Christy Johnson

Christy Johnson is an environmental and regulatory compliance coordinator for Georgia Transmission Corporation and project manager for the EPRI-GTC Overhead Electric Transmission Line Siting Methodology study. Ms. Johnson has served as a coordinator in GTC's Electric System Maintenance since 1996. Christy is responsible for environmental compliance at electric facilities in GTC's transmission and distribution system. She monitors construction sites for compliance with federal and state environmental regulations, providing designs and implementation plans for remedial site stabilization projects. Christy provides technical assistance to internal planning, legal and maintenance staffs and has been called upon to provide expert testimony to state environmental regulatory agencies. Her previous work with Soil Systems Incorporated involved archaeological investigations of historic and prehistoric sites. Christy was responsible for the coordination of several cultural resource surveys and mitigation projects in Maryland, South Carolina and Delaware. Christy holds a Bachelor of Arts in Anthropology and a Master of Landscape Architecture from the University of Georgia in Athens.

Dr. Elizabeth A. Kramer

Dr. Liz Kramer received her B.S. in Forest Resources from Michigan State University, her Masters in Forest Science from the Yale School of Forestry and Environmental Studies, and her PhD in Ecology from the University of Georgia. She is currently a public service assistant and the director of the Natural Resource Spatial Analysis Laboratory (NARSAL) at the Institute of Ecology, College of Environment and Design. The mission of NARSAL is to conduct research, training and public service and outreach in the application of geospatial technology to natural resource management and planning. A primary goal is to conduct work in an interdisciplinary fashion to bring ecological science to the environmental policy arena.

Some projects that the lab is involved with include: GIS and remote sensing analysis for a multi-disciplinary study of stream structure and function in the Chattahoochee watershed; the integration of landscape, geomorphic and biological indicators for understanding water quality in Piedmont streams in the Etowah Watershed; Georgia GAP and the SE Regional GAP, a biodiversity mapping program; the development of a GIS enabled Greenspace Planning tool; Georgia Land Use Trends Project (GLUT), an analysis of 25 years of land use change for the State of Georgia; the development of a Regional Greenspace Plan with local governments in the Upper Etowah River Watershed; and the development of a multi-species aquatic Habitat Conservation Plan for the Upper Etowah Watershed.

Steven Richardson

Steven Richardson's practice focuses on representing companies, Tribes and individuals on land and water issues before the U.S. Departments of the Interior, Agriculture and Energy; other federal agencies; the U.S. Congress; and state and federal courts. He specializes in providing strategic, legal and legislative counseling for clients seeking project approvals for the use and occupation of federal, state, Tribal and private lands. Mr. Richardson has three decades of public and private experience in using sound science, innovative strategies and cutting-edge technology to design, develop and expedite the approvals that get projects built on time and at lower cost, using state of the art environmental documentation techniques and innovative project management solutions.

Prior to joining Van Ness Feldman, Mr. Richardson served for five years as the chief of staff for the Bureau of Reclamation, where he oversaw the daily operation of the largest wholesaler of water in the country, serving more than 31 million people and providing water for farmland that produces sixty percent of the nation's vegetables and twenty-five percent of its fruits and nuts, and producer of more than 40 billion kilowatt hours of electricity each year. During his tenure at the Department of the Interior, Mr. Richardson served for seven years as a principal policy advisor to Secretary of the Interior Bruce Babbitt. In that role, he directed the environmental compliance, habitat conservation planning and mitigation activities for two federal agencies in daily contact and consultation with the U.S. Fish and Wildlife Service.

Mr. Richardson also served as the deputy director of the Bureau of Land Management and was responsible for the management and use of 264 million acres of land, about one-eighth of the land of the United States. Additional positions held by Mr. Richardson include: professional staff member and counsel to Congressman Mike Synar (D-OK), Chairman of the Environment, Energy and Natural Resources Subcommittee of the Government Operations Committee; senior counsel for The Wilderness Society; staff director and chief counsel to the House Oversight and Investigations Subcommittee of the Interior and Insular Affairs Committee (now the Resources Committee); and legislative counsel to Representative Edward Markey (D-MA). In addition, Mr. Richardson served as counsel on the U.S. Senate Judiciary Subcommittee on the Constitution, which was chaired by then-Senator Birch E. Bayh, Jr. (D-IN). Mr. Richardson is admitted to practice in the District of Columbia and the State of Indiana.

Chris Smith

Christopher D. Smith is a GIS analyst for Photo Science, Inc. Mr. Smith has more than seven years experience in Geographic Information Systems and Cartography. He has experience with ARC/INFO software, ArcView software, ArcIMS software, ArcSDE and Trimble GPS equipment and software. His experience with GIS includes cartographic design (including publishing a map in ESRI's annual ESRI map book), database design and development and creating, maintaining, and editing spatial data. He has performed geographic analysis on a wide variety of projects using GIS and other methods as tools. He also has experience with developing and designing geographic related web sites, as well as developing GIS custom applications. Mr. Smith has worked on site at Georgia Transmission Corporation for Photo Science, Inc. for five years. Previously, he worked with the Montgomery Water Works and Sanitary Sewer Board in Montgomery, Ala., as a GIS co-op through the University of North Alabama. He also worked for the International Fertilizer Development Center as a GIS intern. Chris holds a Bachelor of Science in Professional Geography from the University of North Alabama, with a Certificate in GIS.

Dr. Paul D. Zwick

Dr. Paul D. Zwick holds a Doctor of Philosophy in Environmental Engineering Science and a Master of Arts in Urban and Regional Planning. He is an associate professor and chair of the Urban and Regional Planning Department at the University of Florida. Dr. Zwick is also the director of the Geo-Facilities Planning and Information Research Center (GeoPlan), which was established in 1984 in the Department of Urban and Regional Planning at the University of Florida's College of Design, Construction and Planning. The center was developed in response to the need for a teaching and research environment in Geographic Information Systems (GIS). His research emphasis has been directed at the design, development and analysis of paradigms used for computer applications in urban and environmental planning, and engineering. Specifically, Dr. Zwick's research efforts have been directed at the analysis and design of dynamic models and the use of spatial analysis systems, commonly referred to as geographic information systems. For the past four years, he has been the principal investigator for the development of an environmental geographic information system for the Florida Department of Transportation and for the Florida Geographic Data Library. The FGDL is a data library for the dissemination of GIS data to the citizens of Florida, including middle schools and high schools, libraries, planning agencies, private corporations and businesses, and citizens. Dr. Zwick recently completed a five year project, as co-principal investigator, with a team of multidisciplinary researchers to identify and locate statewide greenway corridors and recreational trails. Dr. Zwick is continuing his greenways work as co-principal investigator for a grant with the U.S. Department of Environmental Protection, locating greenway opportunities in the Southeastern United States. This work has been in progress for the past two years and is expected to become an ongoing funded project with the EPA.

Contributors

Also contributing significantly to the EPRI-GTC research effort were Georgia Transmission's Herschel Arant, Bob Fox, R. Vince Howard and John Lasseter.

B
LIST OF ACRONYMS AND GLOSSARY OF TECHNICAL TERMS

List of Acronyms

AHP	Analytical Hierarchy Process
CEQ	Council on Environmental Quality
DEM	Digital Elevation Model
EPRI	Electric Power Research Institute
FEMA	Federal Emergency Management Agency
GAP	National GAP Analysis Program
GDT	Geographic Data Technologies
GeoPlan	Geo-Facilities Planning and Information Research Center
GIS	Geographic Information System
GLUT	Georgia Land Use Trends
GPC	Georgia Power Company
GTC	Georgia Transmission Corporation.
IMM	Interactive Mapping Methodology
ITS	Integrated Transmission System
LCP	Least Cost Path
MEAG	Municipal Electric Authority of Georgia
NARSAL	Natural Resource Spatial Analysis Laboratory
NEPA	National Environmental Protection Act
NLCD	National Land Cover Dataset
NPHP	National Register of Historic Places
NWI	National Wetland Inventory
NWR	National Wildlife Refuge

PSI	Photo Science Inc.
RUS	Rural Utility Service
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFW	United States Fish and Wildlife
USGS	United States Geological Survey

Glossary of Terms

Access Roads – Existing or new corridors that provide vehicular access to transmission line rights-of-way for construction and maintenance activities.

Accumulated Cost Surface – A grid-based map indicating the total "cost" of routing a linear feature from a starting location to all other locations in a project area by the optimal (least cost) path.

Analytic Hierarchy Process (AHP) – A decision-making process designed to help groups set priorities and make the best decision possible when both qualitative and quantitative aspects of a problem need to be considered. By reducing complex issues to a series of pairwise comparisons and then synthesizing the results, AHP not only helps decision-makers arrive at the best solution, but also provides a clear rationale for the decision reached. (From Expert Systems documentation)

Built Environment – An area of existing or proposed development found within the landscape, typically dominated by commercial, industrial, residential, and cultural structures.

Composite Suitability Surface – See Discrete Cost Surface.

Calibration – A set of graduations to indicate values or positions.

Criteria – A standard on which a judgment or decision may be based.

Derived Data – The result of applying analytical procedures to existing data to generate new information, as opposed to Source Data that is field-collected or obtained from a reputable data warehouse.

Delphi Process – A traditional method developed to obtain the most reliable consensus among a group of experts by a series of questionnaires interspersed with controlled feedback; the process offers a structured method of consultation that may reduce bias and allow groups of individuals as a whole to resolve a complex problem.

Discrete Cost Surface – A grid-based map indicating the relative "goodness" for locating a route at any location within a project area considering a multiple set of criteria map layers. Most often the surface's range of values are from 1=most preferred through 9=least preferred. Excluded areas are assigned a value of null or no-data. Also termed a Composite Suitability Surface.

Electric Power Research Institute (EPRI) – A non-profit research-based organization presently serving over 1000 energy organizations worldwide, founded in 1973 to provide technology-based and environmental solutions for the energy industry and society by managing a comprehensive program of scientific research, technology development, and product implementation.

Exclusion – A feature completely eliminated or removed from the analytical process; past research and committee debate has deemed these features to be unsuitable for siting of transmission facilities; justified need will allow for rare exceptions to be included within the model on a case by case basis (i.e., military bases).

Expert Choice – A software application developed in 1983 to assist the group decision making process; based on AHP principles, this application provides a medium whereby through the prioritization of multiple variables and assessment, decision makers can attain solutions to critical organizational issues.

Feature – In the EPRI research project, these are represented within the Siting Model conceptual diagram as yellow boxes. These features will serve as the base for the grids used to generate suitability surfaces.

Geographic Information Systems (GIS) – An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.

Georgia Transmission Corporation (GTC) – A statewide non-profit electric utility cooperative providing transmission services to rural energy customers since 1993. Prior to then, GTC was a part of Oglethorpe Power Corporation a generation and transmission cooperative formed in 1974. GTC is member-owned by 39 regional Electric Membership Cooperatives (EMCs) throughout Georgia that serve more than 3 million residential, commercial, and industrial customers.

Impedance – The amount of resistance (or cost) required to traverse a line from its origin to its destination node or to make a turn (i.e. move from one arc thru a node to another arc). Resistance may be a measure of travel distance, time, speed, or travel times the length, etc. Higher impedance indicates more resistance to movement, with 0 indicating no cost. Often, a negative impedance value or null value indicates an absolute barrier that cannot be transversed. (From ArcInfo Glossary)

Layer – In the EPRI research project, these are represented within the Siting Model conceptual diagram as green boxes. These layers are grids representing various aspects of suitability, such as slope, building density, proximity to cultural resources, etc.

Layer Weights – A percentage assigned to a specific layer of data based on its preference or importance as relative to the remaining variables in a given comparison of features or perspectives.

Least Cost Path – The path, among possibly many, between two points that has the lowest traversal "cost." In this definition, "cost" is a function of time, distance, or other factors defined by the user. See also impedance. (From ArcInfo Glossary)

Least Preferred Path – A route that is modeled or created by a mathematical algorithm, which analyzes suitability scores determined by features in a given study area. The path in theory connects point A to point B or points in between by recognizing the least suitable areas between the source points.

Linear Infrastructure – An existing network or system in a given area composed of transportation or utility based facilities (i.e. roads, highways, railways, pipelines, and transmission lines).

Macro Corridors – Large, uninterrupted, and irregular paths which are developed by multiple models to in order to define a study area for more detailed analyses.

Methodology – A set of methods and procedures used to solve a problem.

Metadata – A document referencing the critical details of a spatial dataset; this information provides important aspects of the dataset, such as its source, author, date of creation, scale and appropriate uses.

Model – A representation of reality used to simulate a process, understand a situation, predict an outcome, or analyze a problem. A model is structured as a set of rules and procedures, including spatial modeling tools available in a geographical information system (GIS). (From ArcInfo Glossary)

Most Preferred Path – A route that is modeled or created by a mathematical algorithm, and analyzes suitability scores determined by features in a study area. The path connects point A to point B or points in between by utilizing the most suitable areas, which are contiguous betweens the source points.

Natural Environment – Naturally occurring physical features of the landscape. These features are represented by the hydrography, flora, fauna, and topography of a given area.

Optimal Route – The most desirable or suitable location for a transmission line route.

Orthophotography – Aerial photography that has been rectified such that it is equivalent to a map of the same scale. It is a photographic map that can be used to measure true distances, an accurate representation of the earth's surface.

Pair-Wise Comparison – A structured comparison of two variables to determine preferences.

Perspective – In the Siting Methodology, alternatives for corridors selection have been standardized to represent community values (Built Environment), protection of biotic resources (Natural Environment), and engineering considerations (Engineering Requirements). They are represented within the Siting Model conceptual diagram as blue boxes.

Sensitive Areas – Areas on a map that are susceptible to degradation from proposed construction or maintenance activities.

Siting Model – A multi-tiered conceptual framework developed to calculate and assess alternatives in siting transmission facilities.

Source Data – Base data that is field-collected or obtained from a reputable data warehouse, as opposed to Derived Data that is the result of applying analytical procedures to existing data to generate new information. For example, a building centroid dataset is source data that is not used directly in the model. However, Building Density and Building Proximity are derived from the source data.

Stakeholders – External individuals with vested interest in an issue or problem, such as the more than 400 officials from government, utilities, academia and community groups that took part in the EPRI-GTC study.

Study Area – An area delineated to encompass the necessary extent for analysis of a routing or siting problem. Data consisting of aerial photography, land ownership, environmental constraints, and cultural features is collected and later analyzed within this study area to determine a preferred path and a composite of alternatives for a transmission facility.

Transmission Line – A power line that typically serves as a means of transporting electric energy from generation facilities to users.

Visual Exposure (VE) – A grid-based map value indicating the number of times a location is seen from a set of "viewer" locations, such as a group of houses (points), a network of roads (lines) or set of identified suburban subdivisions (polygons).

C
GEOGRAPHIC INFORMATION SYSTEMS METADATA

Engineering

Linear Infrastructure

Rebuild Existing Transmission Lines

GIS Layer(s): GTC Transmission Lines; ITS Transmission Lines

Methodology: Existing transmission lines are buffered depending on the width of the transmission line right of way

Source: Georgia Transmission Corporation

Note: This data set was created from GPS points acquired from helicopter reconnaissance in 1997; Transmission lines since that time have been added from X,Y coordinates of structures supplied by GTC Transmission line designers

Scale/Accuracy: Sub-Meter

Source: Georgia Power Company

Note: This data set was created from GPS points acquired from helicopter reconnaissance in 1997

Methodology of updating facilities is unknown at this time

Scale/Accuracy: Sub-Meter

Parallel Existing Transmission Lines

GIS Layer(s): GTC Transmission Lines; Other ITS Transmission Lines

Methodology: Existing transmission lines are buffered depending on the width of the transmission line right of way the derived data is a buffer from the previous buffer, which represents the area needed for an additional transmission line adjacent to the existing utility corridor

Source: Georgia Transmission Corporation

Note: This data set was created from GPS points acquired from helicopter reconnaissance in 1997 Transmission lines since that time have been added from X,Y coordinates of structures supplied by GTC Transmission line designers

Scale/Accuracy: Sub-Meter

Source: Georgia Power Company

Note: This data set was created from GPS points acquired from helicopter reconnaissance in 1997

Methodology of updating facilities is unknown at this time

Scale/Accuracy: Sub-Meter

Parallel Gas Pipelines

GIS Layer: Pipelines

Methodology: The existing pipeline is buffered depending on the width of the pipeline ROW plus the area needed for an additional transmission line ROW

Source: Georgia Department of Transportation

Note: This dataset contains utility pipelines and transmission lines Features were captured from the Georgia Department of Transportation's General Highway Base Map This data set does not include all utility pipelines and transmission lines Distributed by: Georgia GIS Data Clearinghouse

All pipelines are selected from the dataset The utility map was clipped and reprojected from UTM 83 Zone 16 The dataset is also enhanced by digitizing pipelines from the Georgia ITS (Integrated Transmission System) book and Aerial Photography

Scale/Accuracy: 1:31,680

Parallel Roads

GIS Layer(s): Streets; Tax Parcel Map

Methodology: The road ROW is buffered to represent the area needed for a transmission line along the secondary paved roads

Source: Geographic Data Technology – Dynamap/1000 v 110

Note: This dataset contains public roads including interstates, state highways, county roads, and city streets, which are classified by FCC code The layers where provided for each individual county These layers where merged together

Scale/Accuracy: 1: 12,000 (+/-33')

Source: Various Counties Tax Assessor Offices

Note: Tax Assessor Maps are acquired from County Tax Assessor Offices to digitize Transportation Right of Ways and Special Parcels (see Special Parcel Metadata) or acquired in a digital coverage if available

Scale/Accuracy: Per County

Parallel Interstates ROW

GIS Layer(s): Streets; Tax Parcel Map

Methodology: The Interstate ROW is buffered to represent the area needed for a transmission line along the interstates

Source: Geographic Data Technology – Dynamap/1000 v 110

Note: This dataset contains public roads including interstates, state highways, county roads, and city streets, which are classified by FCC code The layers where provided for each individual county These layers where merged together

Scale/Accuracy: 1: 12,000 (+/-33')

Source: Various Counties Tax Assessor Offices

Note: Tax Assessor Maps are acquired from County Tax Assessor Offices to digitize Transportation Right of Ways and Special Parcels (see Special Parcel Metadata) or acquired in a digital coverage if available

Scale/Accuracy: Per County

Parallel Railway ROW

GIS Layer(s): Railroads; Tax Parcel Map

Methodology: The railway ROW is buffered to represent the area needed for a transmission line along the railway

Source: Geographic Data Technology – Dynamap/1000 v 110

Scale/Accuracy: 1:12,000 (+/- 33')

Source: Various Counties Tax Assessor Offices

Note: Tax Assessor Maps are acquired from County Tax Assessor Offices to digitize Transportation Right of Ways and Special Parcels (see Special Parcel Metadata) or acquired in a digital coverage if available

Scale/Accuracy: Per County

Road ROW

GIS Layer(s): Tax Parcel Map

Methodology: Transportation Row's are digitized from Tax Parcel Map using aerial photography as reference

Source: Various Counties Tax Assessor Offices

Note: Tax Assessor Maps are acquired from County Tax Assessor Offices to digitize Transportation Right of Ways and Special Parcels (see Special Parcel Metadata) or acquired in a digital coverage if available

Scale/Accuracy: Per County

Future GDOT Plans

GIS Layer(s): Future DOT Plans

Methodology: Not Applicable

Sources: GDOT Plans – digital or hard copy
Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: Plans that are received as digital CAD drawings are converted to ArcView GIS shapefiles and modified appropriately to generate a polygon coverage of the extent that will be effected by the Future Road

If the plans are received as hard copy drawings, these are digitized on screen using ArcView GIS and using Aerial Photography as reference

Scale/Accuracy: 1:12,000 (+/- 33')

Scenic Highways

GIS Layer(s): Parkways and Scenic Rivers; Tax Parcel Map

Methodology: The scenic highway ROW is buffered to represent the area to avoid along a scenic highway

Source: U.S. Geological Survey, Digital Line Graph Data – (Linear Federal Land Features of the United States – USGS)

Note: This file was originally digitized by the National Mapping Division based on the sectional maps contained in 'The National Atlas of the United States of America' published by the USGS in 1970; The sectional maps were updated during 1978-1981 and digitized in the early 1980s; The data were updated in 1995 using 1:1,000,000-scale and 1:2,000,000 scale Bureau of Land Management State base maps; These data were published on CD-ROM in 1995; Using Arc/INFO software, the DLG optional format files were converted to Arc/INFO coverage's using the DLGARC command Only linear federal land features and attribute information were extracted for inclusion ;The individual State coverages were then merged together using the Arc/INFO command APPEND

Scale/Accuracy: 1:2,000,000

Source: Various Counties Tax Assessor Offices

Note: Tax Assessor Maps are acquired from County Tax Assessor Offices to digitize Transportation Right of Ways and Special Parcels (see Special Parcel Metadata) or acquired in a digital coverage if available

Scale/Accuracy: Per County

Slope

Slope 0% – 15%; 15% - 30%; and > 30%

GIS Layer(s): Slope

Methodology: Reclassification: Reclassify to 0-15%; 16% - 30%; > 30%

Source: USGS 75 Min Digital Elevation Model

Note: The DEMs (Digital Elevation Models) for the study area were merged together in a seamless surface Using ESRI's slope algorithm, a slope surface was created

Scale/Accuracy: 1:24,000 (+/-40')

Intensive Agriculture

Center Pivot Irrigation

GIS Layer(s): Center Pivot Irrigation Agriculture Fields

Methodology: Not Applicable

Source: Aerial Photography

Note: The center pivot points were "heads-up" digitized as a point file using ArcView 32; The center of the irrigation pivot was used as its location Aerial photography taken is used as a geo-referenced image for center pivot location

The center pivots where buffer by a distance measured from the aerial photography; The buffer was edited depending of the rotation of the center pivot fields

Scale/Accuracy: 1:12,000 (+/-33')

Pecan Orchards

GIS Layer(s): Land Use/Land Cover

Methodology: Not Applicable

Source: Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The polygons were digitized on screen from imagery derived from aerial photographs taken on per project basis Data was collected through identification of land cover areas using ArcGIS Land Cover is compared to field gathered data to insure accuracy

Classifications: Natural Forests, Undeveloped land, Row Crops and Horticulture, Managed Pine Plantations, Pecan Orchard, Fruit Orchards, Mines and Quarries, Commercial/Industrial, Institutional, Recreational, Utility Right of Way, Transportation, Hydrology

Scale/Accuracy: 1:12,000 (+/-3333')

Fruit Orchards

GIS Layer(s): Land Use/Land Cover

Methodology: Not Applicable

Source: Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The polygons were digitized on screen from imagery derived from aerial photographs taken on per project basis Data was collected through identification of land cover areas using ArcGIS Land Cover is compared to field gathered data to insure accuracy

Classifications: Natural Forests, Undeveloped land, Row Crops and Horticulture, Managed Pine Plantations, Pecan Orchard, Fruit Orchards, Mines and Quarries, Commercial/Industrial, Institutional, Recreational, Utility Right of Way, Transportation, Hydrology

Scale/Accuracy: 1:12,000 (+/-3333')

Natural Environment

Public Lands

USFS

GIS Layer(s): Public Lands and Forests

Methodology: Not Applicable

Source: Georgia Department of Natural Resources, Georgia Department of Transportation County Maps

Note: This dataset provides 1:100,000-scale data depicting the locations of public lands within the State of Georgia It includes polygon representations of National, State and county parks; National and State historic sites; National Wildlife Refuges; National Wilderness Areas; Wildlife Management Areas; Wild and Scenic Areas; archaeological sites; off-road vehicle areas; U.S. Department of Agriculture land; and other areas The data were collected and located by the Georgia Department of Natural Resources (GADNR) and the U.S. Geological Survey (USGS) The locations were mapped onto existing 1:100,000-scale maps and also digitized from existing mylar maps Data was previously collected in 1986-87 by GADNR and USGS from existing 1:63,360- and 1:126,720-scale Georgia Department of Transportation County Maps which included State owned lands as well as existing county parks Much of this data was not updated in 1993

Scale/Accuracy: 1:100,000 (+/- 166')

WMA – State Owned

GIS Layer(s): DNR Managed Lands

Methodology: Not Applicable

Source: Georgia Department of Natural Resources

Note: This dataset provides 1:24,000-scale data depicting boundaries of land parcels making up the public lands managed by the Georgia Department of Natural Resources (GDNR) It includes polygon representations of State Parks, State Historic Parks, State Conservation Parks, State Historic Sites, Wildlife Management Areas, Public Fishing Areas, Fish Hatcheries, Natural

Areas and other specially designated areas The data were collected and located by the Georgia Department of Natural Resources Boundaries were digitized from survey plats, lines on U.S. Geological Survey 1:24,000-scale topographic maps that were added from land survey plat or other information, or already existed on the maps

Scale/Accuracy: 1:24,000 (+/- 40')

WMA – Non-State Owned

GIS Layer(s): DNR Managed Lands

Methodology: Not Applicable

Source: See WMA – State Owned

Other Conservation Land

GIS Layer(s): DNR Managed Lands

Methodology: Not Applicable

Source: See WMA – State Owned

Streams/Wetlands

Trout Streams (100' Buffer)

GIS Layer(s): Trout Streams

Methodology: Buffer trout streams by 100'

Source: Georgia Natural Heritage Program (GNHP), USGS 75 min Quadrangle

Note: USGS blue lines are selected that are identified by GNHP and converted to an individual layer

Scale/Accuracy: 1:24000 (+/-40')

Streams <5cfs Regulatory Buffer

GIS Layer(s): Streams greater or less than 5 cfs

Methodology: Buffer streams < 5 cfs by regulatory distance

Source: U.S. Army Corp of Engineers, USGS 75 Min Quadrangles

Note: This layer represents the streams or portions of streams that yield a stream flow greater than or equal to 5 cfs The basis for this theme is the USGS blue line layer A runoff coefficient of 16 cfs/mi^2 for streams in this basin was used to determine the land area of a basin that will be drained before the water reaches a flow of 5 cfs It was determined that the land area required to generate such a flow in this basin is approximately 313 mi^2 Drainage basins were delineated to find those with total land areas at these limits Streams below the lower boundary of each basin and subsequent downstream reaches were selected as those with flows of greater than 5 cfs

Accuracy/Scale: 1:24,000 (+/-40)

Rivers/Streams >5cfs Regulatory Buffer

GIS Layer(s): Streams greater or less than 5 cfs

Methodology: Buffer rivers/streams > 5 cfs by regulatory distance

Source: See Streams <5cfs Regulatory Buffer

Forested Wetlands and 30' Buffer

GIS Layer(s): Land Cover/Land Cover; Hydric Soils; National Wetlands Inventory

Methodology: Intersect National Wetlands Inventory with Hydric Soils (if available) Land Cover All wetlands that fall within Hardwood and Mix Forests and Managed Pine Plantations are considered NWI forested wetlands Buffer the intersected wetlands by a 30' distance

Source: Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The polygons were digitized on screen from imagery derived from aerial photographs taken on per project basis Data was collected through identification of land cover areas using ArcGIS Land Cover is compared to field gathered data to insure accuracy

Classifications: Natural Forests, Undeveloped land, Row Crops and Horticulture, Managed Pine Plantations, Pecan Orchard, Fruit Orchards, Mines and Quarries, Commercial/Industrial, Institutional, Recreational, Utility Right of Way, Transportation, Hydrology

Scale/Accuracy: 1:12,000 (+/-3333')

Source: Soil Survey of Georgia Counties, United States Department of Agriculture, Soil Conservation Service

Scale/Accuracy: 1:24,000 (+/- 40')

Source: U.S. Fish and Wildlife Service National Wetlands Inventory

Note: All NWI maps for the state of Georgia were reprojected from UTM NAD 83 Zone 16 & Zone 17 meters to Geographic NAD83 Decimal Degrees and merged into one layer

Scale/Accuracy: 1:24,000 (+/-40')

Non-Forested Wetlands and 30' Buffer

GIS Layer(s): Land Cover/Land Cover; Hydric Soils; National Wetlands Inventory

Methodology: Intersect National Wetlands Inventory and Hydric soils (if available) with Land Cover All wetlands that fall outside Hardwood and Mix Forests and Managed Pine Plantations are considered NWI non-forested wetlands Buffer the intersected wetlands by a 30' distance

Source: See Forested Wetlands and 30' Buffer

Non-Forested Costal Wetlands and 30' Buffer

GIS Layer(s): Land Cover/Land Cover; Hydric Soils; National Wetlands Inventory

Methodology: Intersect/Buffer: Intersect National Wetlands Inventory and Hydric Soils (if available) with Land Cover All wetlands that fall outside Hardwood and Mix Forests and Managed Pine Plantations are considered NWI non-forested wetlands Buffer the intersected wetlands by a 30' distance

Source: See Forested Wetlands and 30' Buffer

Floodplain

GIS Layer(s): 100 year floodplain

Methodology: Not Applicable

Source: Flood Insurance Rate Maps, USGS 75 min Quadrangle

Note: The Q3 FEMA FLOODPLAIN DATA are downloaded from the Georgia GIS Clearinghouse The layer is checked for spatial integrity by comparing the flood coverage a USGS 75 min quadrangle If the Flood zones do not align with the topology and blue lines on the USGS 75 min Quadrangles, the polygons were "heads-up" digitized using ArcGIS Digital USGS Topographic maps were used as a guide Flood Insurance Rate Maps were used as a source

Scale/Accuracy: 1:24,000 (+/- 40')

Land Cover

Hardwood and Mixed Forests

GIS Layer(s): Land Use/Land Cover

Methodology: Not Applicable

Source: Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The polygons were digitized on screen from imagery derived from aerial photographs taken on per project basis Data was collected through identification of land cover areas using ArcGIS Land Cover is compared to field gathered data to insure accuracy Classifications: Natural Forests, Undeveloped land, Row Crops and Horticulture, Managed Pine Plantations, Pecan Orchard, Fruit Orchards, Mines and Quarries, Commercial/Industrial, Institutional, Recreational, Utility Right of Way, Transportation, Hydrology

Scale/Accuracy: 1:12,000 (+/-3333')

Undeveloped Land (Pastures, Scrub/Shrub, Clear Cut, and Abandoned Fields)

GIS Layer(s): Land Use/Land Cover

Methodology: Not Applicable

Source: See Hardwood and Mixed Forests

Row Crops and Horticulture

GIS Layer(s): Land Use/Land Cover

Methodology: Not Applicable

Source: See Hardwood and Mixed Forests

Managed Pines

GIS Layer(s): Land Use/Land Cover

Methodology: Not Applicable

Source: See Hardwood and Mixed Forests

Developed Land

GIS Layer(s): Land Use/Land Cover

Methodology: Merge all Urban Land Use/Land Cover Categories

Source: See Hardwood and Mixed Forests

Wildlife Habitat

Species of Concern

GIS Layer(s): Species of Concern Habitat

Methodology: Not Applicable

Source: *University of Georgia*

Scale/Accuracy: *1: 24,000 (+/-40')*

Natural Areas

GIS Layer(s): Natural Areas

Methodology: Not Applicable

Source: *University of Georgia*

Scale/Accuracy: *1: 24,000 (+/-40')*

Built Environment

Eligible NRHP Structures

GIS Layer(s): Historic Structures

Methodology: Buffer Eligible NRHP Buildings 1500'

Source: Architectural Historic Consultant, USGS 75 Minute Quadrangles
Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: Structures are field surveyed and determined NRHP (National Register of Historic Places) listed, eligible, possibly eligible, not eligible by an Architectural Historian All structures that are listed, eligible, or possibly eligible are mapped by placing a centroid at the approximate center of the structure using USGS 75 Minute Quadrangles and best available photography

Scale/Accuracy: 1:24,000 (+/-40')

Building Density

GIS Layer(s): Buildings Centroids

Methodology: A density surface is created from building centroids within the study area and is classified by six defined: 0-005 bldg/ac, 005-02 bldg/ac, 02-1 bldg/ac, 1-4 bldg/ac, 4-25 bldg/ac, and 25+ bldg/ac

Source: Aerial Photography taken per project basis, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The building centroids were digitized on screen using ArcGIS software Aerial photography is used as a geo-referenced image for building location identification

Building for all projects are stored in an Oracle table named RTE_BUILDINGS as SDE layers Buildings are collected on a per project basis

Scale/Accuracy: 1:12,000 (+/- 3333')

Proximity to Buildings

GIS Layer(s): Buildings Centroids; Building Footprints

Methodology: All buildings not represented in building footprints are given a 40' buffer to represent the extent of the smaller structures A proximity surface is created from the Building buffers and the Building Footprints, and is classified into four defined categories: (0-300', 300-600', 600-900', 900-1200')

Source: Aerial Photography taken per project basis, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The building footprints were digitized on screen using ArcGIS software Only buildings of certain size have their footprints digitized For example buildings that appear to be commercial buildings, industrial buildings, hospitals, government buildings, agricultural buildings, special structures such as water towers are utility type structures (water stream plants, power plants, etc...) and Apartment/Condo Buildings Aerial photography is used as a geo-referenced image for building footprint delineation

Scale/Accuracy: 1:12,000 (+/-3333')

Source: Aerial Photography taken per project basis, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The building centroids were digitized on screen using ArcGIS software Aerial photography is used as a geo-referenced image for building location identification

Building for all projects are stored in an Oracle table named RTE_BUILDINGS as SDE layers Buildings are collected on a per project basis

Scale/Accuracy: 1:12,000 (+/- 3333')

Spannable Lakes and Ponds

GIS Layer(s): Lakes and Ponds

Methodology: Proximity: A proximity surface is created from Day Care Parcel, School Parcel (K-12), and Church Parcel is classified by nine defined categories: (0-100', 100-200', 200-300', 300-400', 400-500', 500-750', 750-1000', 1000-1500', 1500'+)

Source: Georgia Department of Transportation

Note: This dataset contains polygonal hydrologic features, including lakes, ponds, reservoirs, swamps, and islands Data were captured from Mylar separates containing the "blue-layer" from the U.S. Geologic Survey's 1:24,000-scale quadrangle maps Individual quadrangles were combined and edge matched using Arc/Info GIS software, and then clipped into individual county tiles using boundary data from the Georgia Department of Transportation's 1:31,680-scale County General Highway Maps

Scale/Accuracy: 1:24,000

Proposed Development

GIS Layer(s): Proposed Developments Plans accepted by local government.

Methodology: Not Applicable

Sources: Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

County Planning and Development Departments

Note: Proposed Developments are digitized on screen using orthophotography and the Development Plans as sources

Scale/Accuracy: 1:24,000 (+/- 40')

General Land Divisions

Edge of Fields

GIS Layer(s): Land Use/Land Cover

Methodology: The perimeters of areas classified as Agriculture are buffered by the width of the proposed transmission line easement Next the perimeter of areas classified as Planted Pine and Hardwood forests are buffered by the width of the proposed transmission line easement These two buffers are then intersected. Stream buffers are removed and visual interpretation of the resulting layer is performed to ensure only areas of opportunity are present

Source: Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The polygons were digitized on screen from imagery derived from aerial photographs taken on per project basis Data was collected through identification of land cover areas using ArcGIS Land Cover is compared to field gathered data to insure accuracy

Classifications: Natural Forests, Undeveloped land, Row Crops and Horticulture, Managed Pine Plantations, Pecan Orchard, Fruit Orchards, Mines and Quarries, Commercial/Industrial, Institutional, Recreational, Utility Right of Way, Transportation, Hydrology

Scale/Accuracy: 1:12,000 (+/-3333')

Land Lots

GIS Layer(s): Tax Parcel Maps

Methodology: Land lots are digitized using tax parcel maps and orthophotography The perimeters of land lots are buffered by the width of the proposed transmission line easement

Source: Various Counties Tax Assessor Offices

Note: Tax Assessor Maps are acquired from County Tax Assessor Offices to digitize Transportation Right of Ways and Special Parcels (see Special Parcel Metadata) or acquired in a digital coverage if available

Scale/Accuracy: Per County

Land Use

Undeveloped

GIS Layer(s): Land Use/Land Cover

Methodology: Merge all Land Use/Land Cover categories that are not Urban

Source: Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The polygons were digitized on screen from imagery derived from aerial photographs taken on per project basis Data was collected through identification of land cover areas using ArcGIS Land Cover is compared to field gathered data to insure accuracy

Classifications: Natural Forests, Undeveloped land, Row Crops and Horticulture, Managed Pine Plantations, Pecan Orchard, Fruit Orchards, Mines and Quarries, Commercial/Industrial, Institutional, Recreational, Utility Right of Way, Transportation, Hydrology

Scale/Accuracy: 1:12,000 (+/-3333')

Non-Residential

GIS Layer(s): Land Use/Land Cover

Methodology: Merge: Merge all Land Use/Land Cover categories that are Urban with the exception of Residential

Source: See Residential Land Use

Residential

GIS Layer(s): Land Use/Land Cover

Methodology: Not Applicable

Source: See Residential Land Use

Excluded Areas – *The Linear Infrastructure features are not included in the excluded areas. If existing corridors reside in these areas, it is acceptable to cross in existing corridors or parallel to existing corridors*

NRHP Listed Archeology Districts and Sites

GIS Layer(s): Archeology Sites

Methodology: Only listed sites are selected from database An Area of Potential Effect (APE) buffer may need to be created The APE buffer distance is a regulatory distance

Source: Georgia Archaeological Site Files (UGA, Athens)

Note: This layer represents as point data the archaeological sites within the study area as provided to GTC by consultants. The site files at the Georgia Archaeological Site Files (UGA, Athens) were researched to obtain information about previously identified archaeological sites Site centroids are based on UTM coordinates as recorded on State of Georgia Archaeological Site Forms through September 6, 2001 and were projected by Brockington from Easting and Northing coordinates in UTM NAD 27, Zone 16 into the coordinate system described below

Scale: Varies due to source

NRHP Listed Districts and Structures

GIS Layer(s): Historic Districts; Historic Structures

Methodology: An APE buffer will be created for Historic structures using 1,500 feet

Source: Architectural Historic Consultant, USGS 75 Minute Quadrangles

Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: Districts are field surveyed and determined NRHP (National Register of Historic Places) listed or eligible by an Architectural Historian All districts are mapped by placing a polygon of the approximate area of the district using USGS 75 Minute Quadrangles and best available photography

Scale/Accuracy: 1:24,000 (+/-40')

Source: Architectural Historic Consultant, USGS 75 Minute Quadrangles

Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: Structures are field surveyed and determined NRHP (National Register of Historic Places) listed, eligible, possibly eligible, not eligible by an Architectural Historian All structures that are listed, eligible, or possibly eligible are mapped by placing a centroid at the approximate center of the structure using USGS 75 Minute Quadrangles and best available photography

Scale/Accuracy: 1:24,000 (+/-40')

Eligible NRHP Districts

GIS Layer(s): Historic Districts

Methodology: Not Applicable

Source: Architectural Historic Consultant, USGS 75 Minute Quadrangles

Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: Districts are field surveyed and determined NRHP (National Register of Historic Places) listed or eligible by an Architectural Historian All districts are mapped by placing a polygon of the approximate area of the district using USGS 75 Minute Quadrangles and best available photography

Scale/Accuracy: 1:24,000 (+/-40')

Building + Buffers

GIS Layer(s): Footprints; Buildings Centroids

Methodology: Buffer Building Centroids by 40' and half the proposed transmission line easement width Buffer Building Footprints by half the proposed transmission line easement width

Source: Aerial Photography taken per project basis, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The building footprints were digitized on screen using ArcGIS software Only buildings of certain size have their footprints digitized For example buildings that appear to be commercial buildings, industrial buildings, hospitals, government buildings, agricultural buildings, special structures such as water towers are utility type structures (water stream plants, power plants, etc...) and Apartment/Condo Buildings Aerial photography is used as a geo-referenced image for building footprint delineation

Scale/Accuracy: 1:12,000 (+/-3333')

Source: Aerial Photography taken per project basis, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The building centroids were digitized on screen using ArcGIS software Aerial photography is used as a geo-referenced image for building location identification

Building for all projects are stored in an Oracle table named RTE_BUILDINGS as SDE layers Buildings are collected on a per project basis

Scale/Accuracy: 1:12,000 (+/- 3333')

Airports

GIS Layer(s): Airports

Methodology: Airports boundary adjusted to include glide path Glide paths are determined by the closest tree line or existing overhead utilities on either end of the airport runways

Source: Geographic Data Technology – Dynamap/1000 v 110

Note: This dataset contains all international and regional airports

The layers where provided for each individual county These layers where merged together

Scale/Accuracy: 1: 12,000 (+/-33')

EPA Superfund Sites

GIS Layer(s): EPA Superfund Sites

Methodology: Not Applicable

Source: U.S. EPA Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database

Note: This database can be accessed through the EnviroFacts Data Warehouse web site This site allows general users to access most EPA source databases regarding waste, water, toxics, air, radiation, and land The data can be accessed through the online Superfund Query Form found within the EPA's main web site Queries are made on a County basis, and the addresses of the individual sites will be used to geocode each of the sites The point file that is created will be overlain on aerial photography for the project study area The physical boundary of the sites will be delineated through visual interpretation of the photos

Scale/Accuracy: 1: 12,000 (+/-33')

Non-Spannable Water Bodies

GIS Layer(s): Lakes/Ponds

Methodology: Create an internal buffer of half the maximum span distance Next, union the Buffer with Lakes and Ponds Areas inside the Lakes/Ponds, but outside Buffer are Non-Spannable

Source: Georgia Department of Transportation

Note: This dataset contains polygonal hydrologic features, including lakes, ponds, reservoirs, swamps, and islands Data were captured from Mylar separates containing the “blue-layer” from the U.S. Geologic Survey’s 1:24,000-scale quadrangle maps Individual quadrangles were combined and edge matched using Arc/Info GIS software, and then clipped into individual county tiles using boundary data from the Georgia Department of Transportation’s 1:31,680-scale County General Highway Maps

Scale/Accuracy: 1:24,000

State and National Parks

GIS Layer(s): DNR Managed Lands; Public Lands and Forests

Methodology: Not Applicable

Source: Georgia Department of Natural Resources

Note: This dataset provides 1:24,000-scale data depicting boundaries of land parcels making up the public lands managed by the Georgia Department of Natural Resources (GDNR) It includes polygon representations of State Parks, State Historic Parks, State Conservation Parks, State Historic Sites, Wildlife Management Areas, Public Fishing Areas, Fish Hatcheries, Natural Areas and other specially designated areas The data were collected and located by the Georgia Department of Natural Resources Boundaries were digitized from survey plats, lines on U.S. Geological Survey 1:24,000-scale topographic maps that were added from land survey plat or other information, or already existed on the maps

Scale/Accuracy: 1:24,000 (+/- 40’)

Military Facilities

GIS Layer(s): Military Facilities

Methodology: Not Applicable

Source: Geographic Data Technology – Dynamap/1000 v 110

Note: This dataset was extracted from the Landmarks data layer, which is classified by FCC code The D10 FCC classification was selected out and converted to a shape file to represent military facilities

Scale/Accuracy: 1: 12,000 (+/-33’)

Mines and Quarries

GIS Layer(s): Land Use/Land Cover

Methodology: Not Applicable

Source: Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800', Pixel Resolution: 1'

Note: The polygons were digitized on screen from imagery derived from aerial photographs taken on per project basis Data was collected through identification of land cover areas using ArcGIS Land Cover is compared to field gathered data to insure accuracy

Classifications: Natural Forests, Undeveloped land, Row Crops and Horticulture, Managed Pine Plantations, Pecan Orchard, Fruit Orchards, Mines and Quarries, Commercial/Industrial, Institutional, Recreational, Utility Right of Way, Transportation, Hydrology

Scale/Accuracy: 1:12,000 (+/-3333')

City and County Parks

GIS Layer(s): Special Parcels

Methodology: Not Applicable

Sources: Aerial Photography, Control: Survey Grade GPS, Photo Scale: 1"=800',
Pixel Resolution: 1

County Tax Assessor

Note: Special Parcel boundaries are on screen digitized using aerial photography as a base map Tax Assessor Maps are used to determine boundary lengths and azimuths The record in the counties Tax Digest are linked to there corresponding parcel by the PIN (Parcel Identification Number), which is entered as an attribute at the time the parcel boundary is delineated

Scale/Accuracy: 1:24,000 (+/- 40')

Day Care Parcel

GIS Layer(s): Special Parcels

Methodology: Not Applicable

Source: See City and County Parks

Cemetery Parcel

GIS Layer(s): Special Parcels

Methodology: Not Applicable

Source: See City and County Parks

School Parcel (K-12)

GIS Layer(s): Special Parcels

Methodology: Not Applicable

Source: See City and County Parks

USFS Wilderness Area

GIS Layer(s): Public Lands and Forests

Methodology: Not Applicable

Church Parcel

GIS Layer(s): Special Parcels

Methodology: Not Applicable

Source: See City and County Parks

USFS Wilderness Area

GIS Layer(s): Public Lands and Forests

Methodology: Not Applicable

Wild/Scenic Rivers

GIS Layer(s): Parkways and Scenic Rivers

Methodology: A regulatory buffer is created for both sides of the Wild/Scenic River

Source: U.S. Geological Survey, Digital Line Graph Data – (Linear Federal Land Features of the United States – USGS)

Note: This file was originally digitized by the National Mapping Division based on the sectional maps contained in 'The National Atlas of the United States of America' published by the USGS in 1970 The sectional maps were updated during 1978-1981 and digitized in the early 1980s The data were updated in 1995 using 1:1,000,000-scale and 1:2,000,000 scale Bureau of Land Management State base maps These data were published on CD-ROM in 1995 Using Arc/INFO software, the DLG optional format files were converted to Arc/INFO coverages using the DLGARC command Only linear federal land features and attribute information were extracted for inclusion The individual State coverages were then merged together using the Arc/INFO command APPEND

Scale/Accuracy: 1:2,000,000

Ritual Importance

GIS Layer(s): Source currently unknown

Methodology: Not Applicable

Wildlife Refuge

GIS Layer(s): Public Lands and Forests

Methodology: Not Applicable

Source: Georgia Department of Natural Resources, Georgia Department of Transportation County Maps

Note: This dataset provides 1:100,000-scale data depicting the locations of public lands within the State of Georgia It includes polygon representations of National, State and county parks; National and State historic sites; National Wildlife Refuges; National Wilderness Areas; Wildlife Management Areas; Wild and Scenic Areas; archaeological sites; off-road vehicle areas; U.S. Department of Agriculture land; and other areas The data were collected and located by the Georgia Department of Natural Resources (GADNR) and the U.S. Geological Survey (USGS) The locations were mapped onto existing 1:100,000-scale maps and also digitized from existing mylar maps Data was previously collected in 1986-87 by GADNR and USGS from existing 1:63,360- and 1:126,720-scale Georgia Department of Transportation County Maps which included State owned lands as well as existing county parks Much of this data was not updated in 1993

Scale/Accuracy: 1:100,000 (+/- 166')

D
APPENDIX D

GIS Siting Model Techniques:

- **Least Cost Path,**
- **Delphi Process and**
- **Analytical Hierarchy Process**

Least Cost Path Algorithm for Identifying Optimal Routes and Corridors

Determining the best route through an area is one of the oldest spatial problems. Meandering animal tracks evolved into a wagon trail that became a small road and ultimately a super highway. While this empirical metamorphosis has historical precedent, contemporary routing problems involve resolving complex interactions of engineering, environmental and social concerns.

In the past, overhead electric transmission lines and other siting applications required thousands of hours huddling around paper maps, sketching hundreds of possible paths, and then assessing their feasibility to "eyeball" the best routes using a straight edge and professional experience. While the manual approach capitalizes on expert interpretation and judgment, often it is criticized as a closed process that lacks a defendable, documented procedure and fails to fully engage alternative perspectives of what constitutes a preferred route.

Routing Procedure

The use of the *Least Cost Path* (LCP) procedure for identifying an optimal route based on user-defined criteria has been used extensively in GIS applications for siting linear features and corridors. Whether applications involve movement of elk herds, herds of shoppers, or locating highways, pipelines or overhead electric transmission lines, the procedure is fundamentally the same — 1) develop a discrete cost surface that indicates the relative preference for routing at every location in a project area, 2) generate an accumulated cost surface characterizing the optimal connectivity from a starting location (point, line or area) to all other locations based on the intervening relative preferences, and 3) identify the path of least resistance (steepest downhill path) from a desired end location along the accumulated surface. See *Author's Note 1* for more information on applying LCP to routing applications.

Figure D-1 schematically shows a flowchart of the GIS-based routing procedure for a hypothetical example if siting an overhead electric transmission line that avoids areas that have high housing density, far from roads, near or within sensitive areas and have high visual exposure to houses.

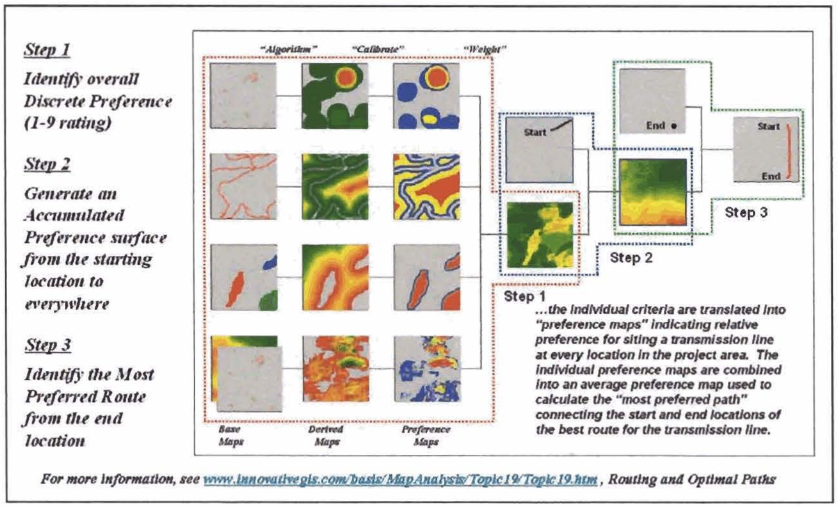

Figure D-1
GIS-Based Routing Uses Three Steps to Establish a Discrete Map of the Relative Preference for Siting at Each Location, Generate an Accumulated Preference Surface from a Starting Location(S) and Derive the Optimal Route from an End Point as the Path of Least Resistance Guided by the Surface

These four criteria are shown as rows in the left portion of the figure. The *Base Maps* are field collected data such as elevation, sensitive areas, roads and houses. *Derived Maps* use computer processing to calculate information that is too difficult or even impossible to collect, such as visual exposure, proximity and density. The discrete *Preference Maps* translate this information into decision criteria. The calibration forms maps that are scaled from 1 (most preferred—favor siting, gray areas) to 9 (least preferred—avoid siting, red areas) for each of the decision criteria.

The individual cost maps are combined into a single map by averaging the individual layers. For example, if a grid location is rated 1 in each of the four cost maps, its average is 1 indicating an area strongly preferred for siting. As the average increases for other locations it increasingly encourages routing away from them. If there are areas that are impossible or illegal to cross these locations are identified with a "null value" that instructs the computer to never traverse these locations under any circumstances.

Identifying Corridors

The technique generates accumulation surfaces from both the Start and End locations of the proposed power line. For any given location in the project area one surface identifies the best route to the start and the other surface identifies the best route to the end. Adding the two surfaces together identifies the total cost of forcing a route through every location in the project area.

The series of lowest values on the total accumulation surface (valley bottom) identifies the best route. The valley walls depict increasingly less optimal routes. The red areas in Figure D-2 identify all of locations that within five percent of the optimal path. The green areas indicate ten percent sub-optimality.

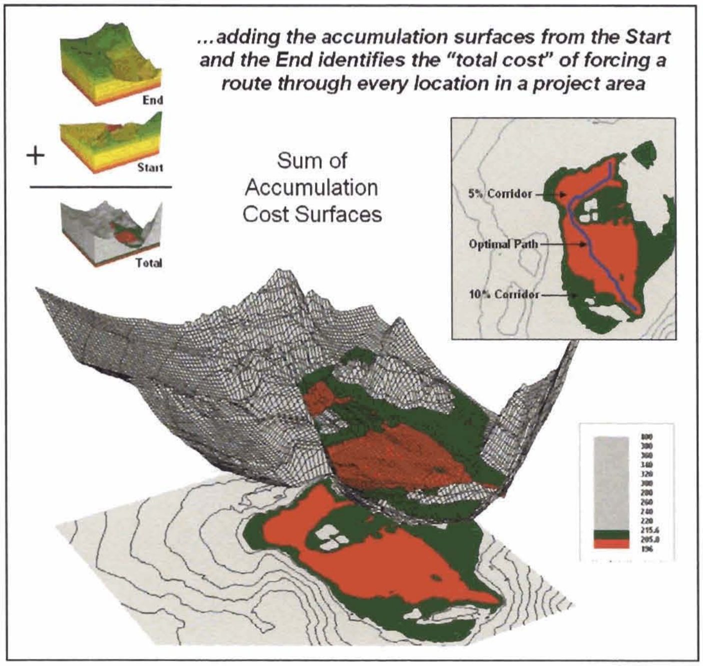

Figure D-2
The Sum of Accumulated Surfaces is Used to Identify Siting Corridors as Low Points on the Total Accumulated Surface

The corridors are useful in delineating boundaries for detailed data collection, such as high-resolution aerial photography and ownership records. The detailed data within the macro-corridor is helpful in making slight adjustments in centerline design.

Using the Delphi Process for Calibrating Map Criteria

Implementation of the LCP routing procedure provides able room for interpretation and relative preferences. For example, one of the criteria in the routing model seeks to avoid locations having high visual exposure to houses. But what constitutes "high" ...5 or 50 houses visually impacted? Are there various levels of increasing "high" that correspond to decreasing preference? Is "avoiding high visual exposure" more or less important than "avoiding locations near sensitive areas." How much more (or less) important?

The answers to these questions are what tailor a model to the specific circumstances of its application and the understanding and values of the decision participants. The tailoring involves two related categories of parameterization—calibration and weighting.

Calibration refers to establishing a consistent scale from 1 (most preferred) to 9 (least preferred) for rating each map layer used in the solution. Figure D-3 shows the result for the four decision criteria used in the routing example.

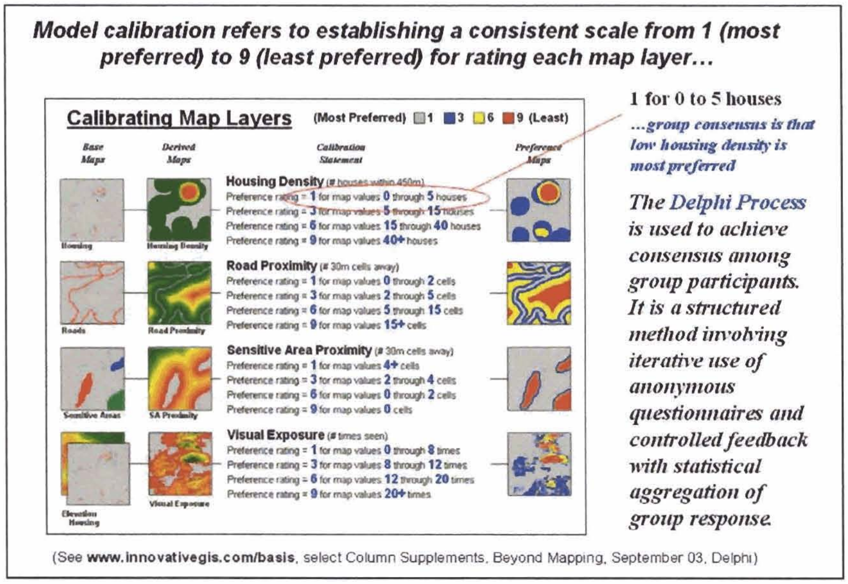

Figure D-3
The Delphi Process Uses Structured Group Interaction to Establish a Consistent Rating for Each Map Layer

The ***Delphi Process***, developed in the 1950s by the Rand Corporation, is designed to achieve consensus among a group of experts. It involves directed group interaction consisting of at least three rounds. The first round is completely unstructured, asking participants to express any opinions they have on calibrating the map layers in question. In the next round the participants complete a questionnaire designed to rank the criteria from 1 to 9. In the third round participants re-rank the criteria based on a statistical summary of the questionnaires. "Outlier" opinions are discussed and consensus sought.

The development and summary of the questionnaire is critical to Delphi. In the case of continuous maps, participants are asked to indicate cut-off values for the nine rating steps. For example, a cutoff of 4 (implying 0-4 houses) might be recorded by a respondent for Housing Density preference level 1 (most preferred); a cut-off of 12 (implying 4-12) for preference level 2; and so forth. For discrete maps, responses from 1 to 9 are assigned to each category value. The same preference value can be assigned to more than one category, however there has to be at least one condition rated 1 and another rated 9. In both continuous and discrete map calibration, the median, mean, standard deviation and coefficient of variation for group responses are computed for each question and used to assess group consensus and guide follow-up discussion. See *Author's Note 2* for more information on applying Delphi to routing applications.

Using the Analytical Hierarchy Process (AHP) for Weighting Map Criteria

Weighting of the map layers is achieved using a portion of the Analytical Hierarchy Process (AHP) developed in the early 1980s as a systematic method for comparing decision criteria. The procedure involves mathematically summarizing paired comparisons of the relative importance of the map layers. The result is a set map layer weights that serves as input to a GIS model.

In the routing example, there are four map layers that define the six direct comparison statements identified in Figure D-3 (#pairs = (N * (N – 1) / 2) = 4 * 3 / 2 = 6 statements) as shown in Figure D-4. Members of the group independently order the statements so they are true, then record the relative level of importance implied in each statement. The importance scale is from 1 (equally important) to 9 (extremely more important).

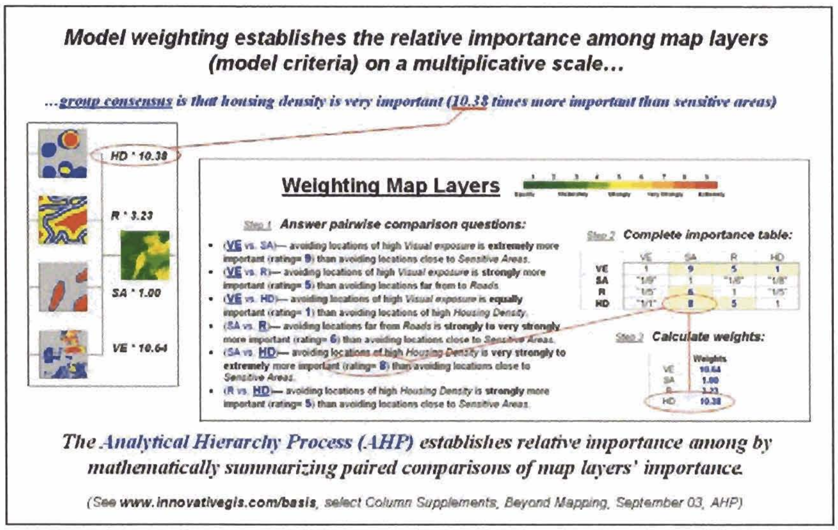

Figure D-4
The Analytical Hierarchy Process Uses Pairwise Comparison of Map Layers to Derive their Relative Importance

This information is entered into the importance table a row at a time. For example, the first statement in the figure views avoiding locations of high Visual Exposure (VE) as extremely more important (importance level = 9) than avoiding locations close to Sensitive Areas (SA). The response is entered into table position row 2, column 3 as shown. The reciprocal of the statement is entered into its mirrored position at row 3, column 2. Note that the last weighting statement is reversed so its importance value is recorded at row 5, column 4 and its reciprocal recorded at row 4, column 5.

Once the importance table is completed, the map layer weights are calculated. The procedure first calculates the sum of the columns in the matrix, and then divides each entry by its column sum to normalize the responses. The row sum of the normalized responses derives the relative weights that, in turn, are divided by minimum weight to express them as a multiplicative scale. See *Author's Note 2* for more information on calculations and applying AHP to routing applications.

The relative weights for a group of participants are translated to a common scale then averaged before expressing them as a multiplicative scale. Alternate routes are generated by evaluating the model using weights derived from different group perspectives.

EPRI-GTC Overhead Electric Transmission Line Siting Experience

Figure D-5 shows the results of applying different calibration and weighting information to derive alternative routes for a routing application in central Georgia. Four routes and corridors were generated emphasizing different Perspectives—*Built* environment (community concerns), *Natural* environment (ecology and cultural concerns), *Engineering* (construction concerns) and the *Simple* un-weighted average of all three group perspectives.

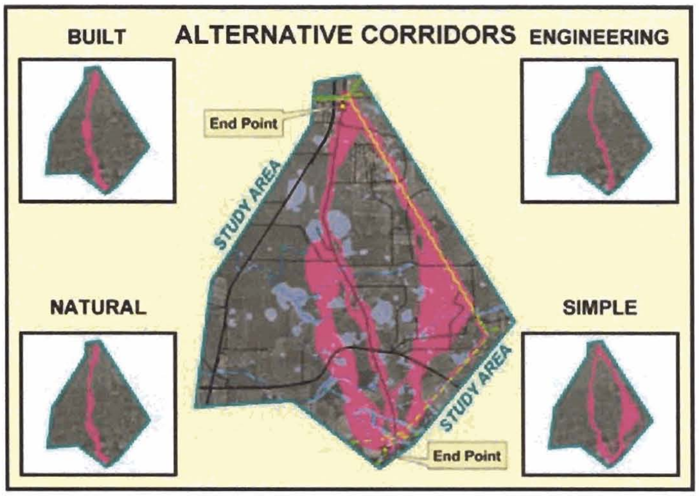

Figure D-5
Alternate Routes are Generated by Evaluating the Model Using Weights Derived from Different Group Perspectives

These results are from a comprehensive model recently developed during a project funded by the Electric Power Research Institute (EPRI) and Georgia Transmission Corporation (GTC). The project team consisted of academics, siting engineers, GIS specialists and various administrators, public relations personnel, legal advisors and other industry experts. Several group sessions involving federal agencies, industry representatives and community groups were held that used Delphi and AHP to calibrate and weight more than twenty criteria. See *Author's Note 3* for more information on the EPRI-GTC Overhead Electric Transmission Line Siting Methodology.

While all four of the routes in Figure D-5 use the same criteria layers, the differences in emphasis for certain layers generate different routes/corridors that directly reflect differences in stakeholder perspective. Note the similarities and differences between the Built, Natural, Engineering and un-weighted routes. The bottom line is that the procedure identified constructible alternative routes that can be easily communicated and discussed.

The final route is developed by an experienced transmission line siting team who combine alternative route segments for a preferred route. Engineers make slight centerline realignments responding the detailed field surveys along the preferred, and then design the final pole placements and construction estimates for the final route.

The ability to infuse different perspectives into the routing process is critical in gaining stakeholder involvement and identifying siting sensitivity. It acts at the front end of the routing process to explicitly identify routing corridors that contain constructible routes reflecting different perspectives that guide siting engineer deliberations. Also, the explicit nature of the methodology tends to de-mystify the routing process by clearly identifying the criteria and how it is evaluated.

In addition, the participatory process 1) encourages interaction among various perspectives, 2) provides a clear and structured procedure for comparing decision elements, 3) involves quantitative summary of group interaction and dialog, 4) identifies the degree of group consensus for each decision element, 5) documents the range of interpretations, values and considerations surrounding decision criteria, and 6) generates consistent, objective and defendable parameterization of GIS models.

E
PHASE 2: ALTERNATIVE CORRIDOR MODEL – DELPHI FEATURE CALIBRATIONS

Built Environment Delphi Results

June 2003 Workshop			
Proximity to Buildings	**Value**	**Proximity to Proposed Development**	**Value**
0-100'	9	0-100'	9
100-200'	9	100-200'	6.9
200-300'	8.1	200-300'	5.1
300-400'	6.5	300-400'	3.3
400-500'	5.5	400-500'	2.6
500-750'	4.8	500-750'	2
750-1000'	2.5	750-1000'	1.7
1000-1500'	1.3	1000-1500'	1
1500'+	1	1500'+	1
Proximity to Eligible Historic Structures		**Visual Vulnerability**	
0-100'	9	Category 9	9
100-200'	8.9	Category 8	8.7
200-300'	8.2	Category 7	7.4
300-400'	5.9	Category 6	6.6
400-500'	5.3	Category 5	4.9
500-750'	4.6	Category 4	4.1
750-1000'	2.8	Category 3	2.7
1000-1500'	2	Category 2	1.7
1500'+	1	Category 1	1
Proximity to Eligible Archaeology Sites		**Proximity to Excluded Areas**	
0-100'	9	0-100'	9
100-200'	8.4	100-200'	9
200-300'	5	200-300'	8.9
300-400'	3.3	300-400'	7.4
400-500'	2.8	400-500'	5.9
500-750'	2.3	500-750'	4.3
750-1000'	1.8	750-1000'	3.3
1000-1500'	1	1000-1500'	2.1
1500'+	1	1500'+	1
Building Density		**Proximity to Schools/Daycares/Churches**	
Category 9	9	0-100'	9
Category 8	7.9	100-200'	9
Category 7	6	200-300'	8.8
Category 6	3.8	300-400'	7.6
Category 5	2.2	400-500'	5.8
Category 4	1	500-750'	3.2
Category 3	1.2	750-1000'	2.2
Category 2	1.4	1000-1500'	1.6
Category 1	2.2	1500'+	1

August 2003 Workshop	
Proximity to Buildings	**Value**
Background	1
900-1200	1.8
600-900	2.6
300-600	4.2
0-300	9
Eligible NRHP Historic Structures	
Background	1
900 - 1200	2.8
600 - 900	3.6
300 - 600	5.2
0 - 300	9
Building Density	
Category 1	1
Category 2	1.6
Category 3	2.7
Category 4	3.8
Category 5	4.9
Category 6	6
Category 7	7.1
Category 8	8.1
Category 9	9
Proposed Development	
Background	1
Proposed Development	9
Spannable Lakes and Ponds	
Background	1
Spannable Lakes and Ponds	9
Land Divisions	
Edge of field	1
Land lots	7.9
Background	9
Proximity to Schools, Daycares, and Churches	
Background	1
900-1200	1.9
600-900	3.5
300-600	4.9
0-300	9

Current Rankings	
Proximity to Buildings	**Value**
Background	1
900-1200	1.8
600-900	2.6
300-600	4.2
0-300	9
Eligible NRHP Historic Structures	
Background	1
900 - 1200	2.8
600 - 900	3.6
300 - 600	5.2
0 - 300	9
Building Density	
0 - 0.05 Buildings/Acre	1
0.05 - 0.2 Buildings/Acre	3
0.2 - 1 Buildings/Acre	5
1 - 4 Buildings/Acre	7
4 - 25 Buildings/Acre	9
Proposed Development	
Background	1
Proposed Development	9
Spannable Lakes and Ponds	
Background	1
Spannable Lakes and Ponds	9
Land Divisions	
Edge of field	1
Land lots	7.9
Background	9
Land Use	
Undeveloped	1
Commercial/Industrial	3
Residential	9

Natural Environment Delphi Results

June 2003 Workshop

Floodplain	Values	Proximity to Protected Animal	Values
100 Year Floodplain	9	0-200'	9
Background	1	200-400'	9
Slope		400-600'	8
Slope 0-3%	1	600-800'	7
Slope 3-10%	3	800-1000'	6
Slope 10-15%	5	1000-1500'	5
Slope 15-20%	7	1500-2000'	4
Slope 20-25%	8	2000-3000'	2
Slope >25%	9	3000'+	1
Streams/Wetlands		**Proximity to Protected Plant Species**	
Trout Streams (50' Buffer)	9	0-100'	9
Spannable Lakes/Ponds	5	100-200'	9
Streams < 5cfs Regulatory Buffer	9	200-300'	9
Rivers/Streams > 5cfs Regulatory Buffer	9	300-400'	8
Forested Wetlands and 30' Buffer	9	400-500'	6
Non-Forested Non-Coastal Wetlands and 30'	9	500-750'	4
Non-forested Coastal Wetlands	9	750-1000'	3
Background	1	1000-1500'	2
Public Lands		1500'+	1
USFS	7	**Proximity to Excluded Areas**	
WMA - State Owned	9	0-100'	9
WMA - Non-State Owned	3	100-200'	9
Other Conservation Land	9	200-300'	8
Background	1	300-400'	7
Land Cover		400-500'	5
Hardwood and Mixed Forests	9	500-750'	3
Managed Pine Plantations	1	750-1000'	1
Clearcut Pines	1	1000-1500'	1
Pecan Orchards	5	1500'+	1
Undeveloped land, Pastures, Scrub/Shrub,	5		
Row Crops and Horticulture	1		
Center Pivot Agriculture	1		
Background	1		

August 2003 Workshop

Floodplain	Values
Background	1
100 Year Floodplain	9
Streams/Wetlands	
Background	1
Streams < 5cfs Regulatory Buffer	5.1
Non-forested Non-Coastal Wetlands	6.1
Rivers/Streams > 5cfs Regulatory Buffer	7.4
Non-forested Coastal Wetlands	8.4
Trout Streams (50' Buffer)	8.5
Forested Wetlands and 30' Buffer	9
Public Lands	
Background	1
WMA - Non-State Owned	4.8
Other Conservation Land	8.3
WMA - State Owned	8.7
USFS	9
Upland Forested Areas	
Background	1
Hardwood and Mixed Forests	9
Agriculture/Silviculture	
Undeveloped land, Pastures, Scrub/Shrub,	1
Managed Pine Plantations	2.2
Row Crops and Horticulture	2.2
Urban	6.5
Pecan Orchards	8.6
Background	9
Protected Terrestrial Animal Species	
Background	1
1500' Buffer	9
Protected Plant Species	
Background	1
500' Buffer	9

Current Rankings

Floodplain	Value
Background	1
100 Year Floodplain	9
Streams/Wetlands	
Background	1
Streams < 5cfs Regulatory Buffer	5.1
Non-forested Non-Coastal Wetlands	6.1
Rivers/Streams > 5cfs Regulatory	7.4
Non-forested Coastal Wetlands	8.4
Trout Streams (50' Buffer)	8.5
Forested Wetlands and 30' Buffer	9
Public Lands	
Background	1
WMA - Non-State Owned	4.8
Other Conservation Land	8.3
WMA - State Owned	8.7
USFS	9
Land Cover	
Undeveloped land, Pastures,	1
Managed Pine Plantations	2.2
Row Crops and Horticulture	2.2
Developed Land	6.5
Pecan Orchards	8.6
Hardwood/Mixed Forests	9

Engineering Environment Delphi Results

June 2003 Workshop	
Existing Utilities	**Values**
Rebuild Existing Transmission	1.9
Parallel Existing Transmission	1
Parallel Gas Pipelines	9
Background	9
Transportation	
Parallel Scenic Highways ROW	9
Parallel Interstates ROW	5.7
Parallel Primary Highways ROW	1.9
Parallel Secondary Paved Roads ROW	1.7
Parallel Secondary Dirt Roads ROW	1
Future GDOT Plans	4.5
Parallel Railway ROW	1.9
Road ROW	2.9
Background	3.1
Land Cover	
Hardwood and Mixed Forests	5.6
Managed Pine Plantations	4.9
Clear-cut Pines	2
Pecan Orchards	6.3
Undeveloped land, Pastures, Scrub/Shrub, Etc.	1
Row Crops and Horticulture	5.8
Center Pivot Agriculture	9
Background	5.4
Proximity to Excluded Areas	
0-100'	9
100-200'	6.9
200-300'	4.5
300-400'	3.1
400-500'	2.1
500-750'	1
750-1000'	1.5
1000-1500'	1.5
1500'+	1

August 2003 Workshop	
Linear Infrastructure	**Values**
Rebuild Existing Transmission Lines	1
Parallel Existing Transmission Lines	1.4
Parallel Secondary Dirt Roads ROW	2.5
Parallel Secondary Paved Roads ROW	3.2
Parallel Gas Pipelines	4.5
Parallel Primary Highways ROW	5
Parallel Railway ROW	5
Background	5.5
Future GDOT Plans	7.5
Parallel Interstates ROW	8.1
Road ROW	8.4
Parallel Scenic Highways ROW	9
Slope	
Slope 0-15%	1
Slope 15-30%	5.5
Slope >30%	9
Center Pivot Irrigation	
Background	1
Center Pivot Agriculture	9

Current Rankings	
Linear Infrastructure	**Values**
Rebuild Existing Transmission Lines	1
Parallel Existing Transmission Lines	1.4
Parallel Roads ROW	3.6
Parallel Gas Pipelines	4.5
Parallel Railway ROW	5
Background	5.5
Future GDOT Plans	7.5
Parallel Interstates ROW	8.1
Road ROW	8.4
Parallel Scenic Highways ROW	9
Slope	
Slope 0-15%	1
Slope 15-30%	5.5
Slope >30%	9
Center Pivot Irrigation	
Background	1
Center Pivot Agriculture	9

F

PHASE 2: ALTERNATIVE CORRIDOR MODEL – AHP PERCENTAGES BY DATA LAYER

Analytical Hierarchy Process Layer Percentages

June 2003 Workshop	
Engineering Environment	**%**
Existing Utilities	64.2%
Transportation	20.8%
Land Cover	10.7%
Proximity to Excluded Areas	4.3%
Natural Environment	**%**
Floodplain	6.9%
Slope	5.1%
Streams/Wetlands	30.3%
Public Lands	9.6%
Land Cover	8.1%
Proximity to Protected Animal Species	13.7%
Proximity to Protected Plant Species	22.7%
Proximity to Excluded Areas	3.5%
Built Environment	**%**
Proximity to Buildings	8.2%
Proximity to Eligible Historic Structures	16.5%
Proximity to Eligible Archaeology Site	3.0%
Building Density	8.5%
Proximity to Proposed Development	2.4%
Visual Vulnerability	14.7%
Proximity to Excluded Areas	21.3%
Proximity to Schools/Daycares/Churches	25.4%

August 2003 Workshop	
Engineering Environment	**%**
Linear Infrastructure	48.3%
Slope	13.3%
Center Pivot Irrigation	42.6%
Natural Environment	**%**
Floodplain	3.6%
Streams/Wetlands	12.1%
Public Lands	9.3%
Upland Forested Areas	10.2%
Agriculture/Silviculture	1.9%
Protected Terrestrial Animal Species	30.0%
Protected Plant Species	32.9%
Built Environment	**%**
Proximity to Buildings	9.6%
Eligible NRHP Historic Structures	11.6%
Building Density	31.3%
Proposed Development	5.3%
Spannable Lakes and Ponds	3.2%
Land Divisions	6.7%
Proximity to Schools, Daycares, and Churches	32.3%

Current Percentages	
Engineering Environment	**%**
Linear Infrastructure	48%
Slope	9%
Intensive Agriculture	43%
Natural Environment	**%**
Floodplain	6%
Streams/Wetlands	21%
Public Lands	16%
Land Cover	21%
Wildlife Habitat	36%
Built Environment	**%**
Proximity to Buildings	12%
Eligible NRHP Historic Structures	14%
Building Density	37%
Proposed Development	6%
Spannable Lakes and Ponds	4%
Land Divisions	8%
Land Use	19%

G
PHASE 2: ALTERNATIVE CORRIDORS WEIGHTING – AHP PAIRWISE COMPARISON QUESTIONS

Pairwise Comparison Question Weights

The stakeholders weighted each Pairwise question using the chart shown below.

If **Yes**, circle value in this column	If **No**, circle value in this column	
9	9	Extremely more important
8	8	Very strong to extremely
7	7	Very strongly more important
6	6	Strongly to very strongly
5	5	Strongly more important
4	4	Moderately to strongly
3	3	Moderately more important
2	2	Equally to moderately
1	1	Equally important

Engineering Layer Pairwise Comparison Questions

Are **Existing Utilities** more important than **Transportation Corridors**?

When siting a transmission line is it more preferable to co-locate (parallel) with **existing utilities** or with **transportation corridors**?

Are **Existing Utilities** more important than **Slope**?

When siting a transmission line is it more preferable to co-locate with **existing utilities** or to avoid **steep slopes**?

(What if the line must go in an area of steep slope in order to co-locate with a existing utility?)

Are **Existing Utilities** more important than **Center Pivots**?

When siting a transmission line is it more preferable to co-locate with **existing utilities** or to avoid **center pivot irrigation**?

(What if the line must go through a center pivot irrigation system in order to co-locate with existing utilities?)

Are **Transportation Corridors** more important than **Slope**?

When siting a transmission line is it more preferable to co-locate (parallel) with **transportation corridors** or to avoid **steep slopes**?

(What if the line must go in an area of steep slope in order to co-locate with transportation corridors?)

Are **Transportation Corridors** more important than **Center Pivots**?

When siting a transmission line is it more preferable to co-locate (parallel) with **transportation corridors** or to avoid **center pivot irrigation**?

(What if the line must go through a center pivot irrigation system in order to co-locate with transportation corridors?)

Is **Slope** more important than **Center Pivots**?

When siting a transmission line is it more preferable to avoid **steep slopes** or to avoid **center pivot irrigation**?

Natural Environment Pairwise Comparison Questions

Are **Public Lands** more important than **Hydrography**?

When siting a transmission line is it more important to minimize impact to **public lands** or to **streams/wetlands?**

Are **Public Lands** more important than **Floodplains**?

When siting a transmission line is it more important to minimize impact to **public lands** or to **floodplains**?

Are **Public Lands** more important than **Land Cover**?

When siting a transmission line is it more important to consider **public lands** or **land cover** (i.e., forested vs. undeveloped land)?

(What if the line must go through public lands in order to locate in an agricultural field as opposed to a forested area?)

Are **Hydrography** more important than **Floodplains**?

When siting a transmission line is it more important to minimize impact to **wetlands/streams** or **floodplains**?

Is **Hydrography** more important than **Land Cover**?

When siting a transmission line is it more important to consider **streams/wetlands** or **land cover** (i.e., forested vs. undeveloped land)?

(What if the line must go through streams/wetlands in order to locate in an agricultural field as opposed to a forested area?)

Are **Floodplains** more important than **Land Cover**?

When siting a transmission line is it more important to consider **floodplains** or **land cover** (i.e., forested vs. undeveloped land)?

(What if the line must go in an area of floodplains in order to locate in an agricultural field as opposed to a forested area?)

Built Environment Pairwise Comparison Questions

Is **Proximity to Cultural Resources** more important than **Building Density**?

When siting a transmission line is it more important to stay away from **NRHP eligible historic structures** or to avoid areas of **high building density**?

Is **Proximity to Cultural Resources** more important than **Proximity to Buildings**?

When siting a transmission line is it more important to stay away from **NRHP eligible historic structures** or to stay away from **all buildings**?

Is **Proximity to Cultural Resources** more important than **Lakes and Ponds**?

When siting a transmission line is it more important to stay away from **NRHP eligible historic structures** or to avoid **spannable lakes and ponds**?

Is **Proximity to Cultural Resources** more important than **Proximity to Proposed Developments**?

When siting a transmission line is it more important to stay away from **NRHP eligible historic structures** or to stay away from **proposed developments**?

Is **Proximity to Cultural Resources** more important than **Land lots**?

When siting a transmission line is it more important to stay away from **NRHP eligible historic structures** or to parallel **large property lines**?

Is **Building Density** more important than **Proximity to Buildings**?

When siting a transmission line is it more important to avoid areas of **high building density** or to avoid being close to **individual buildings**?

Is **Building Density** more important than **Lakes and Ponds**?

When siting a transmission line is it more important to avoid areas of **high building density** or to avoid **spannable lakes and ponds**?

Is **Building Density** more important than **Proximity to Proposed Developments**?

When siting a transmission line is it more important to avoid areas of **high building density** or to stay away from **proposed developments**?

Is **Building Density** more important than **Land lots**?

When siting a transmission line is it more important to avoid areas of **high building density** or to parallel **large property lines**?

Is **Proximity to Buildings** more important than **Lakes and Ponds**?

When siting a transmission line is it more important to stay away from **buildings** or to avoid **spannable lakes and ponds**?

Is **Proximity to Buildings** more important than **Proximity to Proposed Developments**?

When siting a transmission line is it more important to stay away from existing **buildings** or stay away from **proposed developments**?

Is **Proximity to Buildings** more important than **Land lots**?

When siting a transmission line is it more important to stay away from **buildings** or to parallel **large property lines**?

Are **Lakes and Ponds** more important than **Proximity to Proposed Developments**?

When siting a transmission line is it more important to avoid **spannable lakes and ponds** or to stay away from **proposed developments**?

Are **Lakes and Ponds** more important than **Land lots**?

When siting a transmission line is it more important to avoid **spannable lakes and ponds** or to parallel **large property lines**?

Is Proximity to **Proposed Developments** more important than **Land lots**?

When siting a transmission line is it more important to stay away from **proposed developments** or to parallel **large property lines**?

H
PHASE 3: PREFERRED ROUTE WEIGHTING – AHP PAIRWISE COMPARISON QUESTIONS

Preferred Route Layer Calculations – Engineering

		Score
When siting a transmission line are the miles of *rebuild of an existing transmission line* more important than the miles of ***co-location with an existing transmission line***?		8
When siting a transmission line are the miles of *rebuild of an existing transmission line* more important than *co-location with roads*?	Equal	7
When siting a transmission line are the miles of *rebuild of an existing transmission line* more important than the *total project cost*?	Equal	4
When siting a transmission line are the miles of ***co-location with an existing transmission line*** more important than *co-location with roads*?		5
When siting a transmission line are the miles of ***co-location with an existing transmission line*** more important than *total project cost*?		3
When siting a transmission line are the *miles of co-location with roads* more important than *total project costs*?	Equal	2

Importance Percentage

Miles of rebuild of existing TL	65.70%
Miles of co-location with existing TL	19.20%
Miles of co-location with existing roads	7.80%
Total project cost	7.40%

Preferred Route Layer Calculations – Natural Environment

		SCORE
When siting a transmission line is it more important to minimize impact to *natural forests* or to ***streams/river crossings***?		-3
When siting a transmission line is it more important to minimize impact to *natural forests* or to ***wetlands***?		-4
When siting a transmission line is it more important to minimize impact to *natural forests* or to ***floodplains***?		-2
When siting a transmission line is it more important to minimize impact to ***stream/river crossings*** or to ***wetlands?***	Equal	1
When siting a transmission line is it more important to minimize impact to ***stream/river crossings*** or to *floodplains*?		4
When siting a transmission line is it more important to minimize impact to ***wetlands*** or to *floodplains*?		4

Importance Percentage

Wetlands	40.30%
Streams/rivers	38%
Floodplains	12.40%
Natural forests	9.30%

Preferred Route Layer Calculations – Built Environment

	SCORE
When siting a transmission line it is more important to avoid ***relocations*** or stay *300 feet away from residences*?	6
When siting a transmission line it is more important to avoid ***relocations*** or stay away from *proposed developments*?	7
When siting a transmission line it is more important to avoid ***relocations*** or stay 300 feet away from *commercial buildings*?	8
When siting a transmission line it is more important to avoid ***relocations*** or stay *300 feet away from industrial buildings*?	9
When siting a transmission line it is more important to avoid ***relocations*** or stay away from the *road edge of school, daycare, church or cemetery parcels*?	3
When siting a transmission line it is more important to avoid ***relocations*** or stay away from *NRHP eligible historic structures*?	6
When siting a transmission line it is more important to stay ***300 feet away from residences*** or to stay away from *proposed developments*?	5
When siting a transmission line it is more important to stay ***300 feet away from residences*** or to stay 300 feet away from *commercial buildings*?	6
When siting a transmission line it is more important to stay ***300 feet away from residences*** or to stay 300 feet away from *industrial buildings*?	7

When siting a transmission line it is more important to stay ***300 feet away from residences*** or stay away from the ***road edge of school, daycare, church or cemetery parcels***?	Equal	1
When siting a transmission line it is more important to stay ***300 feet away from residences*** or to stay away from *NRHP eligible historic structures*?		-3
When siting a transmission line it is more important to stay away from ***proposed developments*** or to stay 300 feet away from *commercial buildings*?		3
When siting a transmission line it is more important to stay away from ***proposed developments*** or to stay 300 feet away from *industrial buildings*?		5
When siting a transmission line it is more important to stay away from *proposed developments* or stay away from the ***road edge of school, daycare, church or cemetery parcels***?		-5
When siting a transmission line it is more important to stay away from *proposed developments* or to stay away from ***NRHP eligible historic structures***?		-3
When siting a transmission line it is more important to stay 300 feet away from ***commercial buildings*** or to stay 300 feet away from *industrial buildings*?		5
When siting a transmission line it is more important to stay 300 feet away from *commercial buildings* or stay away from the ***road edge of school, daycare, church or cemetery parcels***?		-7
When siting a transmission line it is more important to stay 300 feet away from *commercial buildings* or to stay away from ***NRHP eligible historic structures***?		-4
When siting a transmission line it is more important to stay 300 feet away from *industrial; buildings* or stay away from the ***road edge of school, daycare, church or cemetery parcels***?		-9

When siting a transmission line it is more important to stay 300 feet away from *industrial buildings* or to stay away from ***NRHP eligible historic structures***?		-7
When siting a transmission line it is more important to stay away from the ***road edge of school, daycare, church or cemetery parcels*** or to stay away from ***NRHP eligible historic structures***?	Equal	1

Importance Percentage

Relocated residences	44.20%
Road edge of school, daycare, church or cemetery parcels	16.30%
NRHP eligible structures	15.50%
Proximity to houses	13.10%
Proposed development	5.40%
Proximity to commercial development	3.60%
Proximity to industrial development	1.80%

I

ENVIRONMENTAL JUSTICE GUIDELINES

Consideration of environmental justice (EJ) is mandated by Executive Order (EO) 12898, which states that *"each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse health and environmental effects of its programs, policies and activities on minority and low-income populations in the United States and its territories and possessions."*[1] For any project receiving federal funding, Georgia Transmission Corporation (GTC) is required to coordinate with the Rural Utilities Service (RUS) to ensure compliance with EO 12898. The RUS guidelines require the use of U.S. Census Bureau data for determining whether minority and/or low-income populations live within a proposed transmission corridor or substation site and whether these populations could suffer adverse environmental and/or human health effects as a result of the project. The RUS guidelines also specify measures for addressing EJ issues should they occur. An EJ review is triggered by any project that requires an environmental report (ER), environmental assessment (EA) or environmental impact statement (EIS). An ER, EA or EIS is required only if the project receives federal funding. This document describes the steps to be followed by GTC and its consultants in performing environmental justice evaluations.

As soon as the alternate routes or alternate substation sites have been established, an EJ review should be performed by a consultant experienced in compliance with EO 12898. The consultant will use GTC's *Methodology for Analyzing Potential Environmental Justice Areas of Concern* and will comply with the following steps:

1. GTC will submit maps of the alternate routes or substation sites to the consultant. GTC will direct the consultant to review the area for Census blocks (racial analysis) and block groups (income analysis) whose minority and/or low-income populations meet or exceed the EPA Region 4 EJ thresholds.[2] The consultant will also review the area databases for possible cumulative impacts[3] from pollution sources and/or other community disturbances. After the initial review, the consultant will perform a field analysis for data verification.

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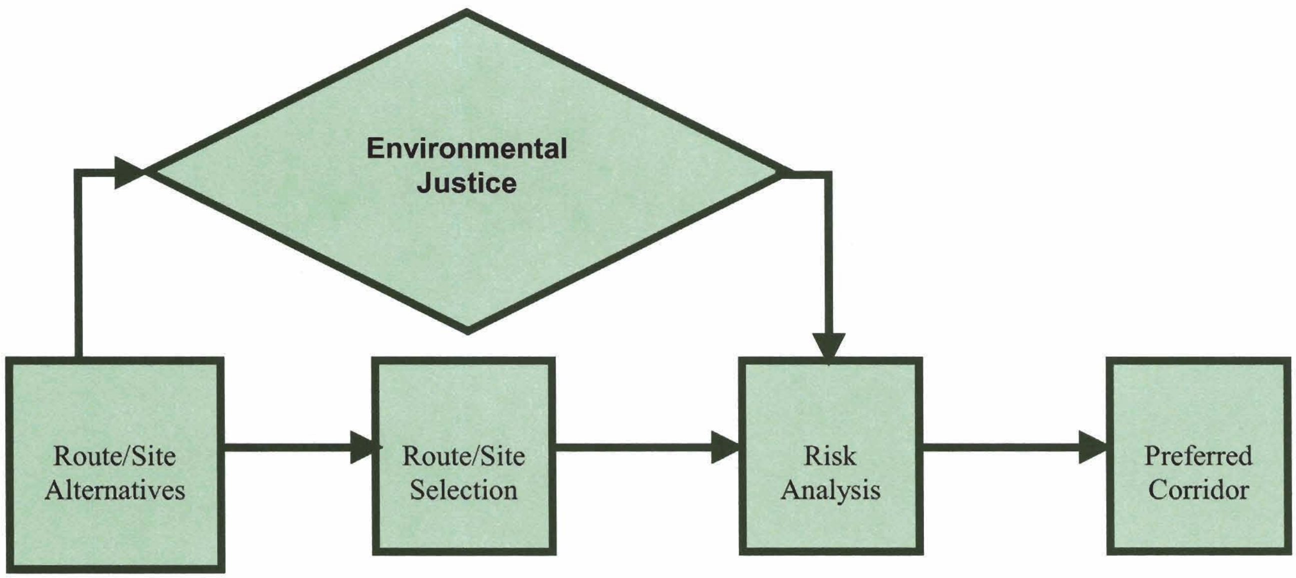
[1] Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. February 11, 1994.

[2] The minority threshold is 35.72% of the area population, and the low-income (poverty) threshold is 17.58% (EPA Region 4. "Interim Policy to Identify and Address Potential Environmental Justice Areas." EPA-904-R-99-004, April 1999.)

[3] This term is defined as "...harmful health or other effects resulting from exposure to multiple environmental stressors…" 65 Fed. Reg. 39665 (2000). Cumulative impacts may occur when a community already contains pollution sources or other factors that may be viewed as detrimental to one's quality of life. Some examples of these factors include, but are not limited to, industrial development (with or without smokestacks), industrial or other odors, the discharge of industrial by-products to air or water, landfills, visual obstructions, or excessive noise from highways or other sources.

2. The consultant's review will result in one of three findings: 1) No Occurrence of Minority/Low-Income Populations; 2) An Occurrence of Minority/Low-Income Populations, but No Adverse Effect; or 3) Possible Adverse Effect to Minority/Low-Income Populations. After performing the EJ review, the consultant will provide to GTC maps and a written report documenting the results of the analysis. The report will contain a clear conclusion regarding whether the project will have a disproportionately high and adverse environmental or human health effect on a minority or low-income population. The consultant will use data gathered during the field survey to submit specific recommendations for avoidance of minority and/or low-income communities (e.g. locating the line along a specific highway, avoiding the southwestern corner of a specific area, etc.).
3. The information from the EJ review will be used as part of GTC's Risk Analysis. It will not be used as a component of the alternate route selection process.
4. If the final route selected has potential EJ implications (a severe Adverse Effect and/or cumulative effect), GTC will notify RUS. RUS will determine the public notification process and the method of notification. Also RUS will accept GTC's mitigation plan or will make recommendations for changes to the mitigation plan.
5. The EJ efforts, consultant's conclusion and a summary of the mitigation plan (if any) will be documented in the ER, EA or EIS.



J
STAKEHOLDER MEETING INVITEES

EPRI – GTC
Stakeholder Meeting Invitation List
Alabama Electric Cooperative
Alabama Power Company
Altamaha Nature Conservancy
American Electric Power
American Transmission Company
Arkansas Electric Cooperative Corp.
Arkansas Power and Light
Association County Commissioner of Georgia
Atlanta Chamber of Commerce
Atlanta Regional Commission
Carroll EMC
CenterPoint Energy
Central Electric Power Cooperative
Central Georgia EMC
Chattahoochee Hill Country
Chattahoochee River Keeper
City of Tallahassee, FL
Cleco
Cobb Chamber of Commerce
Cobb County Community Affairs
Cobb EMC
Colquitt EMC
Council For Quality Growth
Coweta County Commissioner
Dalton Utilities
DNR, Land Protection Branch
DNR, Wildlife Resources Division
DNR-Wildlife Resources Division/Natural Heritage
Duke Power Company
Dunwoody Homeowners Association

EPRI – GTC
Stakeholder Meeting Invitation List
East Cobb Civic Association
East Kentucky Power Cooperative
Entergy Transmission - New Orleans
EPA Region 4, Environmental Accountability Div.
EPA, Region 4, Reg. Wetlands Coord./Permit
Flint EMC
Florida Power and Light
Framatome-anp
GA Agribusiness Council
GA Chapter American Planning Association
GA Chapter American Society of Landscape Architects
GA Department of Natural Resources
GA Department of Transportation
GA Dept. of Community Affairs - Economic Development
GA Dept. of Industry, Trade and Tourism
GA Economic Developers Association
GA Environmental Protection Division - GIS Specialist
GA Environmental Protection Division - Stream Buffers
GA Farm Bureau
GA Greenways Association
GA Natural Heritage Program
GA Realtors Association
GA School Boards Association
GA School Supt Association
GA Water & Soil Conservation Comm., Region II
GA Wildlife Federation
Georgia Conservancy
Georgia Electric Membership Corporation
Georgia Greenspace Program
Georgia Lakes Society
Georgia Municipal Association
Georgia Power Company
Georgia Transmission Corporation
GRTA Board Member
Gulf Power
Gwinnett County Homeowner
Habersham EMC

EPRI – GTC
Stakeholder Meeting Invitation List
Henry County Development Authority
Henry County for Quality Growth
Historic Preservation Division
Home Builders Association of Georgia
HOPE (Homeowners Opposing Powerline Encroachment)
Jacksonville Electric Authority
Lake Allatoona Preservation Authority
Laurens County Commissioner
MEAG
Metro Atlanta Chamber of Commerce
Minnesota Power
Mississippi Power Company
Nashville Electric Service
New Horizon Electric Cooperative Greenville, SC
North Carolina Electric Membership Corp.
North Carolina Electric Service
NPS, Chattahoochee River NRA
PATH
Photo Science, Inc
Progress Energy Carolinas
Progress Energy Florida
Public Service Company of New Mexico
Reliant Energy
Rural Utilities Service
Santee Cooper
Savannah Electric and Gas
Sawnee EMC
Seminole Electric Cooperative
SHPO
Sierra Club
Society of American Foresters Southeastern Society
South Carolina Electric and Gas
South Carolina Public Service Authority
South Georgia RDC
South Mississippi Electric Power Assoc.
Southeast Watershed Research Laboratory
Southern Alliance for Clean Energy

EPRI – GTC
Stakeholder Meeting Invitation List
SW Georgia RDC
Tennessee Valley Authority
The Georgia Conservancy
The Nature Conservancy
The Nature Conservancy (Georgia Chapter)
Trust for Public Lands
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service
U.S. Forest Service
United Peachtree Corners Civic Association
University of Georgia
Wisconsin Public Service Corporation

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SUMMARY OF SURVEY RESPONSES FROM THE ELECTRIC UTILITY STAKEHOLDER WORKSHOP

Electric Utility Workshop Participants*

Alabama Power Co (APC)
600 N 18th St
Birmingham, AL 35291-0782

American Transmission Company, LLC (ATC)
P.O. Box 47
Waukesha, WI 53187-0047

Center Point Energy (CPE)
P.O. Box 1700
Houston, TX 77251-1700

Center Point Energy (CPE)
P.O. Box 1700
Houston, TX 77251-1700

Florida Power & Light Co. (FPL)
P.O. Box 14000 (PDP-JB)
Juno Beach, FL 33408

Framatome – ANP (FRA)
400 S. Tyron St, Suite 2100 WC22K
Charlotte, NC 28285

Georgia Power Company (GPC)
241 Ralph McGill Blvd, Bin 10151
Atlanta, GA 30308-3374

MEAG Power (MEA)
1470 Riveredge Pkwy NW
Atlanta, GA 30062

Wesley Allen
Nashville Electric Service (NES)
1214 Church St
Nashville, TN 37203

Nashville Electric Service (NES)
1214 Church St
Nashville, TN 37203

Nashville Electric Service (NES)
1214 Church St
Nashville, TN 37203

Nashville Electric Service (NES)
1214 Church St
Nashville, TN 37203

New Horizon Electric Coop (NHE)
P.O. Box 1169
Laurens, SC 29360

New Horizon Electric Coop (NHE)
P.O. Box 1169
Laurens, SC 29360

Rural Utilities Service (RUS)
1400 Independence Ave. SW
Stop 1571
Washington, DC 20250

SCE & G (SCE)
Mail Code 030
Columbia, SC 29218

* When more than one person represented a company, there is more than one response coded to that company. If the representative did not respond to any or all questions, there is no response in this summary.

Questionnaire Responses

What is your experience with GIS technology?

1=Low, 2=L/M, 3=Moderate, 4=M/H, 5=High

APC	2
ATC	4
CPE	1
CPE	1
FPL	3
FRA	5
GPC	5
MEA	4
NES	3
NES	1
NES	3
NES	4
NHE	4
NHE	1
RUS	1
SCE	3

How many years of GIS experience do you have?

None, 1, 2 to 5 or >5

APC	0
ATC	2-5
CPE	0
CPE	2-5
FPL	2-5
FRA	>5
GPC	>5
MEA	>5
NES	2-5
NES	1
NES	2-5

NES	2-5
NHE	>5
NHE	0
RUS	0
SCE	2-5

Does your organization use GIS technology in route selection?

Yes or No

APC	No
ATC	Yes
CPE	Yes
CPE	Yes
FPL	Yes
FRA	Yes
GPC	Yes
MEA	Yes
NES	Yes
NES	Yes
NES	Yes
NES	Yes
NHE	Yes
NHE	Yes
RUS	Yes
SCE	Yes

If YES, what GIS system(s)is used?

ATC	ARC/Info
CPE	Our transmission system is placed in GIS & our consultant uses GIS to some extent in line routing.
CPE	Not sure. Survey & Mapping department GIS group is responsible for in house production. Consultants are responsible for other.
FPL	Varies – we use multiple consultants for line route siting studies.
FRA	ERDAS, ArcMAP, SPAHS, AutoCAD MAP
MEA	No formal system, but GIS info assembled & analyzed by engineers & land personnel for relevance & general use in routing & siting.
NES	ESRI ARC 8.3

NES	ARCVIEW
NES	ARCVIEW
NES	ARCVIEW/ARCINFO
NHE	The process is done through an outside source - Framatome.
NHE	We use Framatome ANP, DE&S to site out lines.
RUS	Just starting to use GIS. Don't know what system RUS is training on.
SCE	Work in this area is outsourced, generally to Framatome.

If YES, describe how GIS is used (e.g., base mapping, siting team reference, manual map analysis, automated routing selection, presentations etc.)?

ATC	Currently base mapping, siting team reference, manual map analysis, presentation, constraints identification, alternatives comparison, permitting & licensing applications, etc. – NOT automated route (C/L) selection yet. Also used for maintenance activities. access routes, restrictions, etc.)
CPE	Base mapping, presentations
CPE	Base mapping, presentations to public
FRA	Base mapping, route analysis, presentations
FPL	Base mapping, supplementary manual mapping efforts, presentation materials.
GPC	All of the above
MEA	Mapping, manual map analysis
NES	Base mapping, presentations, manual map analysis
NES	Base mapping, siting team reference, presentations, property ownership identification, zoning info, land use
NES	Land base maps, aerials & land use & other geographic info is currently available on our GIS system
RUS	Base mapping as I understand
SCE	Used to depict factors such as view sheds, wetlands, etc.

Based on the discussions and your experience, how would you rank the general approach used in EPRI-GTC siting methodology?

1=Low, 2=L/M, 3=Moderate, 4=M/H, 5=High

APC	2
ATC	4
CPE	4
CPE	5

FPL	5
FRA	3
GPC	4
MEA	4
NES	3
NES	5
NES	4
NHE	4
NHE	5
RUS	5
SCE	5

How would you rank your understanding of the basic procedures used in EPRI-GTC siting methodology?

1=Low, 2=L/M, 3=Moderate, 4=M/H, 5=High

APC	4
ATC	4
CPE	4
CPE	5
FPL	5
FRA	4
GPC	4
MEA	5
NES	4
NES	5
NES	4
NES	4
NHE	5
NHE	4
RUS	4
SCE	5

Based on your experiences, what is the likelihood that your organization would adopt the EPRI-GTC or similar GIS-based siting methodology?

1=Low, 2=L/M, 3=Moderate, 4=M/H, 5=High

APC	2
ATC	4
CPE	1
FPL	4
FRA	2
GPC	3
MEA	4
NES	2
NES	3
NES	3
NHE	2
NHE	3
RUS	1
SCE	3

In your own opinion what is the major strength(s) of the EPRI-GTC siting approach?

APC	Identifying study area.
ATC	Transparency to general public – helps remove the concern that routing was arbitrary or didn't consider the issues that the affected individuals find important.
CPE	It provides a kind of transparency to the line routing process.
CPE	approach is :open book" and explainable to the public.
FPL	Very data driven process. Very comprehensive process. Consistency in application. Eliminates arbitrary study area boundaries.
FRA	Effort that has gone into establishing weights.
GPC	1) Major strength is in selecting study routes. 2) Establishes a structured method.
MEA	provides objective and consistent approach to siting.
NES	Mathematical model that is quantitative and is a process that could be defendable.
NES	3 corridor models.
NES	We could definitely use the methodology to limit the amount of public involvement we currently incorporate. Identifying the macro corridors based on engineering/env. & other rating factors before going to the public – narrowing the study area ahead of time.

NES	An organized approach that is a very good start to creating some "Industry Standards" as it relates to line siting. Also the way the software is flexible enough to handle several approaches.
NHE	It provides a platform or standard to use on all siting projects.
NHE	Considers almost all issues that need to be considered in siting a line.
RUS	It's scientific, objective & provides a solid basis for decision making.
SCE	The science/math behind the approach is very sound. I think factors, categories, weightings etc. will be regionally specific, if not, site specific.

In your own opinion what is the major weakness(es) of the EPRI-GTC siting approach?

APC	Too many exceptions, each project is different. Un-tested in court in Alabama; how do explain the results in court?
ATC	I think the general model is good, but the Model would need to be customized to reflect regional differences in values and regulatory requirements/guidelines. We also strongly believe in having much more public involvement during our route (C/L) development and through the public hearings on our projects.
CPE	Cost may not be emphasized enough.
FPL	Mathematics (Delphi Process) could be overwhelming to non-utility stakeholders. Subjectivity of weighting process.
FRA	Exclusion of major parts of the study area, final route evaluation.
GPC	1) Unknowns about the weight factors of different aspects. 2) Public support. 3) Political support or approval. 4) How do you get the public involved. 5) Process must be supported by the courts.
MEA	It doesn't consider "politics" (but then, how would you factor politics into an objective procedure?).
NES	Not enough public input as to ranking or weighting of factors/critical elements. Public input will probably be process defined by utility.
NES	As it exists, it is customized for state of Georgia. Obviously, it can be tailored to other areas.
NES	Don't know a better way to do it, but obtaining and loading criteria will be a major problem. Criteria could vary from urban to rural areas or even between similar urban areas.
NHE	It appears that some cost issues are not taken into account such as access roads, property values etc., but other than that the system appears to have a strong platform.
RUS	I don't see any major weakness. I think it's a good approach to siting transmission lines.
SCE	Lack of on-going public involvement. Maybe the GTC web site does a good job getting info out to the public, but I believe that providing the opportunity for on-going public involvement will prove to be necessary. (Note: Not all projects need a sting study.)

Based on your experiences, do you think your Organization would likely support general industry/region-wide guidelines for GIS-based Transmission line siting?

Yes or No ?

APC	No
ATC	No, I can see a need for at least variants of the model just in the area we serve, urban (high density), rural-ag, & a suburban/semi rural areas due to differing values/restrictions in each area.
CPE	Yes
CPE	Yes
FPL	Maybe, can't answer for others in Florida.
FRA	Yes
GPC	Unknown at this time
MEA	Yes
NES	Not sure
NES	Yes
NES	No, Our board has "adopted" a citizen's advisory committee methodology that is working very well for us; however, see my answer to #4 above.
NES	Yes
NHE	Yes
NHE	Yes
RUS	Yes
SCE	Yes, it would take some selling, but possible

If YES, do you think your Organization would likely be involved in the guidelines?

Yes or No ?

ATC	Yes
CPE	Yes
CPE	Yes
FRA	No
MEA	Yes
NES	Yes
NHE	Yes
NHE	Yes
RUS	No
SCE	Yes

One key objective of the overall EPRI-GTC siting methodology is to develop a good process for identifying a proposed transmission route that is comprehendible, objective, comprehensive consistent, quantitative and defendable.

Do you think we are making progress?

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree

APC	4
ATC	4
CPE	5
CPE	5
FPL	5
FRA	5
GPC	4
MEA	4
NES	4
NES	5
NES	5
NES	4
NHE	4
NHE	5
RUS	5
SCE	1

Please comment on strengths/weaknesses of the overall procedure:

APC	Good progress in defining Study Area. The program can not replace good judgment.
ATC	Transparency & understandability to the affected public.
CPE	The scientific approach used is more defensible than a more subjective approach. In CenterPoint & other Texas utilities, we are required to have public forums which is not emphasized in this process.
CPE	I strongly agree that this methodology provides a consistent, objective approach. It is somewhat different from the process currently employed by our consultant but many of the components are the same or similar. Individual land owner input is lacking, which may be problematic in Texas because the Texas PUC has emphasized landowner education and involvement in the routing process.

FPL	Strengths – Data driven, objective & comprehensive. Weaknesses – Process created & factor weighting done by expert panels – lay people may not "buy into" such an academic/computer based process (recall discussion on gaming the process.)
FRA	Strength: Impressed with work that has gone into developing criteria/weights. Weakness: Final Route assessment.
GPC	The overall concept has a lot of possibilities can we get buy-in from public, politicians and courts.
MEA	Appears overall to be a non-biased approach to siting. However, in the end, final results must be determined by engineers or routing team. A weakness may be that there is not enough public involvement in the process.
NES	*See #4*
NES	It may be more complex than the general public (including regulators) can understand.
NES	Good documentation regarding decision making rationale.
NES	As mentioned before obtaining good criteria that is properly loaded based on a well balanced and represented cross section of stakeholders.
NHE	Weakness- limiting community input and feedback.
SCE	Again, I think that public involvement in some format, or other, is necessary if for no other reason, to avoid a legitimate challenge, late in the process, that the property owner, or a community has been blind-sided.

A critical element of the EPRI-GTC process is Criteria Selection involving a team of transmission line siting experts and GIS specialists who identify map criteria (exclusion and preference maps) and structure the routing model to unique circumstances in various regions.

Do you think that works?

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree

ATC	4
CPE	4
CPE	4
FPL	4
FRA	5
GPC	4
MEA	5
NES	3
NES	5
NES	4

NHE	4
NHE	5
RUS	4
SCE	4

Is there a better alternative for establishing site selection criteria?

ATC	I think that the criteria needs to be reviewed confirmed for different project settings but I think this is a good starting point.
CPE	Try to get as broad a base of stakeholders input as possible.
FPL	Probably not.
NES	Appointed stakeholders in community affected by proposed power line.
NES	No
NES	No, as long as there is flexibility when project-specific issues present.
NES	Not sure – no suggestions
NHE	In special situations, I feel that it is necessary to get input from the general public on the criteria selection.
SCE	Not sure.

Please comment on strengths/weaknesses of the Criteria Selection procedure:

APC	I think the experts in the industry should route the line taking into account all aspects & impacts (environnemental, maintenance etc.) I don't think you want the public or government routing your lines. I think if your company uses good discretion and judgment then most property owners understand. You always have a few that will challenge your judgment.
ATC	The criteria may change (or their relative importance) from project area to project area. It will be more useful & defensible if/when it has been applied to a number of projects and a track record is developed that supports the model results.
FPL	Some criteria are more "pertinent" on projects than others; each project probably warrants a case-by-case analysis to establish appropriate criteria.
NES	To develop study area, or macro corridors would agree that criteria selected by team of siting experts; disagree that same team develop criteria for individual corridor or criteria for selecting a route.
NES	It is good to have the criteria specific to each model type.
NES	Have to be careful in selecting your team.
NES	Criteria selection is good as long as it is understood to be used as a guideline that should be tweaked based on project location.
NHE	*Weakness – adjust based on individual projects*

SCE	The selection of factors and categories could be up to debate. But as a methodology is used and developed over many projects, the methodology will develop an inherent strength and will eventually be viewed as a credible process.

Underlying the EPRI-GTC approach is the Delphi procedure involving iterative calibration and feedback of group participants for calibrating the preference maps used in the routing model.

Do you think that the Delphi procedure works?

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree

ATC	4
CPE	4
CPE	4
FPL	4
GPC	4
MEA	4
NES	4
NES	4
NES	4
NES	5
NHE	5
NHE	5
RUS	4
SCE	4

Please comment on strengths/weaknesses of the Delphi procedure:

ATC	The iterative nature of the scoring is important.
FPL	I like its detail and thoroughness. I think it would be difficult for non-experts to understand it if used infrequently. We have used a simpler pair-wise comparison of factors.
GPC	It provides a satisfactory approach.
MEA	As became evident during the process, it can be swayed by one group with particularly strong opinions.
NES	May depend on scope <distance> of project.
NES	Absolutely good approach.
NHE	Results are only as good as the knowledge of each voter on the subject area.
SCE	So long as diversity of participants is evident, I think the process is defendable

Another tool for refining the model is the AHP procedure (Analytical Hierarchy Process) involving pair-wise comparisons of routing criteria. Is it a good process for weighting the relative importance of the preference maps?

Do you think that the AHP procedure works?

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree

ATC	4
CPE	4
CPE	4
FPL	4
GPC	3
MEA	3
NES	4
NES	4
NES	4
NHE	5
NHE	5
RUS	4
SCE	3

Please comment on strengths/weaknesses of the AHP procedure:

ATC	I'd be interested in seeing how the AHP ranking scores would vary between the publics in rural vs. urban project settings just to quantify the variability.
FPL	I'm a fan of a pair-wise comparison process. Routing decisions have to be made by making a balancing of factors. Sensitivity analyses are interesting to perform as well.
GPC	Depends on the one doing the comparisons.
NES	See 7.
NES	Procedure works.
NHE	It provides a fair result based on average results from groups of individuals.
SCE	Have not used this – no comment/opinion.

The EPRI-GTC methodology should develop Alternative Routes (a.k.a. Most Preferred Path; Least Cost Path) involving route optimization based on exclusion maps and calibrated/weighted preference maps, Macro study area and alternative routes?

Do you think that this is a good process for identifying the

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree

APC	4
ATC	5
CPE	4
CPE	4
FPL	4
GPC	4
MEA	4
NES	4
NES	4
NES	4
NES	4
NHE	5
NHE	5
RUS	4
SCE	4

Please comment on strengths/weaknesses of the Alternative Routes procedure:

APC	Alternate routes always should be considered.
CPE	Approach is very objective, but does not take individual landowner input into consideration. I know this has more to do with selecting a preferred route.
FPL	Weighting/calibrating drives the alternative routes subject to sensitivity analysis. Here is the stage where many of the mgt participants indicated that they bring in multi-disciplinary judgment from siting professionals to identify the alternate routes (and ultimately select the preferred route.)
GPC	This is the strength of the process.
NES	I like the fact that the model can evaluate "hundreds/thousands" of route/segment options that a human may overlook due to lack of time or mental fatigue. May identify and option that otherwise would have been overlooked.
NES	This procedure could help in benefit/cost analysis. For instance can you justify the Preferred Route if it cost 50% more than the Least Cost Path.
RUS	Consideration of alternative routes demonstrates that the selection of a preferred route was ultimately made by a comparison of 2 or more routes with similar values.

Do you think The Preferred Route procedure involving route segment evaluation and siting team judgment in manually editing/connecting segments is a good process for identifying the best routes?

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree

APC	3
ATC	4
CPE	4
CPE	4
FRA	4
GPC	4
MEA	5
NES	2
NES	4
NES	5
NES	4
NHE	5
NHE	4
RUS	3
SCE	4

Please comment on strengths/weaknesses of the Preferred Route procedure:

ATC	Based on WI. Regs – our PSCW is the group that ultimately chooses the "preferred route."
CPE	It would be almost impossible to do this step by automation because of landowner issues.
FPL	Strengths – at some point, professional judgment has to be applied to data. Weakness – same as of strength. Naysayers can argue that the application of professional judgement can be "arbitrary".
MEA	I think this is a necessary step in getting to a preferred route.
NES	Should include community input into final route selection.
NES	I think it is very important for the design team to "touch/feel" the route segments. Also, the team may be able to evaluate social & political issues that the model could not consider.
SCE	I guess the weakness would be the injection of the human element into a process that is a computer method based up to that point. But I don't know how else you arrive at a final center line.

Does your organization have a formal procedure that utilizes public Input into the siting process?

Yes or No

APC	No
ATC	Yes
CPE	*Yes*
CPE	Yes
FPL	Yes
FRA	Yes
GPC	No
MEA	No
NES	Yes
NES	Yes
NES	Yes
NES	Yes
NHE	Yes
NHE	Yes
RUS	Yes
SCE	Yes

If YES, briefly describe the process and how it might fit into a GIS-based siting process.

ATC	We use a variety of methods – scoping meetings, public info meetings, newsletters, individual group meetings etc., depending on the project.
CPE	If 25 or more landowners are affected, we hold one or more public meetings where we discuss need, engineering/construction, environmental, ROW requirements, EMF and ask attendees to respond to a questionnaire.
CPE	Public input is facilitated by at least one open house where route segments & other information is presented at stations and a questionnaire is made available. Land owners are invited by direct mailing & the public is notified by newspaper notice approx. 2 weeks prior to open house.
FPL	Public input is very important for a number of reasons: 1. Provide appropriate notice for projects. 2. Obtain local specific input for projects. 3. Validate criteria of study; also maybe relative importance/weighting of criteria.
MEA	Nothing formal – it depends on where the line is located (rural vs. urban), length, public official request, etc.

NES	Form community group of affected/impacted stake holders from study area. Ask them to evaluate criteria/route/weight.
NES	1) Need defined by planning 2) Management meets with local gov't leaders 3) Local gov't selects members of a citizens advisory committee (CAC) 4) Hold meetings with CAC to discuss engineering design, project need and identify routing factors (e.g. proximity to houses, etc.); Hold public open house; Hold follow-up CAC to weight factors for alternative routes; Run analysis to rank routes; CAC recommends a preferred route 6) N.E.S. Board considers route for approval.
NES	Workshops & formation of a CAC – Citizens Advisory committee. Representatives are usually politicians, business-folks & representatives from special interest groups.
NHE	Public meetings ask for input.
NHE	Community meetings (1 or 2); 1st at very beginning when no corridors have been selected & 2nd after several alternate routes have been selected, prior to selecting the preferred route.
SCE	We do research to depict various factors on a map or maps. We use an initial public meeting to explain the project, the need, and to gather public input. Alternative routes are identified and we hold another public meeting to present and get comment on the alternative routes.

Does your organization have a formal procedure for information dissemination and public relations involved with siting?

Yes or No

APC	No
ATC	Yes
CPE	Yes
CPE	Yes
FPL	Yes
FRA	Yes
GPC	Yes
MEA	No
NES	Yes
NES	Yes
NES	Yes
NHE	Yes
NHE	Yes
RUS	No
SCE	Yes

If YES, briefly describe the process and how it might fit into a GIS-based siting process.

ATC	Again project specific in scope, but we try to be open and responsive & share information as it is developed, so we may use GIS maps showing constraints/opportunities/possible routes in newsletters or discussions with elected officials.
CPE	The PUCT requires newspaper notices in major newspapers & letters to landowners crossed or within distance criteria (300' for lines below 345 KV & 500' for 345KV +)
CPE	There are public notice procedures required by the state which mandate direct mail notices and newspaper notices to specific groups – landowners, city/county officials, other utilities.
FPL	Mass mailings, news releases & open house meetings are our typical mechanisms. We are integrating GIS-based products into these efforts more and more. We have a long way to go and much room for improvement in this area.
GPC	We develop a communication plan for each major project. The plan includes information about the project, political contacts and general information about the need and route of the project.
MEA	See above
NES	Develop communication plan as to target audience and message.
NES	(1) Corp. communications dept. sends info to customers in study area includes invitations to open house; Also address media inquiries regarding project; (2) Corp. affairs dept. addresses political concerns – open dialogue with local gov't leaders etc.
NES	We have a Public Relations Dept.
NHE	Letters are sent inviting all property owners to attend the public meeting. Newspaper articles are also issued.
NHE	Community meetings (1 or 2); 1st at very beginning when no corridors have been selected & 2nd after several alternate routes have been selected, prior to selecting the preferred route.
SCE	We meet with elected officials, including the PSC ahead of time. Rotary clubs, civic groups etc. might also be presented to.

Any additional comments?

APC	If you use this program for one line, do you have to on all your lines (to be consistent? For legal reasons?) Different state laws dictate your approach to routing a line.
FPL	This model lays a great foundation for line route siting. Customization will have to occur to account for regional differences (criteria weightings). The science is extraordinary – you are to be commended for a job well done. One other thought: the process sets a good foundation for establishing the parameters for a routing study to the public.

MEA	Many thanks to the "GTC team" for undertaking this much needed effort!
NES	Good meeting, I think model has good potential, may need refinement as to targeting urban vs. rural application. Urban application may need additional input.
NES	To date, we have gone through 5 CAC Processes; board has approved each preferred route.
SCE	I don't think that in the near term, say next 5 – 10 years, that public involvement can be eliminated.

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LOCATIONS OF ONLINE REFERENCE MATERIALS

References to Related Online Materials

Least Cost Path Algorithm: The online book *Map Analysis*, Topic 19, "Optimal Paths and Routing" by Joseph K. Berry presents a detailed discussion on the Least Cost Path procedure for GIS-based identifying optimal routes and corridors. See:

www.innovativegis.com/basis/MapAnalysis/Default.html

Calibrating and Weighting Map Criteria: Supplemental discussion and an Excel worksheet demonstrating the calculations are posted at:

www.innovativegis.com/basis/

Select "Column Supplements" for Beyond Mapping, September, 2003.

- Delphi and AHP Worksheet link contains Excel worksheet templates for applying the Delphi Process for calibrating and the Analytical Hierarchy Process (AHP) for weighting as discussed in this sub-topic (Geo World, September 2003).
- Delphi Supplemental Discussion link describes the application of the Delphi Process for calibrating map layers in GIS suitability modeling.
- AHP Supplemental Discussion link describes the application of AHP for weighting map layers in GIS suitability modeling.

EPRI-GTC Siting Model: The EPRI-GTC Overhead Electric Transmission Line Siting Methodology is discussed in detail in a Geo World feature article, April 2004, posted online in the Geo World archives at:

www.geoplace.com/gw/2004/0404/0404pwr.asp

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APPENDIX M

Articles, Presentations and Conferences Items Related to the EPRI-GTC Siting Methodology

Since 2001, the Environmental Sector of EPRI has made the Overhead Electric Transmission Line Siting Methodology a priority research project. By funding this project through one of their multi-year research programs, the EPRI-GTC Tailored Collaboration Project provided EPRI, GTC and other stakeholders with an opportunity to work with some of the foremost GIS experts.

Status reports were given on the project at the Fall 2003 and Winter 2004 EPRI Advisory Council meetings. In addition, Photo Science, Inc. and Dr. Joseph Berry presented the results of this research at various conferences. EPRI and GTC have made presentations at several conferences and workshops and published articles in trade and academic publications.

GeoTech

A paper on the Delphi and AHP aspects of the project were presented at GeoTech, Toronto, Ontario, Canada, March 28-31, 2004 entitled "Optimal Path Analysis and Corridor Routing: Infusing Stakeholder Perspective in Calibrating and Weighting of Model Criteria."

[See http://www.innovativegis.com/basis/present/GeoTec04/GIS04_Routing.htm for an online copy of the paper]

GeoWorld Article

This methodology is being introduced to other forums beyond the electric industry. In April 2004 Volume 17, No. 4, of GeoWorld, a paper entitled "A Consensus Method Finds Preferred Routing," was published, describing the geo-technology used in the EPRI-GTC Overhead Electric Transmission Line Siting Methodology.

Transmission & Distribution World Article

This EPRI-GTC study was the subject of a six-page feature story in the February 2005 issue Transmission and Distribution World Magazine. *(GIS-Based Line-Siting Methodology; Georgia Transmission collaborates with EPRI to develop a standardized, defensible siting strategy. Barry Dillon.)* The article is available at magazine's archive, www.tdworld.com.

GTC News Releases

In 2004, information about the EPRI-GTC Overhead Electric Transmission Line Siting Methodology was sent to newspapers in Georgia and industry trade publications. Another news release will be issued when this report is made available to the public.

California Energy Commission Presentation

On April 21, 2004, EPRI was invited to present the Overhead Transmission Line Siting Methodology to staff from the California Energy Commission.

Environmental Concerns on Rights-of-Way Management Symposium

GTC's abstracts have been accepted by the Symposium: one for a presentation and the other for an interactive workshop.

Conference Presentations

The EPRI-GTC Overhead Electric Transmission Line Siting Methodology project was presented at the 2004 Transmission and Distribution World Expo, the 2004 Geospatial Information and Technology International Conference, the 2004 GIS for the Oil and Gas Industry Conference and the 2004 Environmental Systems Research Institute International Conference.

A Consensus Method Finds Preferred Routing

By Jesse Glasgow, Steve French, Paul Zwick, Liz Kramer, Steve Richardson and Joseph K. Berry

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Determining the best route through an area is one of the oldest spatial problems. Meandering animal tracks evolved into a wagon trail that became a small road and ultimately a superhighway. Although this empirical metamorphosis has historical precedent, contemporary routing problems involve resolving complex interactions of engineering, environmental and social concerns.

Previously, electric transmission line siting required thousands of hours around paper maps, sketching hundreds of possible paths, and then assessing feasibility by "eyeballing" the best route. The tools of the trade were a straightedge and professional experience. This manual approach capitalizes on expert interpretation and judgment, but it's often criticized as a closed process that lacks a defendable procedure and fails to engage the perspectives of external stakeholders in what constitutes a preferred route.

Selection of preferred routes – and the prerequisite choice of broad, generalized routing called corridors – is a growing source of public controversy and regulatory scrutiny throughout the United States. The electric industry has responded with many initiatives, including a new GIS-based system that could radically change the way electric utilities evaluate and select transmission line routes.

The GTC/EPRI Project

The Electric Power Research Institute (EPRI) and Georgia Transmission Corp. (GTC) are developing a prototype GIS tool that integrates satellite imagery with layers of statewide GIS datasets. In addition, standard business process and site-selection methods are being created in the hopes of developing new industry standards. The GTC/EPRI Transmission Line Siting Methodology Research Project is an example of how geotechnology can be used to improve productivity and help address a critical industry-wide challenge.

GTC, provider of electric transmission for 39 electric cooperatives, is sponsoring the EPRI project that's being developed with the participation of utilities, government agencies, elected officials and community stakeholders from Georgia and neighboring states. Transmission lines carry bulk power from generating facilities to local distribution systems that, in turn, carry electricity to homes and businesses. EPRI is a nonprofit energy research consortium that provides science- and technology-based solutions for the world's energy industry.

GIS Needed

Although the exact set of factors to be considered may change in different parts of the country, most transmission line routing requires attention to *environmental* (e.g., wetlands and flood plains), *community* (e.g., existing neighborhoods and historic sites) and *engineering* (e.g., slope and access) factors.

GISs are explicitly designed to manage and combine large amounts of spatially distributed data. In fact, transmission line siting can be thought of as a special case of land suitability analysis that drove much of GIS' early development.

Authority to use land is critical for electric transmission lines. GIS siting methodology attempts to use sound science and technology to expedite approvals, getting projects built on time and at lower costs. The National Environmental Policy Act (NEPA) and best-management practices require documentation that constrains project siting. The purpose of documentation isn't to generate reams of paperwork, but to foster excellent siting decisions. However, the site selection process can take years and millions of dollars, and it often disenfranchises affected parties.

The documentation process doesn't mandate a standard routing procedure or particular substantive results. It does require, however, a thorough study of consequences of proposed actions. It requires proponents to look at the effects of alternatives as well as articulate satisfactory explanations, including rational connections among facts found and choices made.

Adopting GIS methodology streamlines the decision documentation process and promotes consistent, quantitative and defensible "standards" for examining data, articulating explanations and demonstrating connections among facts and choices. GIS siting procedures help proactive companies implement strategies that anticipate critical land-use issues affecting transmission line placement.

Approach Overview

The EPRI Transmission Line Siting Methodology is analogous to a funnel into which geographic information is input and a preferred route emerges (see Figure M-1). Geographic information is calibrated and analyzed in phases with increasing resolution. Proceeding down and through the funnel, the suitability analysis process continuously refines the corridor(s) most suitable for transmission line construction.

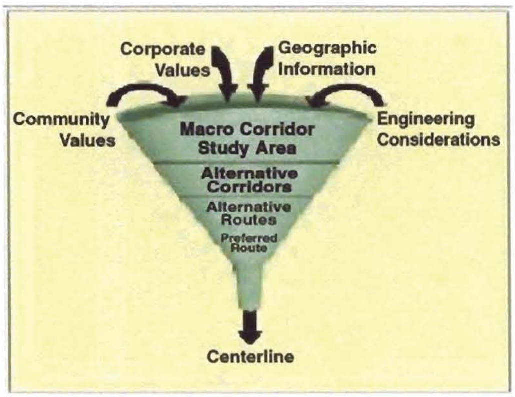

Figure M-1
The Route-Selection Process can be Conceptualized as a Funnel that Successively Refines Potential Locations for Siting a Transmission Line

For example, at the macro corridor level, statewide data based on 30-meter satellite imagery are used to identify the study area, whereas at the alternate-routes step, four-meter grid cells are used to capture highly resolved information such as the position of buildings to identify preferred routes.

Geographic features are organized by scale (resolution) and discipline. To rank individual features by suitability and weight feature groups by relative importance, internal and external stakeholder input is gathered using the "Delphi Process" that builds consensus as well as the "Analytical Hierarchical Process" (AHP) for pair-wise comparison. Four separate suitability surfaces are created, placing more decision-making preference on the following:

1. Optimizing engineering considerations
2. Built environment consequences
3. Natural environment impacts
4. Averages of preference factors

After the four preference surfaces and a map of areas to avoid (e.g., airports, large water bodies) are available, Photo Science Inc.'s Corridor Analyst software is used to measure the accumulative preference for all possible routes connecting the endpoints. The total accumulative preference surface from the start and endpoints is classified to delineate the top 3 percent of all possible routes. The process results in four alternative corridors reflecting the routing preferences contained in the suitability surfaces (see Figure M-2).

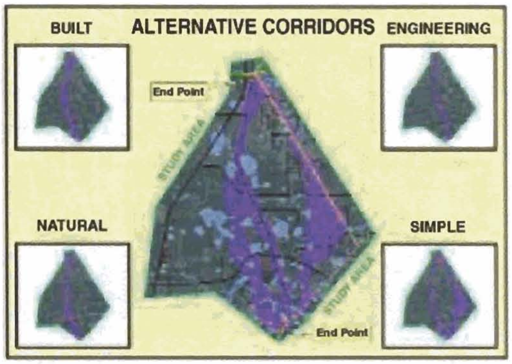

Figure M-2
Alternate Routes are Generated by Evaluating the Siting Model Using Weights Derived from Different Group Perspectives

Adding Data

Within the alternative corridors, additional data are gathered (e.g., buildings and property lines), and a team of routing experts define a network of alternative route segments for further evaluation (see Figure M-3). Statistics, such as acreage of wetlands affected, number of streams crossed, number of houses within close proximity, etc., are automatically generated for each of the alternate route segments.

Segments with connectivity are defined, and segment statistics are summed to create alternative route statistics. Based on spatial data and other factors, the siting team uses AHP pair-wise comparison to assign weights to the alternative routes, resulting in a relative ranking of each route alternative. The highest-ranking route identifies the preferred route corridor (see Figure M-4).

Detailed field surveys are conducted along the preferred route (collecting data using Global Positioning System, photogrammetry, light detection and ranging, and conventional surveying techniques) to map cultural, ecological, topographical and physical features. Engineers make slight centerline realignments and then design the final pole placements and construction estimates based on the information.

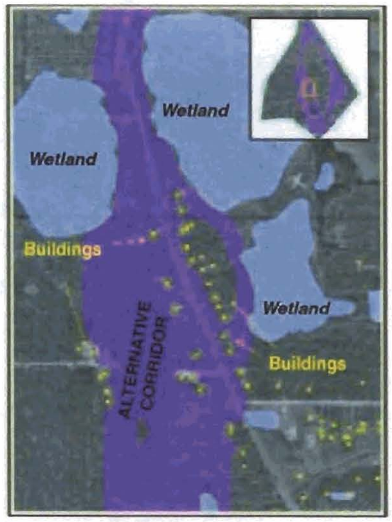

Figure M-3
Within the Alternate Corridors, Additional Data are Gathered Such as Exact Building Locations from Aerial Photography

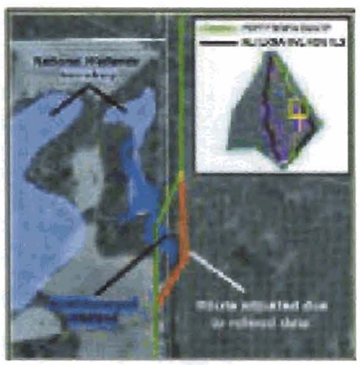

Figure M-4
A GIS-Generated Preferred Route is Adjusted as Necessary Based on Detailed Field Information and Site-Specific Construction Requirements

Input for determining the calibration and weighting of routing criteria was gathered from subsets of the stakeholders appropriate for the group's focus, whether engineering, natural environment or built environment.

Preference values were assigned based on a standardized process predefined by the model-development team. For each of the engineering layers (slope, linear features and selected land uses), individual stakeholders valued each feature (from 1 to 9) for a range of opportunities. The value 1 indicated the most-preferred feature in the map layer, while 9 was assigned to the least preferred. For example, 0-15 percent slopes identified the best conditions, 15-30 percent was moderate, and greater than 30 percent identified the worst conditions.

A modified Delphi Process was used to gain consensus for preference values. The values assigned by group participants to each category were averaged, and the standard deviation was calculated. If the deviation of the individual preference values for a particular feature was small, the group agreed that there was consensus and assigned the average preference value for the feature. If the deviation for a feature was large, the group proceeded to discuss the range of values and developed consensus through a sequence of re-evaluations.

Engineering Considerations

Those participating in the engineering analysis included engineers and scientists from utilities and state infrastructure agencies involved with site selection for transmission lines. The group was selected to provide specific knowledge regarding the collocation of power lines with other linear features, including transmission lines, roadways, railroads and other utilities.

After all the layer features had been evaluated, the selected preference values for all features were used to create a raster surface of preferences for the individual engineering layers. The AHP process was used to weight the map layers to reflect relative importance, and a weighted average was calculated to derive the overall engineering preference surface. This procedure for calibrating and weighting map criteria also was used for assessing the project effect on the natural and built environment Perspectives.

Natural Environment

Numerous federal and state laws such as the Endangered Species Act, the Clean Water Act, National Pollution Discharge Elimination System, and wetlands and riparian buffer regulations drive the selection of environmental criteria. Many of the rules require obtaining permits from regulatory agencies and often require mitigation of impacts. Additional environmental criteria have been established as part of GTC's business policies, such as avoiding lands with private conservation easements as well as state and federally owned lands.

The natural environment stakeholder group included members of the regulator community such as the U.S. Army Corps of Engineers, U.S. Environmental Protection Division and Georgia Department of Natural Resources as well as local representatives from non-government organizations in the environmental community.

For the most part, the group reached consensus for factors that had good regulatory foundations. For criteria without regulatory rules, such as public-land issues and other land-use categories, it was more difficult to reach group agreement. A few of the factors initially considered by the environmental group, such as intensive agriculture and small water-retention ponds, turned out to be better considered by the engineering or built groups.

Built Environment

NEPA and various state-level policies require consideration of aspects of the built environment, such as historic sites. However, the most important obstacle to siting new transmission lines has been opposition from homeowner and community groups. An effective transmission line siting method can't be blind to community and neighborhood preferences.

The built environment stakeholder group provided input on community concerns for appropriate calibration and weighting of preference surfaces. The group included professionals in historic planning, regional planning, community development and local government as well as representatives from homeowner and neighborhood organizations. The stakeholders first calibrated the scale for each measure and then determined the importance weighting for the following built environment layers: proximity to buildings, proximity to cultural resources, building density, proximity to proposed development, visual vulnerability and proximity to excluded areas.

Actual buildings were handled as avoidance areas, and a fairly high level of consensus was reached. The same process was conducted with a group of utility professionals, and similar results were achieved.

Lessons Learned

In January 2004, a workshop was held with transmission line siting professionals from 10 utility companies. The professionals were asked to review and comment on the methodology described in this article. The GTC/EPRI methodology is generally similar to the processes that other utilities currently are using. All were using some type of GIS-based system, and most used a process that focused on more-detailed data as siting alternatives were narrowed.

Most utility representatives thought that this new methodology was more organized, comprehensive and consistent than their current practice, and most thought the methodology would produce consistent routing based on sound and documented science. Particular interest was expressed in the efficiency of the macro corridor analysis technique to guide the collection of successively more-detailed data.

Probably the most important difference among utilities was in how they handled public involvement. Some utilities ask stakeholders to identify criteria and weight them for each project; others develop alternative routes and ask stakeholders to select from that set; still others rely on an internal siting team with little involvement from the public.

Our experience found that asking citizen stakeholders to work directly with weights and criteria among group perspectives didn't produce a viable model. Citizens tried to "game the system" in setting weights to favor their perspective, often producing unintended results. Our final approach combines the criteria and weights identified by citizen stakeholders with those identified by professionals. This process incorporates public opinion and professional experience to create a consistent model that can be used on a range of projects.

In addition, we found that stakeholders often confused proximity measures with the feature itself. When stakeholders set large proximity zones around features they considered valuable, they would inadvertently force the route into other valuable areas. We also found that it was important to include data about land use in the model.

In an effort to reduce cost, the research team initially considered all buildings the same regardless of use. It became evident that it's necessary to have the model distinguish among residential, commercial and industrial buildings. Most stakeholders considered residential buildings more sensitive than commercial and industrial structures, and the model needed to be able to resolve at least this crude level of land-use distinction.

GTC intends to apply the methodology for all future transmission projects. The structure and rigorous procedure is no substitute for the judgment, values or perspectives of the stakeholders, and it depends – more than ever – on the skill and experience of the professional staff involved.

The GTC/EPRI routing methodology provides a structure for infusing diverse perspectives into siting electric transmission lines. Traditional techniques rely on expertise and judgment that often seems to "mystify" the process by not clearly identifying the criteria used or how it was evaluated.

The GIS-based GTC/EPRI approach is an objective, consistent and comprehensive process that encourages multiple perspectives for generating alternative routes, and it thoroughly documents the decision process. The general approach is readily applicable to other siting applications of linear features such as pipelines and roads.

Note: *For more information on routing and optimal path procedures, visit the Web at http://www.innovativegis.com/basis/MapAnalysis, select Topic 19, Routing and Optimal Paths. Links to further discussion of Delphi and AHP in calibrating and weighting GIS model criteria are included.*

Georgia Transmission News Release

Community Groups Examine Transmission Line Siting Research
GTC, EPRI Conduct Final Workshop and Begin Preparing Final Report

TUCKER, Ga. – More than 25 community stakeholder groups gathered here March 10 with Georgia Transmission Corporation (GTC) and the Electric Power Research Institute (EPRI) to evaluate a national transmission line siting research effort that promises to deliver a standard process for selecting transmission line corridors.

The meeting was the final of four workshops conducted as part of an effort to develop a standard geographic information system (GIS) tool and business processes for improving site selection. Called the EPRI Transmission Line Siting Methodology Research Project, it is scheduled to conclude in June with a supporting software program and report to the industry. Workshops were held with Georgia's Integrated Transmission System (ITS) participants, government agencies, utilities, elected officials and community organizations from Georgia and neighboring states.

The one-day March workshop featured an overview of a proposed siting method and the supporting software program. The method being evaluated was developed with these same groups at a workshop last year. Participants represented agribusiness, chambers of commerce, educators, regional development agencies, local governments, environmental and conservationist groups, homeowners and planners.

"Throughout the country, the Federal Energy Regulatory Commission, electric utilities and state regulatory agencies are under pressure to help the electric utility industry become more accountable in its site-selection processes," said Bob Fox, GTC manager of Transmission Projects. "We believe the method we've developed with EPRI is impartial, consistent and addresses the relevant issues that participants said were most important."

The proposed siting method includes identifying avoidance areas, calibrating and weighting siting criteria and developing potential transmission line corridors based on that information. The software program utilizes satellite imagery and GIS analysis to select macro corridors and create alternate routes. For GTC's purposes, the weighting criteria are based upon input from external stakeholders and ITS members, which consist of GTC, Georgia Power Company, MEAG Power and the city of Dalton. The research was led by EPRI and Dr. Joseph Barry, University of Denver, Dr. Steven French, Georgia Institute of Technology, Dr. Elizabeth Kramer, University of Georgia and Dr. Paul Zwick, University of Florida.

"We have received excellent participation in this project with more than 200 stakeholders attending our workshops, and this has been key in the successful development of our methodology," said John W. Goodrich-Mahoney, EPRI program manager. "We plan to keep stakeholders engaged and involved. Once we've tested the methodology in real-time for one-year, we will revisit its effectiveness with stakeholders for possible revisions.

GTC is a not-for-profit cooperative with more than $1 billion in assets, providing electric transmission service to 39 electric membership cooperatives throughout Georgia. EPRI is a nonprofit organization that manages global research, technology development and product implementation.

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The Electric Power Research Institute (EPRI), with major locations in Palo Alto, California, and Charlotte, North Carolina, was established in 1973 as an independent, nonprofit center for public interest energy and environmental research. EPRI brings together members, participants, the Institute's scientists and engineers, and other leading experts to work collaboratively on solutions to the challenges of electric power. These solutions span nearly every area of electricity generation, delivery, and use, including health, safety, and environment. EPRI's members represent over 90% of the electricity generated in the United States. International participation represents nearly 15% of EPRI's total research, development, and demonstration program.

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