seed the generation of potential transportation alignments based on a least-cost path over a cumulative environmental cost surface. The core of the method employs Analytical Hierarchy Process (AHP) coupled with GIS, which enables sketching corridors by connecting inputs from decision makers, stakeholders and public participation in a straightforward and flexible way.

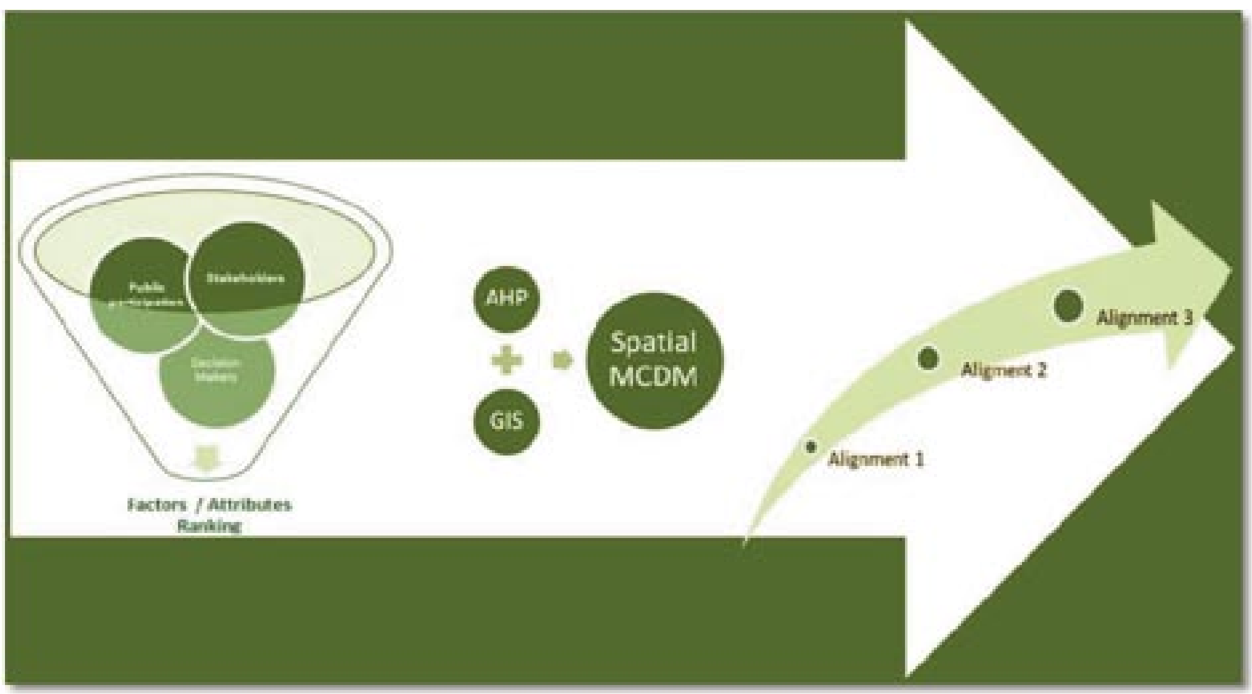


Figure 8.1. Simplified overview of the ECO-PAL workflow.

Subjective Rational for Ranking and Weights: To illustrate the basic methodology behind how ECO-PAL (a GIS-based MCDM) works, a practical demonstration is provided that uses four biophysical factors

(Drainage Density, Slope, Urban Areas and Wetlands). The goal is to address assignment of subjective, but rational ranking for these factors as inputs in the decision making process and demonstrate how CRS&SI technologies can be used to support the process in an automatic approach. The case study is developed in a 30-mile corridor from Hernando, MS, to Collierville,TN, where the Final I-269 (shown in red) served as reference to attest the efficiency of the method.

<u>Data Sources:</u> Data used were gathered from National Hydrography Dataset (NHD) for drainage, National Land Cover Database (NLCD) 2001 for wetlands, National Elevation Dataset (NED-10m) for slope, and Memphis Metropolitan Planning Organization for the limits of urban areas.

<u>Assigning Values:</u> For assigning values, assumptions may be summarized by stating that high values equate to high environmental impacts. Thus, the ideal paths would likely be found by a combination of low drainage density, greatest distance from urban areas, flat terrain, and greatest distance from wetlands. On the other hand, high impacts would be derived by a combination of areas with high stream density, low distance to urban areas, low distance to wetlands, and moderate to rugged terrain.

<u>Distance from Urbanized Areas:</u> Ranked by distance away from urban areas, the desired function of I-269 is to serve as a bypass. Therefore, the alignment should not intersect the metropolitan Memphis area, but also should not be too far away to functionally benefit the community served. For this factor, 5 attributes are selected in which increasing distance from the urbanized areas were given lesser ranks. (Developed Areas Avoidance)

<u>Drainage Density:</u> Three classes were used: high, moderate and low drainage density. The higher the drainage density, the greater the rank in terms of environmental impacts. (Stream Avoidance)

<u>Slope Classes:</u> Slope classes are created from reclassification NED 10m data. Three classes of slope were considered: highest slope degree (>20%), medium (5-20%) and low (<5%). The lower the slope, the lower the rank and the lower the allocated cost. (High-Slope Avoidance)

<u>Wetlands:</u> Ranked by distance away from wetlands with increasing distance resulting in lower ranking. The closer the distance to wetlands the higher the rank and associated environmental cost. (Wetland Avoidance)

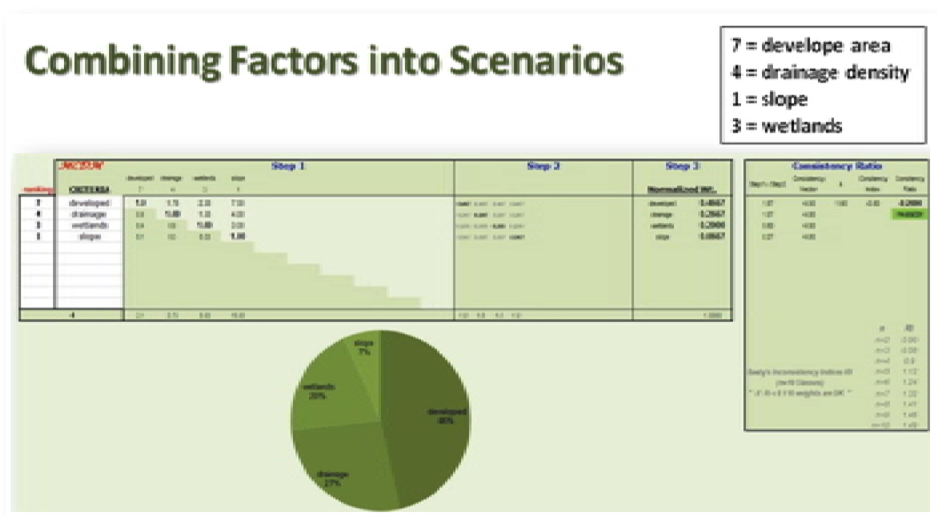


Figure 8.2. Through a simple interface, factors (geodata layers) are identified and criteria established. The MCDM enables criteria to be assigned rankings and factors (layers) are assigned weights. The results are stored in a text file used as a lookup table for assigning desired rankings and weights to geodata.

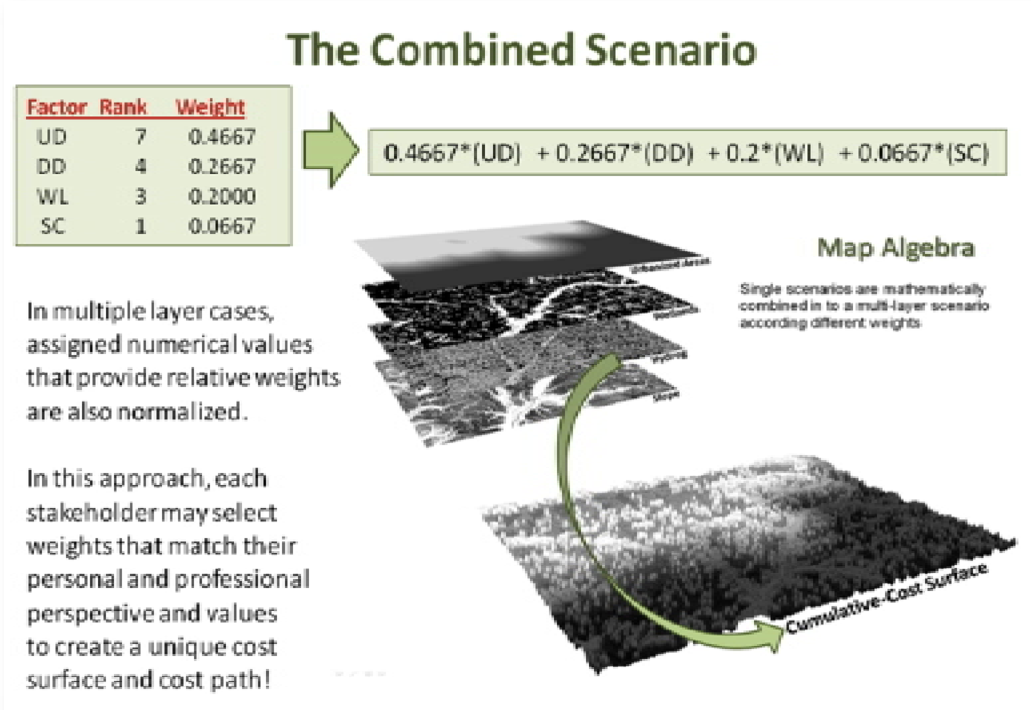


Figure 8.3. The ECO-PAL Toolkit computes rankings and weights based on user inputs. Values are checked for consistency, stored in lookup tables, and are applied to the geodata factors to create input raster data sets. Weights are used as coefficients and applied to inputs as they are combined. The result is a cumulative cost surface upon which end points are designative. A "least cost path" or "cost corridor" is created between termination points and is the basic result used in ECO-PAL.

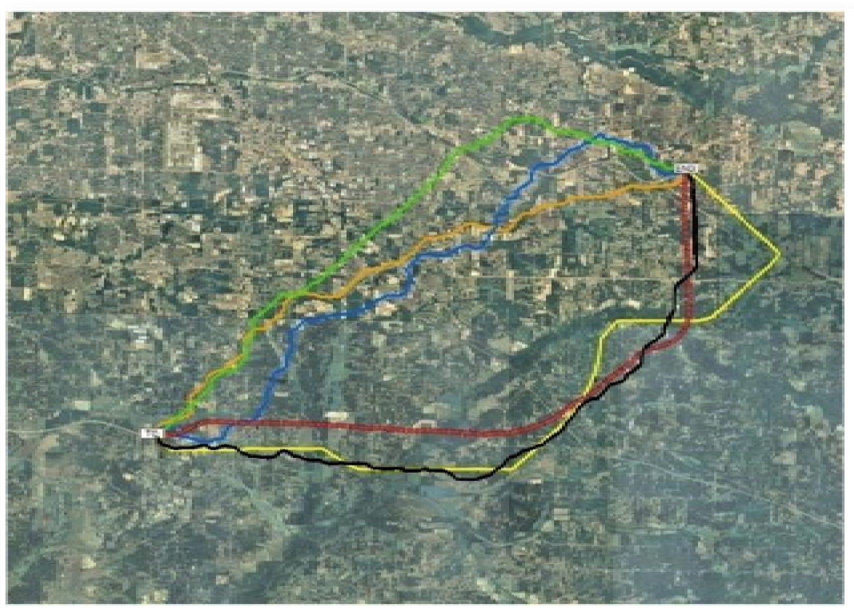
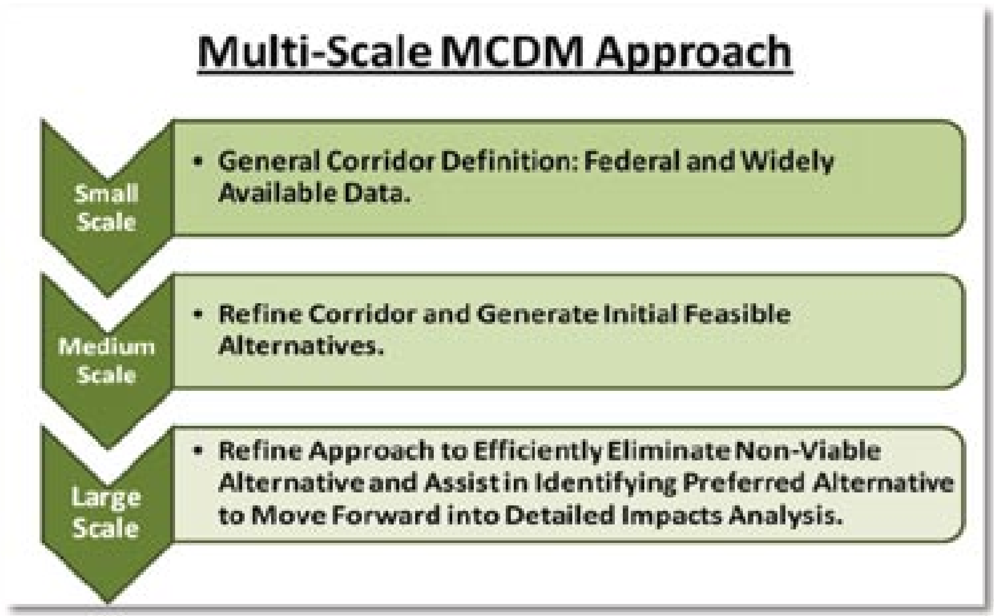


Figure 8.4. After computing the cumulative cost surface from the combination of different geodata layers scenarios, alignments are computed as least cost paths. Depicted are the resultant cost paths for the individual inputs showing urban (in yellow), wetlands (in green), stream crossings (in blue), and slope (in orange). The actual EIS alignment is shown in red and the combination of the four (4) inputs is shown in black.

This simplified example with minimal input factors and basic attributes demonstrates the fundamentals of ECO-PAL and GIS-based MCDM. However, it is worthwhile to note that this initial example produced a combined result (black line) that generally approximates the final selected alignment for I-269.

<u>Test Case 2: Understanding the Multi-Scale Approach for Corridor Design:</u> A practical overview of the multi-scale approach is presented within the GIS decision making framework of ECO-PAL.

A major challenge in multi-criteria decision making is defining methods and procedure to handle data and analysis across different scales. The project developed a multi-scale approach that optimizes initial analysis steps to support a top-down decision-making workflow. This is done to compute a project-wide corridor that connects termination points of interest. Within this broad corridor, refinements are implemented to generate feasible corridors and further enhanced to efficiently eliminate non-viable alternatives and provide insight for the selection of a preferred alignment. A project corridor is computed first and then it is progressively narrowed using appropriate inputs until the corridor reaches a map-scale suitable to ECO-PAL and delivers products similar to a1000-foot right-of-way corridor for EIS ground work.



These multi-scale MCDM methods are fully supported by a well designed and implemented GeoData Catalog as described in Chapter 2. The catalog presents CRS&SI geodata ranging from federal to county levels which may be used to provide vital inputs to ECO-PAL system using broadly available data for initial corridor definition. Regional and local data are used in subsequent corridor refinement steps. Progressive refinement of feasible alignments is conducted by using increasingly detailed data in conjunction with appropriate rankings for factors and attributes per level. Given the high diversity and availability of geodata, the ECO-PAL multi-scale approach is presented as a highly adaptive toolkit useful for automated computing of transportation corridor boundaries and alignments.

With the definition of general corridor boundaries, this broad definition becomes a useful working limit for the next level of alignment processing and for subsequent refinement. From this initial broad corridor boundary definition, ECO-PAL enables a straightforward process to achieve map-scale alignments comparable with manually derived alignments subject to ground surveying. Figures 8.5 illustrates workflow for general corridor broad-area definition.

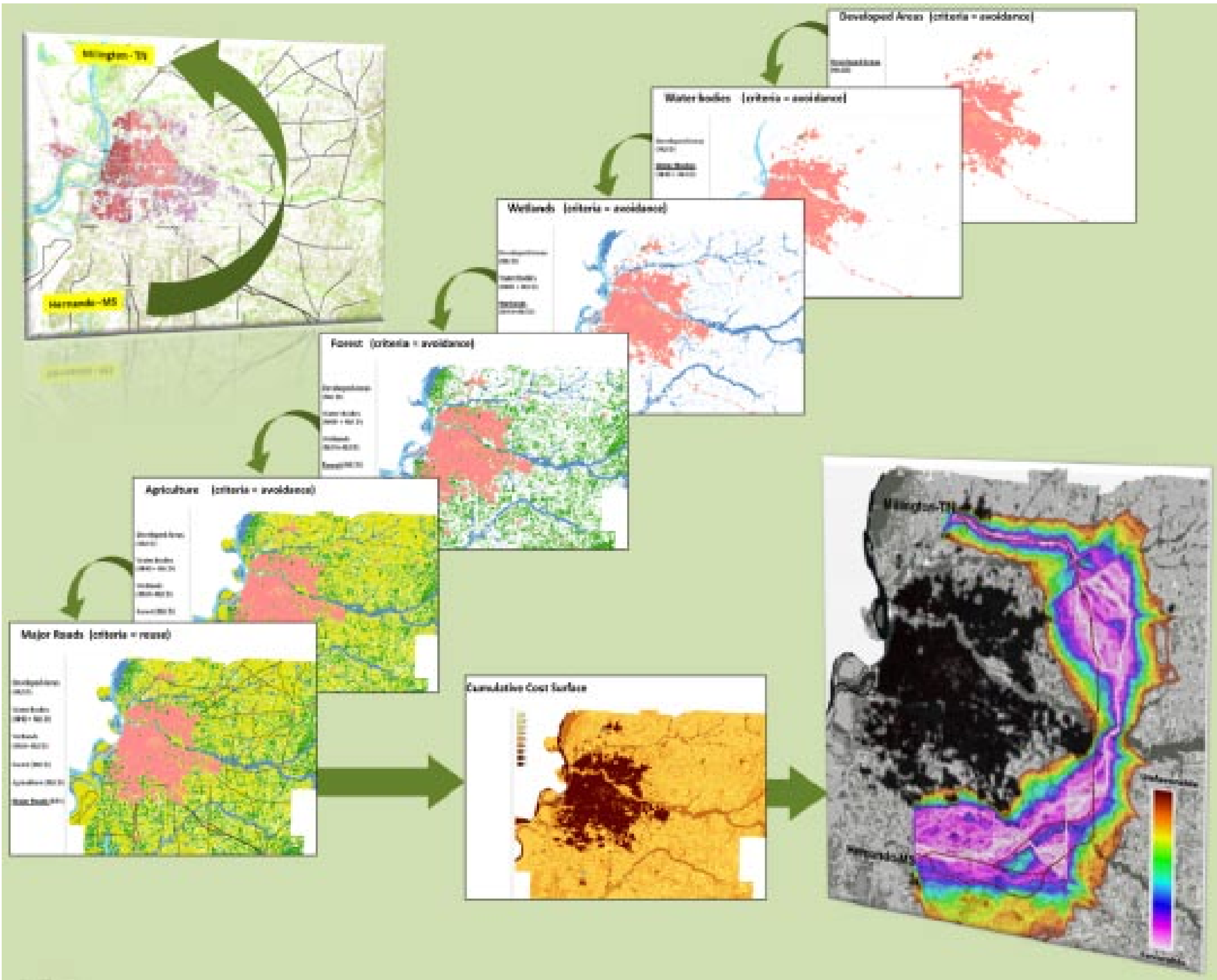


Figure 8.5. Workflow for computing the I-269 SIU-9 bounding corridor connecting Hernando, MS, to Millington, TN, based on generally available Federal geodata. The color-shaded corridor boundary shown in the lower-right of the figure presents increasing intensity colors grading into purple and white showing areas predicted from general data to provide favorable "low-cost" pathways for potential alignments. Note that EIS alignments all lie within the boundary and are shown as red lines.

Test Case 3: Using ECO-PAL for Alignment Refinement and Analysis: As a semi-automated approach, ECO-PAL provides a highly efficient method for generating alternative corridor alignments. Each alternative alignment generated presents a scenario that expresses different values placed on geodata and the underlying features they represent. ECO-PAL enables alignments to be generated through a progressive approach though which factors, attributes and rankings are adjusted, clarified, and refined. In doing so, ECO-PAL provides key benefits for rapidly computing and drawing alternative corridor alignments.

What can be achieved through progressive adaptation is the optimization of a series of scenarios that deliver to the transportation planner capabilities to efficienly combine inputs that are used in a process of computing and adjusting scenario-driven alignments. Progressive adaptation evolves the generation and refinement of alignments leading to a clear set of feasible alignments that may be readily considered for the selection of a preferred alignment. Furthermore, in automating the process of refinement, input captured through the public participation process or from stakeholder or decision maker input may be easily incorporated and readily "blended" into computed scenarios or used to generate independent alignment options.

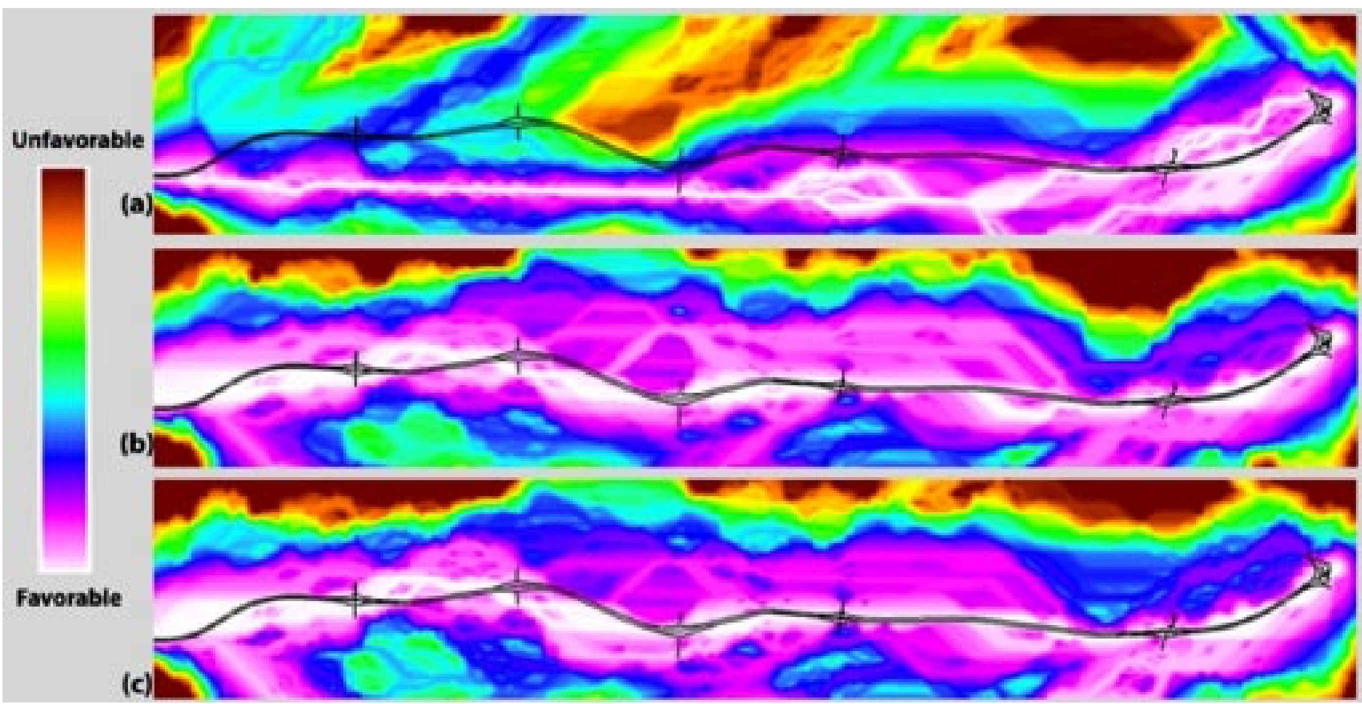


Figure 8.6. ECO-PAL generated least-cost corridors computed from different scenarios each of which focused on expression of planning or stakeholder values or objectives for such themes described as: (a) reusing existing roads; (b) avoiding urban and wetland areas and (c) balancing avoidance of natural, cultural and planning features. Areas shown in increasing intensity (highest areas in purple to white) depict areas favorable for alignment planning. The final design for I-269 is shown as black drawing lines overlaying the shaded corridor. Note the almost exact correspondence between the balanced scenario (c) and the final design for alignment B-1.

The ECO-PAL Toolkit and the underlying methods and analytics were developed to overcome the traditional approach that relies upon lengthy interactive map analysis and manual design of alignments that were evaluated and subsequently field surveyed and adjusted to meet EIS needs. The implementation of ECO-PAL and the evaluations presented all compare results of using the tool against alignments considered in the subject I-269 EIS. The results show that ECO-PAL is able to generate outputs that closely duplicate the general corridor definition, approximate all of the multiple alternatived presented in the EIS, and generate a progressively refined alignment that almost exactly captures the selected B-1 alignment that arose from the EIS process.

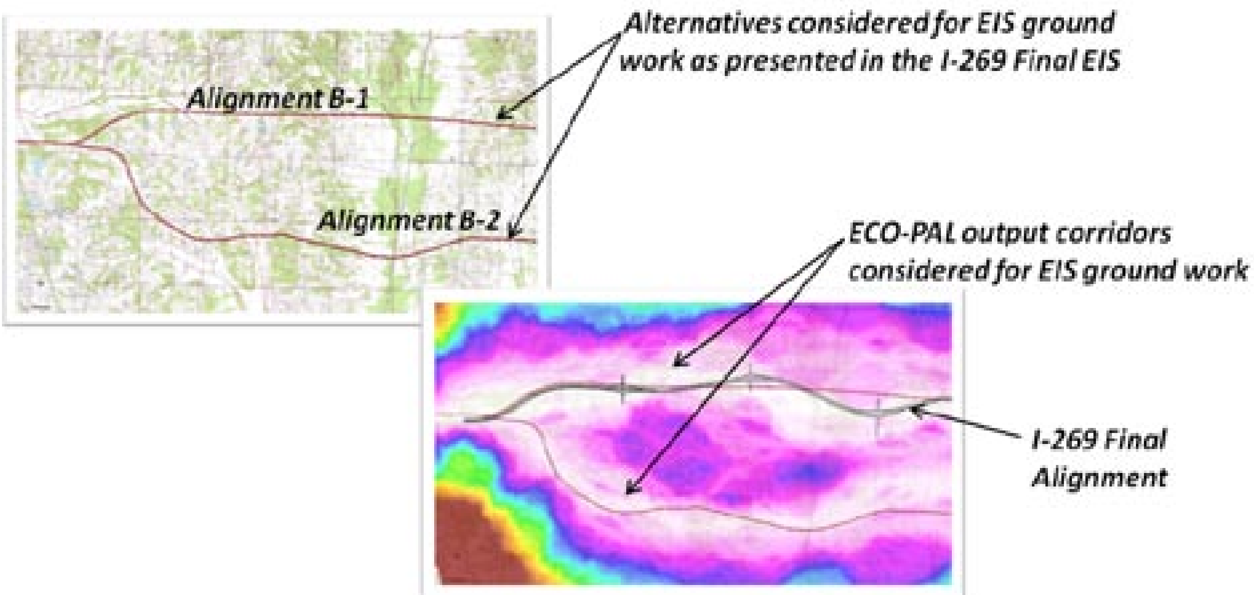


Figure 8.7. Alignments considered in the EIS process overlaying topographic maps are presented in the upper left. In the lower right, results of ECO-PAL are shown as a color-ramped corridor with areas most favoring alignments depicted in increasing color intensity. Alignments used in the EIS are shown in red lines and the final design for I-269 is shown in the black line drawing. Note that the highest intensity areas closely correspond to the selected alignment B-1. However, the general shape and correspondence of the ECO-PAL output more closely approximates the final design than does the EIS alignment. The final design for I-269 considered local factors and also included geometric adjustment as well as plans for access and interchanges. The ECO-PAL results shown above provide visually compelling evidence that this method of automated corridor and alignment generation can produce outcomes that duplicate or enhance results developed through traditional manual methods.

Test Case 4: Evaluating the Accuracy of ECO-PAL Designed Corridors: Presents the analytical comparison of ECO-PAL output to the alignment of the final design of I-269. It is important to highlight that the geometric accuracy assessment reported relates to the 1000-foot right of way corridor for the final design of I-269. The final design is a horizontally adjusted version of Alignment B-1, which was selected in the EIS process after qualifying and quantifying the environmental impacted features based on EIS field work. The final design was adjusted for geometric design, access, property taking, and planned interchanges. Adjustments considered localized factors, many of which were incorporated into ECO-PAL analysis, whereas other adjustment factors were unavailable to ECO-PAL, such as detailed parcel data and relative costs and complexities of property acquisition for highway development. The slight discrepancies between the design file and the ECO-PAL output may be explained by slight adjustments necessitated by localized data unavailable to ECO-PAL in the context of the research project.

The NCRST-SEPP project compiled diverse scenarios in a top-down approach. The scenarios were constructed using different input data and weights within ECO-PAL. Despite the diversity of scenarios and localities, the evaluation of the GIS-based transportation corridors concentrates into the 15 miles along the approved I-269, between the I-55 and US-78 in Desoto County, MS. This particular area has an extraordinary variety of local geodata, ranging from LiDAR topographic surface to meticulous long term plans, which were used to compute alternative corridors. To quantify matching between the final design and the computed alignment, analyses are performed within the 2-mile buffer around the I-269 final design.

Figure 8.8. A 15-mile segment of the final design for I-269 (Source: MDOT Design File) under construction between the I-55 and US-78 and the 2-mile buffer used for the analysis (top). ECO-PAL computed least-cost path corridors are shown on the bottom. Both figures are shown in Google Earth.

Given the final I-269, a 2-mile buffer was computed to serve as limit for the evaluation of the 1000-foot right of way corridor. The accuracy evaluation analytics cover the following three aspects:

Length: Length of the ECO-PAL corridor is compared to the length of the I-269 final design.
Area: The ECO-PAL corridors were quantified according to the proximity to the reference corridor.
Geometric Adjusted Agreement: ECO-PAL raster outputs are “pixilated” and lack smoothness. ECO-PAL enables post-processing to adjust for small deviations in the alignment allowing closer correspondence to the geometries of final roadway designs.

Figure 8.9. The smoothed ECO-PAL results were buffered (1000’ buffer in gray and 300’ buffer in green) and are shown in comparison to the final design for the roadway shown in black (figure developed using Google Earth image and map data integration). Visual examination delivers compelling evidence of the high similarity between the design of the official I-269 and the results delivered by ECO-PAL. Numerical examination showed that the 1000-foot right of way corridor computed in a semi-automatic way from ECO-PAL fits 92.7% within the real 1000-foot right of way corridor as defined by MDOT.

9.0 HIGHLIGHTS, NEXT STEPS, AND CONCLUSIONS

Traditional approaches to the EIS process may be enhanced through the application of CRS&SI technologies. Commercial remote sensing and spatial information provide rich and abundant sources of data that may be used to add value and efficiency to a plurality of practical applications in EIS and planning processes. Just as black and white image photography and scanned data products are giving way to digital image products, iterative manual EIS processes may be replaced by automated CRS&SI technologies in data-driven analysis that enable consideration of diverse factors as well as collaborative decision making.

KEY BENEFITS

- Remote sensing data collection early in a project provides a rich set of resources useful through the project life cycle – A "Collect Once and Use Many" approach may be applied, and data may be readily shared across the project and DOT enterprise.
- The value of CRS&SI has been broadly recognized and the technology is "prime-time" but requires case studies of national relevance to identify best practices and guidelines.
- Use of CRS&SI technologies have been successfully demonstrated and is presently used in multiple states through digital aerial orthoimagery, LIDAR, and efforts to compile data for key environmental and planning practices. Outreach is needed to guide the practice and inform the community of users for consistent, effective, and efficient implementation and application.
- CRS&SI technologies offer meaningful streamlining approaches that also offer the promise of strengthening and integrating various NEPA and pre-NEPA processes.
- Effective application of CRS&SI technologies in the EIS process demonstrates a commitment to preserve the intent of NEPA to consider all alternatives.

Barriers to Adoption

- Pilot applications must give way to case studies that work in real time alongside projects in production mode to deliver validated examples of best practices for practitioners with fully quantified costs and benefits.
- Best practices for data and applications deployed in case studies must be defined in terms of vital data inputs, alternative sources of data for analyses, and documented processing methods to enable transferability of applications.
- Case studies must be implemented in various regions to deliver understanding of how different geographic settings impact implementation and require adaptations.
- This method requires contracting, procurement, and implementation language that DOT practitioners can readily use to ensure that technologies are appropriately contracted, applied, and delivered as needed in actual project development practices. Science must be reduced to practice.

9.1 NCRST-SEPP Case Study Conclusions and Recommendations: Exemplary Case Studies to Validate Best Practices

The NCRST-SEPP project began with fundamental hypotheses that built upon past research success and the growing body of knowledge and expertise of transportation practitioners that project planning and environmental assessments can significantly benefit from the early acquisition of commercial remote sensing data, compilation of spatial data, and use of spatial information technologies and analyses to advance the data-driven processes involved in transportation project development. These hypotheses were substantiated in the testbed study conducted for I-69 SIU #9 focusing on the I-269 bypass of Memphis, TN. Project findings strongly support the useful application of remote sensing and GIS data as well as geospatial technologies and automated analysis techniques to enhance decision making as well as the use and extension of advanced mapping techniques to enhance public participation and the exchange of environmental and planning data and products.

Factors Considered: The NCRST-SEPP project considered factors that included CRS&SI data gathering and organization, project planning and background, characteristics and conditions of the transportation system, public participation and process, social conditions, environmental conditions, and corridor alignment planning and optimization approaches. Out of these project components several overarching areas of beneficial applications and barriers to success emerged. The successful implementation of CRS&SI in the transportation project planning and development process can offer significant enhancements, and the capabilities can be stated as being very close to a technology readiness level for operational deployment given that underlying governing conditions or limiting factors are met and addressed.

Governing Conditions: The governing conditions that must be met to enable CRS&SI enhanced project development are summarized as follows:

- ***Catalog Compilation:*** Compilation of a complete catalog of CRS&SI data available to the project began at the onset of the project. A GeoData Catalog was created and someone on the project team was empowered and responsible for updating the catalog and informing participants about important changes, especially when new data sets of importance are "checked-in" and available to the team.

- ***Gap Analysis:*** Identification of gaps in key data sets across the project area was conducted. This analysis was needed to overcome disparities in data availability. It exposed the "patchwork quilt nature" of geospatial data and capabilities frequently encountered in cases when the project covers multiple governmental units whether they be state or local. In the case of the I-269 testbed, the project covered multiple counties in Mississippi and Tennessee. A geospatial technology and data "divide" was identified that showed sharp distinction between the geospatial "haves" and the "have not's."

- ***Shared Commitment:*** Commitment on the part of agency management, practitioners, staff, and contractors to procure, maintain, and exchange CRS&SI data needed to further aspects of project development. Although there is often reluctance on the part of agencies to exchange data, relationships among practitioners that build trust and willingness to collaborate with other professionals is vital to successful implementation.

- ***Acquisition and Stewardship:*** Acquisition of commercial remote sensing data as well as key GIS data at the onset of the projects that meet the needs of various groups and contractors participating in the project. For each data set identified it was also important to identify the owner or "steward" of that data set so that key questions could be answered about freshness, consistency, completeness, correctness, and other characteristics of the data could be considered and documented.

(Governing Conditions Continued)

- ***Interagency Coordination:*** Early coordination and data exchange among agencies across jurisdictions boundaries and multiple scales from federal, state, and local agencies and organizations.

- ***Champions:*** Within participating agencies, management support for geospatial champions is an important factor for enabling success. These champions are able to succeed most often when they are chartered, empowered to work within teams, and supported by strong institutional leadership.

- ***Institutional Limitations and Reluctance:*** Identification of data and information stovepipes within agencies and organization and overcoming reluctance to share data and buy in to use of commercial remote sensing data, GIS data, and geospatial information and related technologies.

- ***Technology Integration and Interoperability:*** Identification and implementation of CRS&SI technologies that readily and seamlessly utilize geodata for visualization, analysis, modeling, decision making, and providing useful and extensible results must be a central theme of project.

- ***E-Deliverables:*** There is a need for a shared vision that inputs, outputs, and products become part of enhanced e-deliverables that transcend the documentation and methods of final product or report delivery typical of current transportation projects; part-and-parcel of this vision is the requirement that projects make best use of and leverage geodata investments such as statewide data collections or major data collections that provide resources useful for project area studies.

Developing Exemplary Case Studies and Examples of Best Practices: There is an emerging awareness that geodata and GIS for planning and environmental linkages is becoming more of a case of deployment case studies and examples of best practices than a case of proving that the data and analysis methods deliver value.

Members of the research team, advisory panel, partner agencies, and all stakeholders without exception acknowledged that geodata, CRS&SI technologies, and advanced map analysis and products deliver major value. However, there remains the consistently echoed question, "How do we [as practitioners] move forward to fully implement these things as fundamental to our standard methods for doing our jobs and conducting the business of transportation project development?"

What emerges from the NCRST-SEPP and other efforts such as the peer review conducted by Volpe in 2008 is that there is an underlying needs to developing exemplary "deployment case studies" to identify and validate best practices. While enhancements and streamlining benefits have been identified, there remain significant hurdles that must be overcome. These hurdles include domain availability, expertise, and acceptance of needs for data, methods, and accepted standard applications for CRS&SI in basic mapping, overlay analysis, constraints and screening analysis, enhanced modeling, and enhancement of decision-making processes. Furthermore, there is a need for developing top-down and bottom-up support for fostering, developing, refining, and deploying best-practices in CRS&SI technologies in PEL. Fundamental to addressing these needs are standards, methods, and common identification of factors and requirements leading to the successful identification and implementation of best practices.

Characteristic Requirements for Best Practices Deployment Case Studies: Out of the NCRST-SEPP project, several areas can be substantively stated as offering significant promise to enhance the transportation project development process and can be considered as key benefits that may be realized. These key benefits or areas of enhancement opportunity that emerged from the NCRST-SEPP project can be stated in terms of case-study requirements, presented here as desired characteristics.

Characteristic requirements of deployment case studies to validate and further quantify performance benchmarks for best practices in delivering streamlining benefit to transportation projects are suggested and summarized as follows:

- DOT project partners have been identified, including a project champion from a DOT with geodata handling and analysis expertise. In conjunction with partner identification, an on-the-ground project in early stages has been identified as well as project tasks to be conducted in parallel using tradition methods side-by-side with CRS&SI methods [while protecting against bias by preventing early exchange of results]. This enables rigorous examination and comparison of results in ways that include cost benefit analysis as well as compilation of performance measures, comparison metrics, and overall benchmarking of the enhancements delivered.

- A multi-scale matrix or tabulation of geodata is developed for data acquisition, compilation, exchange, use and management in approaching best-practice projects emphasizing standardization of data and sources needed for various aspects of the project development process.

- Fundamental project base maps are prepared using enhanced methods that enable exchange, understanding, and comprehension of the key factors that are routinely considered in developing a specific transportation project.

- Social, cultural, environmental, economic, and ecological base maps are developed that contain data of relevance for top-down and bottom-up consideration. This implies that data included comprise multi-scale data from federal, state, and local sources.

- Preliminary conditions maps are prepared with key layers and fresh (up-to-date information) content that fully address the concerns of stakeholders, resource agencies, planning organization, and transportation departments involved in the project.

- Key modeling and analysis components of the transportation development process, from economic modeling to transportation to traffic to noise, and other areas, as fully as practicable implement CRS&SI technologies in refining inputs, data preprocessing, model enhancement, presentation of model results, and visualization of model outputs to deliver understanding of analysis in ways that transcend the data tabulation and presentation typical of the traditional EIS and project development approach.

- Automated constraints and environmental screening maps are prepared that contain key factors of concern, and these maps are provided to stakeholders (in easily shared and edited formats such as GeoPDF) as part of a process that captures how stakeholders and decision makers value specific environmental, cultural, social, economic, and ecological factors that influence the project's development.

(Characteristic Requirements Continued)

- Automatic methods are employed via GIS-enabled multi-criteria decision making (MCDM) in a manner that incorporates the plurality of values expressed about the project to guide and enables the implementation of specific scenarios, resulting in automated corridor boundaries and general project boundary areas that meet the purpose and needs of the project ("PEL Corridors" as opposed to engineering least-cost path designs). These methods also establish a set of initial feasible corridor alignments that preserve the intent of NEPA to consider all possible alternatives in arriving at a subset of feasible project alternatives.

- Screening methods are deployed that enable rapid elimination of non-viable alternatives by utilizing constraints and screening of key environmental, cultural, social, economic, and ecological layers. These methods enable efficient, effective, seamless, and completely reproducible results for removing alternative alignments from consideration. They produce results easily depicted, explained, and understood and provide a mechanism for conflict management and avoidance, helping to head off needless disputation or non-productive project opposition.

- Refinement methods are employed that downselect feasible alternatives to favored and finally to a preferred alternative. Furthermore, insertion of highly detailed local data is utilized to further refine potential alignments as well as to assist in the evaluation of alternatives to arrive at final alignments to go forward for full engineering analysis and design.

- Geodata, maps, and analysis products are provided as electronic deliverable products (e-deliverables) that may be effectively used by participants and readily adjusted, stored, shared, and used to provide vital feedback to ongoing and long-range planning for the area.

FINAL WORDS

The NCRST-SEPP project team appreciates the opportunity to conduct this vital research project in support of USDOT RITA and welcomes opportunities for meaningful exchanges to extend the results of the project to deliver meaningful benefit to the community of practitioners. The team welcomes feedback about this Technical Guide and is open to discussion as to the design and execution of future deployment case studies for the purpose of furthering the understanding and refinement of best practices for the appropriate use and application of CRS&SI technologies.

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