Arnold Schwarzenegger
Governor

PLANNING ALTERNATIVE CORRIDORS FOR TRANSMISSION

PIER FINAL PROJECT REPORT

Prepared For:
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Public Interest Energy Research Program

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Preface

The California Energy Commission's Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Planning Alternative Corridors for Transmission is the final report for the Planning Alternative Corridors for Transmission project (contract number 500-04-029) conducted by Southern California Edison. The information from this project contributes to PIER's Energy-Related Environmental Research Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-654-4878.

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Acknowledgments

During the three years of the project, the coordinated effort of the Model Development Team, the Planning Alternative Corridors for Transmission (PACT) Project Management Team, Project Steering Committee (PSC), and Technical Advisory Groups (TAGs) contributed to the successful completion of work products and technology transfer activities.

The Model Development and Management Teams convened every other week throughout the project to develop plans, review progress, and evaluate results. Together they reported on the project to the PSC, TAGs, other interested PIER projects, and professional groups. Their dedication to the project objectives, involvement in project design, and attention to detail contributed to completion within the scope of the project.

The Model Development Team includes Southern California Edison (SCE), Facet Decision Systems, Robert Thomas Brown Company and their subcontractor BIG Imagination Group, View Point West, the Energy Commission's Facility Siting and PIER Divisions, Aspen Environmental Group, and Katz and Associates.

The PSC is acknowledged for their review of the project concept, evaluation of progress, and for providing direction for the final products. They contributed the policy and management perspectives of regulators, government organizations, electric utilities, resource agencies, and non-profit organizations to improve the applicability of the final products. They also assisted the Model Development Team with the transmission line test cases used to develop the software applications. The organizations represented on the Project Steering Committee are noted below:

- The California Farm Bureau Federation
- California Independent System Operator
- California Institute for Energy and the Environment
- California Public Utilities Commission
- League of California Cities
- League of Women Voters
- Los Angeles Department of Water and Power
- Native American Heritage Commission
- Pacific Gas and Electric Company
- Regional Council of Rural Counties
- Sacramento Municipal Utility District
- San Diego Gas & Electric Company
- San Francisco Bay Conservation and Development Commission
- San Francisco Public Utilities Commission
- Southern California Association of Governments

- Southern California Edison / Edison International
- U.S. Bureau of Land Management
- U.S. Department of Defense—U.S. Navy
- USDA Forest Service, Pacific Southwest Region
- Western Area Power Administration

Six TAGs were formed to provide subject-matter expertise for the development of decision factors, to review the operation of the software applications, and to provide data for the final test case. Their insight led to a more defensible project development framework. The following individuals or organizations participated in one or more of the PACT TAG activities:

- Aesthetics TAG: California Energy Commission (Energy Commission), EDAW, CH2M Hill, and Lee Roger Anderson.
- Biology TAG: Energy Commission, Pacific Gas and Electric Company (PG&E), CH2M Hill, Aspen Environmental Group, SCE, USDA Forest Service, Western Area Power Administration.
- Community TAG: Energy Commission, Creighton & Creighton; PG&E; League of Women Voters; SCE; Sacramento Municipal Utility District (SMUD); Shute, Mihaly & Weinberger Law firm.
- Cultural Resources TAG: Energy Commission, Office of Historic Preservation, Stewarts Point Rancheria, Tribal Historic Preservation Office—Yurok Tribe, Pechanga Band of Mission Indians, Native American Heritage Commission, Bureau of Land Management (BLM), SCE, Morongo Band of Mission Indians.
- Engineering and Economic TAG: Energy Commission, San Diego Gas & Electric Company (SDG&E), SMUD, SCE, Utility System Efficiencies.
- Land Use TAG: Energy Commission, California Public Utilities Commission (CPUC), Pacific Southwest Region of the USDA Forest Service, League of California Cities, California Farm Bureau Federation, Southern California Association of Governments, League of Women Voters, San Diego Association of Governments, The Trust for Public Land

The vision of the late Dr. James R. Young launched this research endeavor at SCE in the mid-1990s. It was his view that computer tools could be designed for use by both technical and non-technical stakeholders to solve complex problems. Multi-level models, flexible frameworks, and the use of Geographic Information Systems (GIS) technology could be integrated to support better decisions. His contributions and those of his research team played an important role in the initial development of the siting tools that led to the PACT project.

Citation

Deming, M.B. 2009. *Planning Alternative Corridors for Transmission Final Report*. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-09-079.

Abstract and Keywords

The Planning Alternative Corridors for Transmission project was developed to support a defensible siting process for utilities, allowing them to objectively document sensitivities in a study area, accelerate the analysis of multiple siting criteria, and communicate visually with a variety of stakeholders. The primary objective of the Planning Alternative Corridors for Transmission (PACT) project was to produce a web-based, GIS-enabled model to compare multiple criteria for each particular alternative, representing stakeholder values and decision variables by discipline.

This project resulted in the creation of two database development applications: Data Preparation and Web Builder. These applications can produce several types of websites for identifying viable corridors and evaluating selected corridor segments and routes. The final functionality in the application and website was developed using the California I-80 Transmission Corridor test case, supplied by the Pacific Southwest Region of the U.S. Forest Service, augmented by data provided by Pacific Gas & Electric Company.

Keywords: Infrastructure, siting, siting model, PACT model, corridor planning, transmission, transmission siting, GIS, decision model, planning, route evaluation, environmental assessment.

Executive Summary

Introduction

The Energy Commission *2004 Integrated Energy Policy Report Update* (*2004 IEPR Update*) addresses inadequacies in the transmission permitting process and identified a number of strategies to improve transmission planning in state. Noteworthy, is the *2004 IEPR Update's* recommendation to engage stakeholder and public participation early and throughout the planning and permitting process. The *2004 IEPR Update* further recommended that transmission alternatives be examined early in the project planning phase so that environmental review in the permitting phase can focus on routing alternatives and mitigation, rather than raise potential alternatives late in the permitting process. The Planning Alternative Corridors for Transmission project was initiated to address these transmission planning and permitting issues.

Purpose

The Planning Alternative Corridors for Transmission project was a collaborative to create a decision-support model for siting transmission facilities. The project incorporates environmental and engineering analysis and multiple stakeholders' values, allowing users to create unique scenarios that capture their values. The Planning Alternative Corridors for Transmission project turned a complex environmental analysis of alternative locations for proposed energy developments into a clearer and more decision-friendly medium. This unique model provides planners, regulators, interested stakeholders, and decision makers a common, transparent and informational format to facilitate an open and participatory process for siting new electrical facilities.

Project Objectives

- Design and deliver, with the active involvement of the Policy Advisory Committee, an enhanced model capable of analyzing increased power line development and licensing expected in the next decade.
- Increase communications among energy developers, the California Energy Commission and other regulators, and critical stakeholders to improve negotiations, help parties understand trade-offs, and achieve consensus on facility siting inputs, the planning process, and desired outputs.
- Ensure that users have introductory working knowledge of the capabilities of the model and that the model meets user expectations.

Project Outcomes

The Planning Alternative Corridors for Transmission project successfully designed Data Preparation and Web Builder applications for a database on the project website. The website currently displays a test case that documents and communicates environmental and engineering evaluations of alternative transmission line segments and routes.

The website can be accessed at http://pactdss.com. A typical transmission project test case illustrates how the database functions and can be used to:

- Find feasible routes
- Screen alternative routes to meet the project purpose and need
- Evaluate alternative routes from different perspectives
- Choose preferred and alternate routes
- Document environmental assessment results
- Communicate with management, regulatory agencies and other interested stakeholders

Using hypothetical test cases, the model captures multiple values and assesses the relative importance of each value based on specific criteria. By providing a clear process and allowing users to define their preferences and interests, the model can improve communication between individuals and organizations who have a vested interest in the project. Users can visualize, in real-time, the trade-offs inherent to a given project using different inputs.

Utility, public agency, and private company representatives attended workshops for an overview of the project objectives and introductory training on how to use the Data Preparation tool and Web Builder tool on the website. Attendees provided feedback that was used to improve the user-friendliness, functionality, and appearance of the tools.

Conclusions

With guidance provided by the Project Steering Committee and Technical Advisory Groups , the model was created and completed, meeting the project objectives. The Planning Alternative Corridors for Transmission project successfully creates data libraries with the Data Preparation tool, defines decision factors with the Web Builder tool, and displays and provides an interactive medium for data and results on the website. The model was evaluated using three test cases and accommodates different project types but requires additional validation by more users on further test projects.

Users who attended the Planning Alternative Corridors for Transmission model training workshops are equipped with a novice-level working knowledge of the functionality and potential application of the tool set, but most were not trained to the level of independent use.

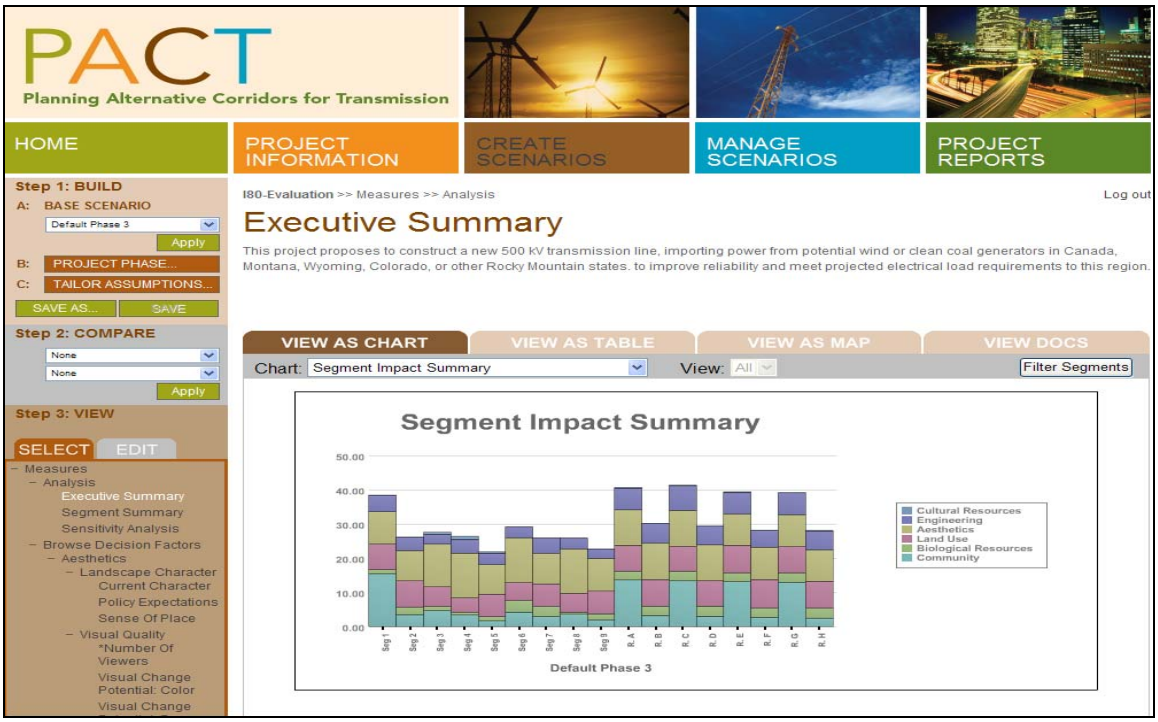


Figure E-1. Example Screen shot of Executive Summary page.

Recommendations

The Planning Alternative Corridors for Transmission model was developed using three test cases and offers a flexible and powerful framework for a broad range of project types. It is recommended that the model be used and tested on as many different actual projects as possible to improve the content, functionality and ease of use. It is also recommended that the model is demonstrated to more users, so it eventually can be applied to more complex cases.

To transfer the Planning Alternative Corridors for Transmission technology from the project development team to more users, it is vital that more training be provided to potential users. Previous training workshops focused on introducing a small number of new users to the tools, and additional training will be required to create proficient, independent users. Improved marketing may also encourage more potential users to participate in future training workshops.

One function, corridor planning, was not evaluated using the I-80 test case and the corridor planning feature on the website could benefit from dedicated testing using an actual project.

Improvements should be made to the project reporting capabilities, and future work should be conducted to develop a user interface on the website that exports complete analytical reports.

Once the project tools have been validated and are ready for transfer to the public, a long-term web hosting solution must be available to ensure that all users have equal access to the tool suite.

Benefits to California

Californians will benefit from the project due to reduced project delays, efficiency, communication, and transparency. The Planning Alternative Corridors for Transmission project model can simplify and expedite environmental analysis and project decisions reducing siting and licensing costs. Data from each project is displayed efficiently in chart, tabular, and map form to ensure the results are accessible to different users. The planning process is made transparent by the model and users are able to see how each decision variable is valued by the project team. The model also uses quantitative analysis to optimize facility siting, minimizing the negative effects to the community and environment.

A series of user manuals were created to guide new users through the Planning Alternative Corridors for Transmission model functions and include specific instructions for creating a project website from start to finish. The user manuals allow accessibility of the Planning Alternative Corridors for Transmission tools, which benefits Californians by opening potential use to those individuals or organizations without a technical background. The manuals encourage a collaborative, transparent process with greater accessibility to potential organizations.

1.0 Introduction

1.1. Background and Overview

In spite of the state's widespread need for new transmission lines, progress has been slow. Siting new lines is a difficult and time-consuming process, due in part to regulatory inconsistencies, multiple stakeholder interests, and adversarial objections. A process allowing early participation in planning to better communicate needs and options would be less adversarial and more likely to facilitate consensus building.

As early as 1991, Southern California Edison (SCE) began researching ways to reduce the costs of complying with environmental rules and regulations. The utility continues to pursue more efficient methods to assess the environmental impacts of operations and compliance costs, and to improve its decision-making capabilities. This project developed a system to facilitate environmental assessments that is more responsive to the concerns of project proponents and other stakeholders.

The newly developed framework can be used by all public and private utilities, and each utility was involved in this project. Its more efficient display of environmental data, better identification of options for maximized environmental benefits, and proactive approach to meeting environmental regulations result in lower compliance costs and these savings are passed on to the customer. Additionally, the public-private partnership proposed for applications of the Planning Alternative Corridors for Transmission (PACT) Project will help to facilitate the regulator's work on reviews, independent analyses, public reviews and hearings, providing constructive feedback to proponents and the public, and offering flexibility to rapidly adjust, edit and resubmit a proposal.

This siting decision framework has the potential to accelerate the planning and licensing process for new facilities from preliminary site assessments and informal public participation, through the rigorous environmental assessment and formal public approvals, to permitting and licensing.

Before this project, SCE's existing siting framework had only been tested in the narrow context of internal site screening for local substations and power lines. Several issues had to be resolved to make the application more user-friendly and efficient. The PACT project was planned to address challenges such as researching data gaps, transforming existing data into useable Geographic Information Systems (GIS) formats, and reducing the complexity of the various technical components and the interrelationships among the working sections of the model (data management, assigning weighted criteria, mapping, stakeholder decisions and output formats). More comprehensive testing and development were employed to resolve the technical issues and expand the model's capabilities to fully realize its potential as a decision support system.

The research objectives of this project included:

- Assemble and involve appropriate technical and stakeholder committees to determine metrics and weighted criteria for each discipline (i.e. biology, cultural) to populate the model.

- Expand current capabilities of the framework to include a broader range of disciplines.
- Determine, obtain, and, when necessary, transform the data required to populate the framework.
- Demonstrate the siting framework's capabilities to analyze and compare transmission line routes and enhance decision making on broader scale transmission line projects.
- Improve the usability of the framework for all appropriate stakeholders.
- Provide materials and training necessary for the framework to be used by energy developers, regulators, and critical stakeholders to enhance negotiations, understand trade-offs and achieve consensus on energy facility planning and siting.
- Determine future steps needed to further enhance the framework to achieve desired objectives.

Using real-time testing methods, this project expanded the existing siting framework to include regional and state-wide applications. More importantly, it enhanced the framework to include the entire project development lifecycle from initial feasibility analyses through filing applications with regulators, increasing the scope for stakeholders to make interactive decisions.

The economic objectives of this project include meeting the PIER goal to improve:

- Reliability, quality and sufficiency of California's electricity by facilitating and improving the process of siting new statewide transmission lines needed to meet energy supply and demand.
- Energy cost/value of California's electricity system by developing a siting process that results in environmentally-informed business decisions and ratepayer benefits such as reduced environmental planning and regulatory costs and improved regional environmental quality.

1.2. Overall Project Goals

- Design and deliver to the Energy Commission, with the active involvement of the Project Steering Committee, an enhanced model capable of analyzing increased power line development and licensing expected in the next decade.
- Increase communications among energy developers, the Energy Commission and other regulators, and critical stakeholders to improve negotiations, help parties understand trade-offs, and achieve consensus on facility siting inputs, the planning process, and desired outputs.
- Ensure that users have a working knowledge of the capabilities of the model and that the model meets user expectations.

2.0 Project Approach

The PACT project approach included four general components:

- Project Steering Committee (PSC)
- Technical Advisory Groups (TAG) for each subject area
- Web-based decision support tools
- Test cases completed and displayed as websites

The project approach had the following objectives:

- Develop a PSC to direct project outcomes
- Create TAGs to provide subject-matter expertise for tool development
- Develop web-based user-friendly decision support tools for electrical facility siting and corridor planning
- Develop test cases to build the application frameworks and to illustrate the application functionality

The PSC provided guidance for developing and creating the decision support tools, focused the project on its stated objectives, and performed technical reviews of the final content. The PSC was comprised of a diverse set of professionals with knowledge of the technical and logistical complexities of transmission line siting. Representatives from state, federal, regional and local regulatory agencies, relevant stakeholders, public and merchant utilities, academic experts, environmental and engineering consultants, and members of applicable resource/issue-specific societies and associations were asked to participate. The role of the PSC was to provide guidance in research direction, review draft and final PACT products, evaluate tangible benefits of the PACT Project to California and provide recommendations, as needed, to enhance these benefits. The PSC also provided recommendations regarding information dissemination, market pathways and commercialization strategies relevant to PACT's capabilities.

Technical Advisory Groups for each discipline were assembled early in the project. TAG members with professional expertise in their respective disciplines were asked to:

- Assess the previous SCE modeling program upon which PACT was based
- Recommend modifications to the SCE model to meet the scope and purpose of PACT
- Assist in the development of PACT's test case scenarios
- Develop issue-specific weighting criteria
- Define data needs, data sources and output
- Recommend data analysis techniques
- Review PACT's issue-specific draft and final products
- Provide input regarding the PACT's user interface

TAGs were created for each of the fundamental disciplines in a siting process:

- Aesthetics

- Biological Resources
- Community
- Cultural Resources
- Engineering
- Land Use

The TAGs identified and defined the decision variables needed to capture the concerns typically associated with their subject matter area. The categories and decision variables provided the framework for the decision process, and represent the basic structure of the website tool.

The planning process represented in the PACT system of tools is based on some fundamental principles for multi-attribute decision analysis. There are three tools in the PACT tool suite: the Data Preparation tool, the Web Builder tool and the project website. Project alternatives are evaluated in the website on the basis of decision criteria that are measured and weighted, and measures and weights can be changed to reflect the views of different stakeholders. The Web Builder tool creates the website, and the Data Preparation tool prepares raw data and GIS layers for Web Builder. These components are described in greater detail in the Project Outcomes section of this document.

To facilitate development for the PACT Project's underlying model and web-enabled tools, three test cases were used to demonstrate functionality of the tool, and are described in further detail in the Project Outcomes section of this document. The performance of each of the components within the modeling process was analyzed using the I-80 test case, which provided a simulation of a siting project for development and testing.

3.0 Project Outcomes

3.1. Project Outcomes in Terms of Stated Objectives

3.1.1. Enhanced Model

The final model website is available at pactdss.com. The test case displayed on the website illustrated the functionality of the model. The interactive website was completed with the collaborative management and model development teams with guidance from the TAGs and the PSC, who made valuable contributions to the project design and direction. The model is based on a planning process that begins with identifying feasible routes, followed by a detailed screening and evaluation of alternatives in order to meet project objectives. Once preferred and alternative routes are selected, environmental assessment results for each route are documented and project impacts are communicated to the project team.

TAGs identified and defined decision factors, and determined the relative weights of the factors for their subject area. The development team created the three-part application with a data preparation tool, a website builder tool, and a website based on the framework established by the siting process and decision variables. The website successfully integrates and balances multiple perspectives, in this case as multiple disciplines, and enables project teams to objectively analyze facility development projects. The PACT project developed the framework to include the disciplines of Aesthetics, Biological Resources, Community, Cultural Resources, Engineering and Land Use.

3.1.2. Improved Communications

The project was generally successful at improving communications among energy developers, the Energy Commission and other regulators, and critical stakeholders to enhance negotiations, understand trade-offs, and achieve consensus on facility siting inputs, the structure of the planning process, and desired outputs. However, more demonstrations to potential users are needed.

The PACT project model was specifically designed to capture multiple values and assess the relative importance of each based on specific criteria. By providing a clear process and allowing users to define their individual preferences and interests, the model improves communication between individuals and organizations with a vested interest in the project. In addition to factor definitions and editing, project definition and scenario building processes, visual options were developed (charts and maps) to improve interaction with the data and among stakeholders. The geographical representation of each decision variable allows users to visualize, in real-time, the environmental and engineering trade-offs inherent to a given project. This transparent forum enables users to define and assign a relative weight to their areas of interest and compare their ideal scenarios to that of others with different values. The model framework supports a collaborative work environment for stakeholders by giving all users equal access to information about the planning process, the project goals, and the optimal analysis of multiple disciplines.

3.1.3. Education of Users

To ensure application users have a novice-level knowledge of the capabilities of the model, and that the model can be upgraded to meet user expectations, the PACT project management team organized workshops and training sessions to introduce potential users to the functionality and use of the model and website.

Interested parties from utilities, public agencies, and private companies attended the workshops where they received an overview of the project objectives, and intensive technical training on how to use the Data Preparation tool, Web Builder tool, and website. The training included obtaining validation from users of the planning processes assumed in the model development, teaching users how to create and display alternative projects with specific attributes, and showing them how attributes and values create unique scenarios for comparison. Feedback was collected from all attendees and was used to improve the user-friendliness, functionality, and appearance of the three components. The training successfully moved the project from the development phase to the demonstration phase, and created a cohort of novice users from different organizations to encourage others to utilize the tool, as well as applying it to their own projects. At this time, however, PACT is still hosted by Facet Decision Systems, the program developer. Efforts are underway to validate the tools and migrate hosting responsibilities to the California Energy Commission.

In addition to the training workshops, the PACT project was presented to prospective users through a poster session at the annual Edison Electric Institute Siting Workshop in 2008. The demonstration focused on the following model functions:

- Viewing impacts for segments and routes
- Viewing all decision factors and their summaries
- Viewing impacts as charts, tables and maps
- Viewing documentation of measurements, assumptions and definitions
- Saving scenarios that have different sets of assumptions

3.2. Additional Project Outcomes

The model is comprised of three tools: the Data Preparation tool, the Web Builder tool and the website. These tools are described in detail in the following sections.

3.2.1. Data Preparation Tool Description

The Data Preparation component of the PACT Project provides tools to format, project, edit, classify, clip, and document spatial and tabular data, thereby standardizing data to be loaded into the Web Builder application. Standardizing data is the first step in preparing data for publication on the project website.

The spatial and tabular data required for detailed modeling can originate from many different sources, each with different data formats, standards and classifications. The Data Preparation application reads the different data sources and provides tools to help the user standardize and classify the data to a format the siting model can use efficiently. Data Preparation consists of the

following tools: a file importer, a geographic projector, a geographic transformer, a tabular data cleaner and classifier, a tabular data joiner, and a geographic clipper. All data manipulations are automatically documented and can be viewed on the final website. Figures 1, 2 and 3 are screenshots from the Data Preparation application.

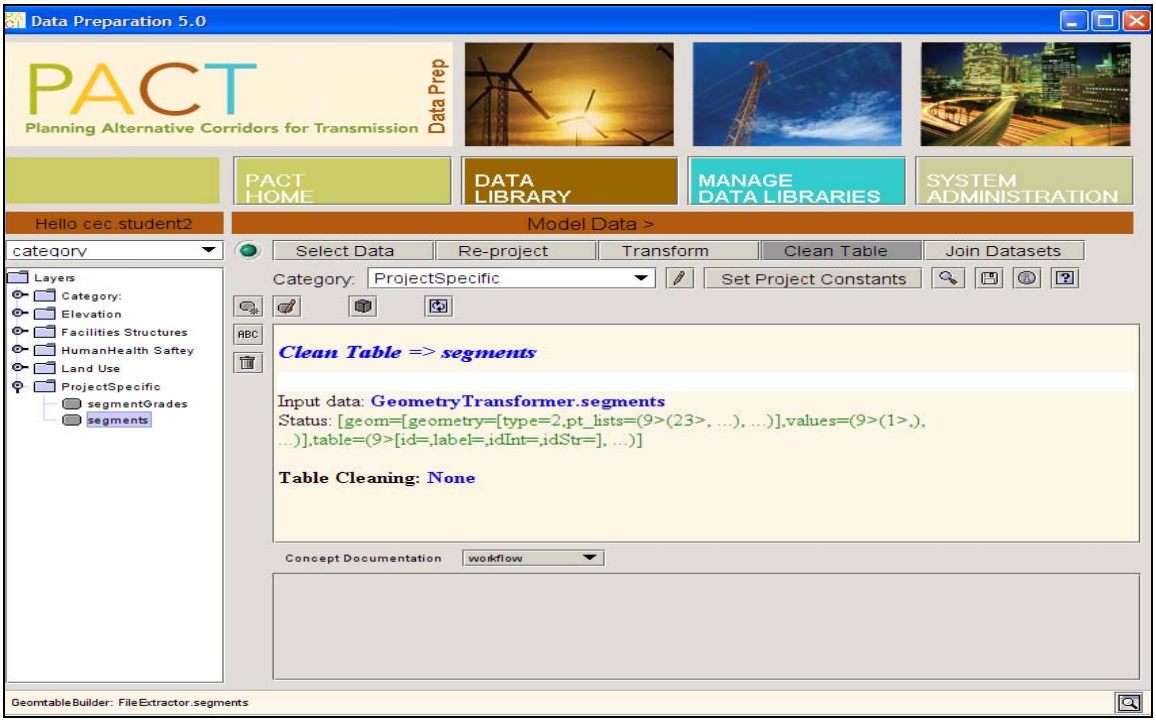


Figure 1. Screen shot of the Table Cleaner tool in the opening page of Data Preparation.

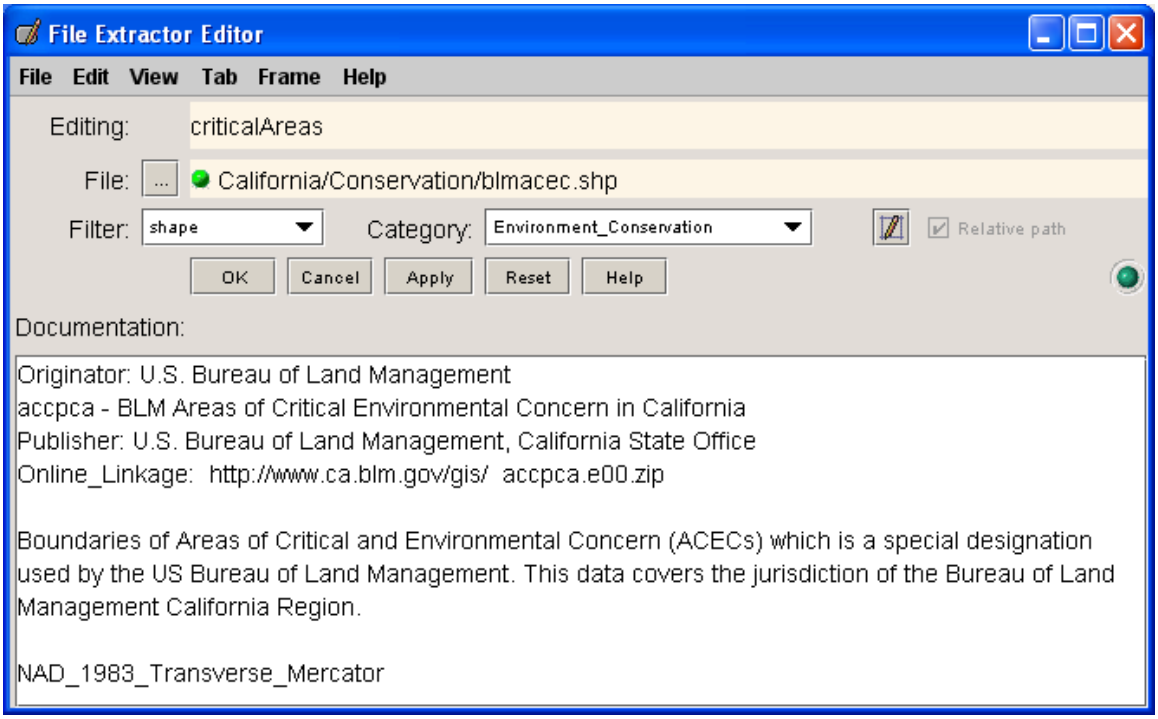


Figure 2. Screen shot of File Extractor Editor tool.

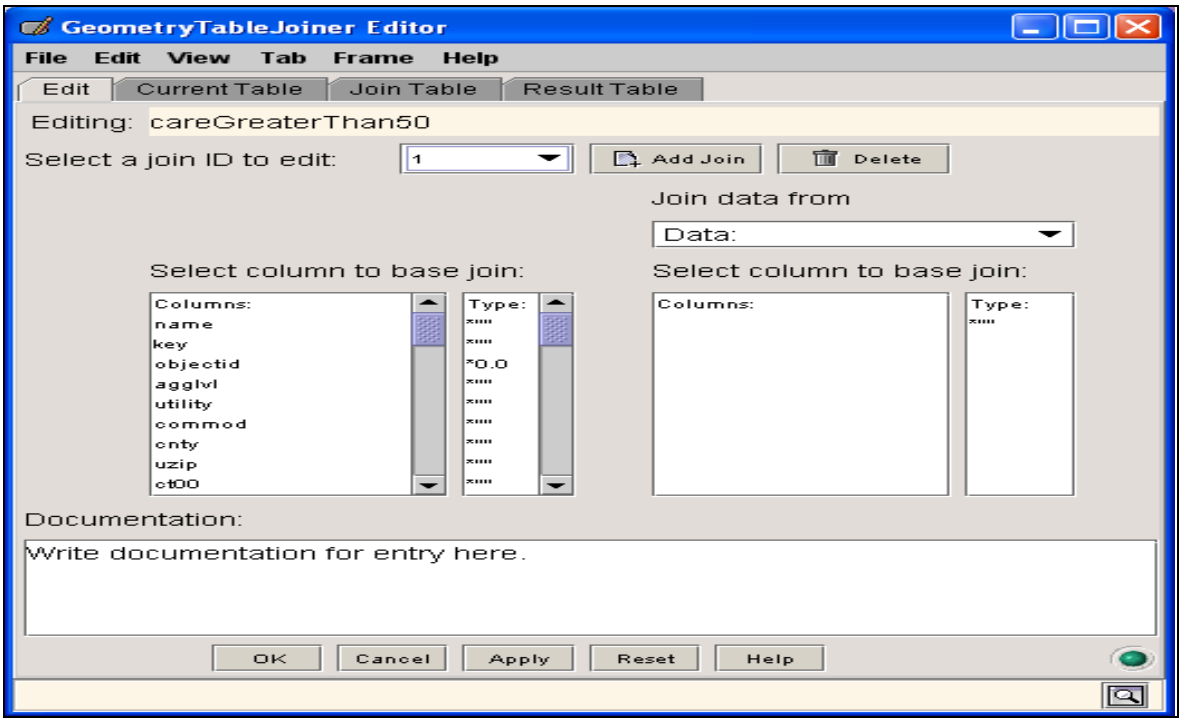


Figure 3. Screen shot of the Geometry Table Joiner Editor tool.

3.2.2. Web Builder Tool Description

The Web Builder component of the PACT project provides tools to create and give meaning to factors in a scenario. It is the second step in the PACT process to prepare data for publication on the final website. Web Builder allows the user to create factors for a particular scenario and publish the factors to a website. The application allows the user to add documentation to factors, associate spatial or tabular data to factors, create a mathematical calculation for the factor, and define a transformation curve.

Web Builder uses the data library created in Data Preparation to create the contents of each factor. When spatial or tabular data is associated with a factor, the website can calculate a result, which is then transformed into a score using the specified curve. The score is weighted based on its relative importance to other decision variables, which reflects the impact of the factor to the total analysis. Each of these components are defined and calculated in Web Builder to produce a website from the information contained in the database and the functions assigned to it in this tool. Documentation about how each factor has been created and calculated is automatically generated on the website, informing the user about the method behind each result.

Figures 4, 5, 6, and 7 are screenshots taken from the PACT Web Builder.

Figure 4. Screen shot of PACT Web Builder home page.

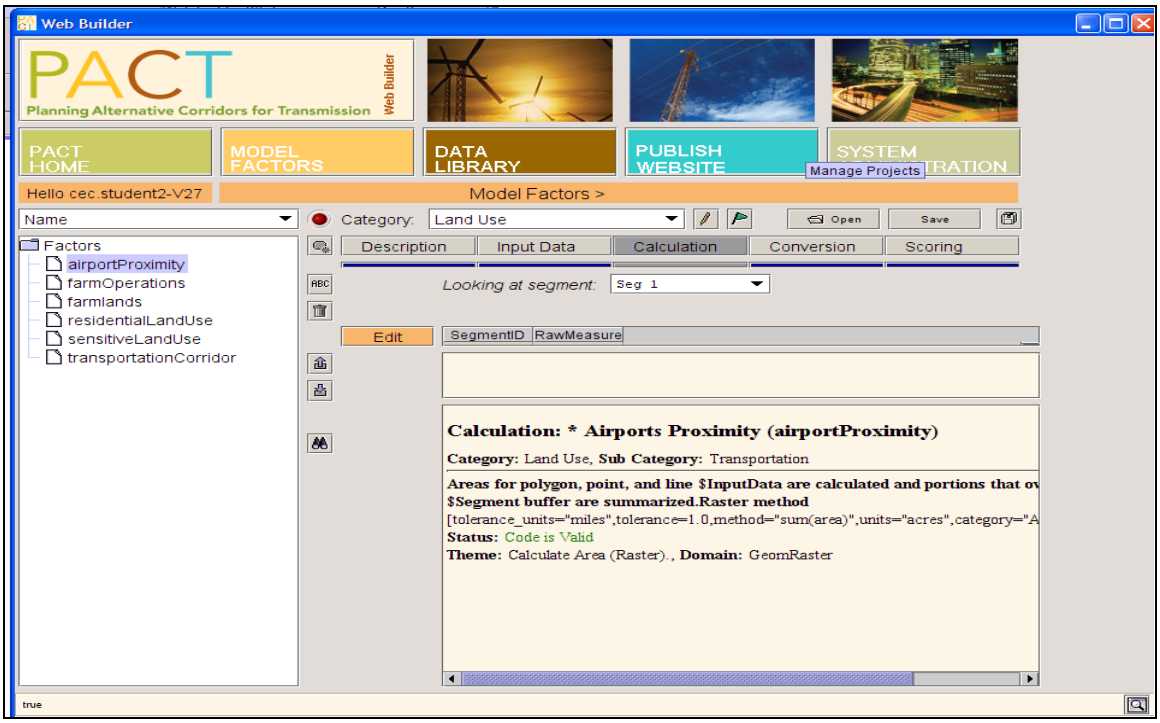


Figure 5. Screen shot of PACT Web Builder model factors page.

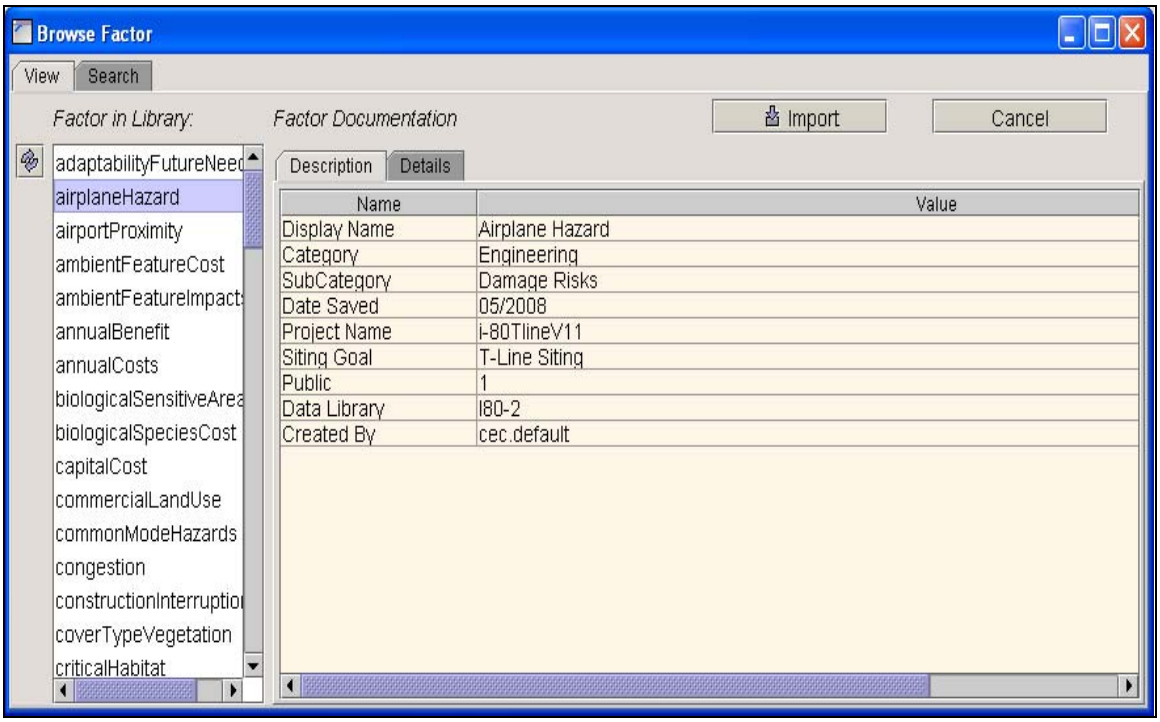


Figure 6. Screen shot of PACT Web Builder data library.

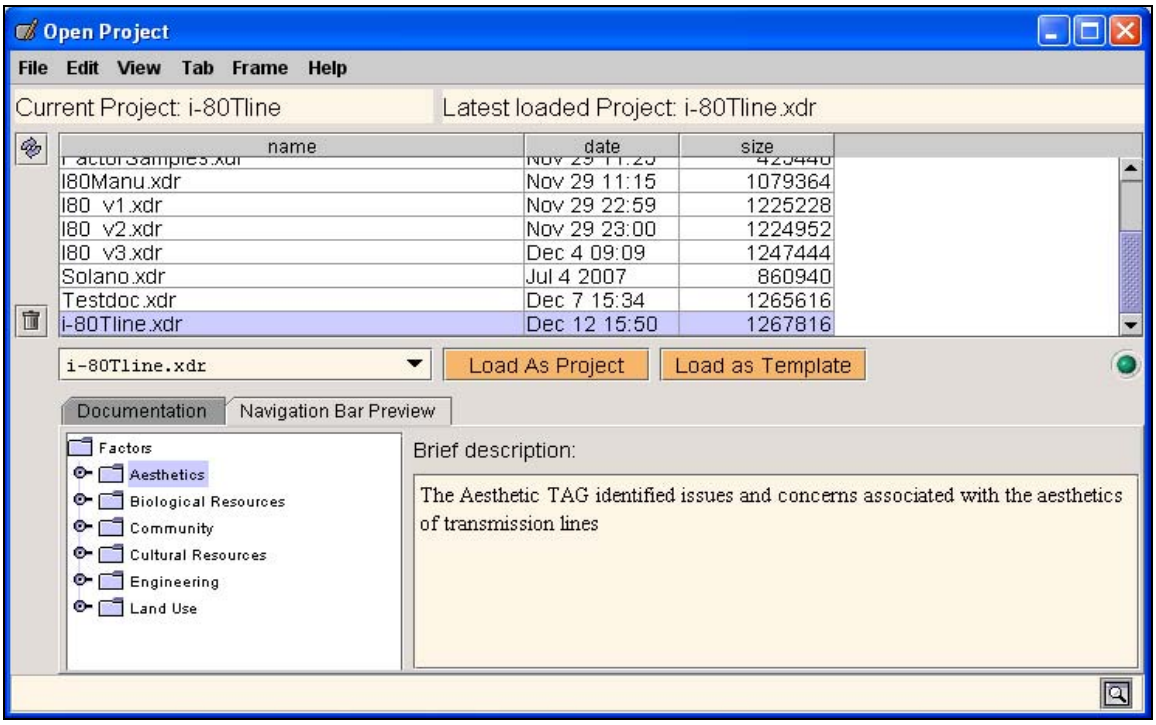


Figure 7. Screen shot of PACT Web Builder open project page.

3.2.3. Website Description

The PACT project website is the primary product of the PACT project and it allows users to view, analyze and compare alternative scenarios for optimal facility siting. A typical project begins with a scoping process where a project is defined, followed by data collection for each decision variable used to analyze the project. The results of the analysis are displayed on the website where users can change certain aspects of the analysis such as weighting and transformation curves to reflect their values. These sets of assumptions have been saved to the website as scenarios and compared against other scenarios as part of the analysis. Figure 8 illustrates the planning process and how the website fits into a project siting framework.

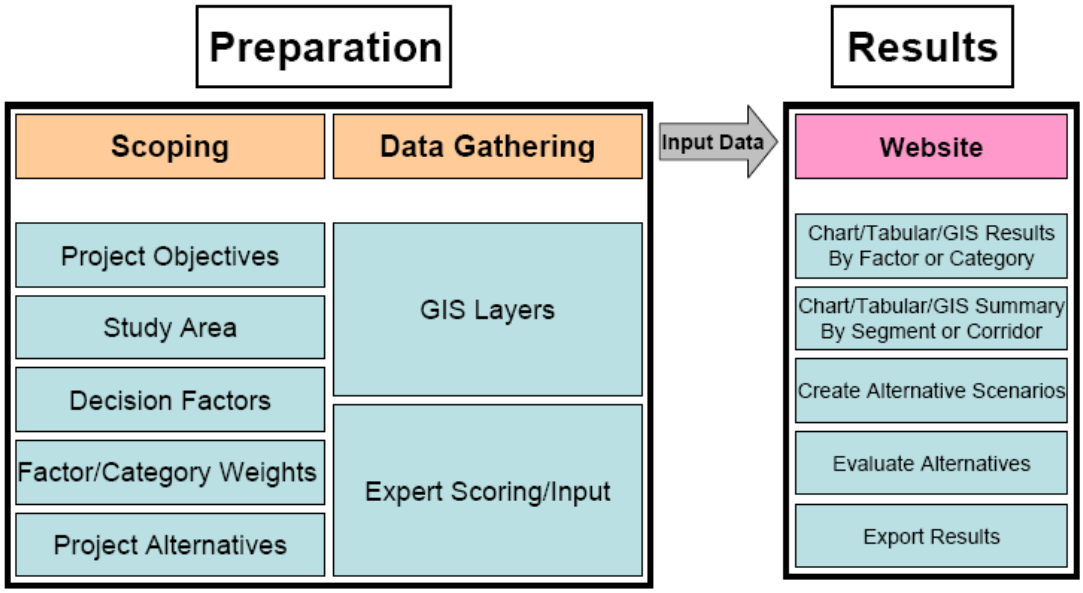


Figure 8. Siting process and website results diagram.

The website is designed to encourage users to follow a logical series of steps. The typical user interacts with the website in the following ways:

- User accesses the PACT website at www.pactdss.com.
- User selects the project for analysis.
- User views factors and their measurements.
- User views the transformation curve for each factor, editing/applying as necessary. Any changes made to the default scenario can be saved as a new scenario.
- Application calculates a factor measurement normalized by the transformation curve into a score.
- User views the weights for each factor and category, and edits/applies as necessary. Any changes made to the default scenario can be saved as a new scenario.
- Application calculates weights for each factor represented as a percentage contribution to the overall results.

- Application multiplies the factor score by the contribution to produce the impact measure.
- User creates new scenarios by modifying the transformation curves, weights, and/or certain editable values of the default and other saved scenarios by clicking SAVE AS.
- User can compare up to three scenarios side-by-side.
- User views chart and tabular results, mapping and information by category, sub-category and factor levels in the tabs labeled: View as Chart, View as Table, View as Map, and View Docs.
- User views chart and tabular summaries in the Executive Summary by category or the Segment Summary by line segment.
- User completes sensitivity analysis using factor correlations.

The website provides analyzed results of multiple criteria, within the context of a project's objectives. There are two ways of displaying results in the website, as a summarized analysis or by individual components. The results can then be viewed in either chart, tabular or map form using the respective tabs on each page.

3.2.4. Website Sections

The components section of the website includes factors, their measurements, and their user-specified significance. The key evaluation components available to the user in the website can be broken up into two areas: Browse Decision Factors, and Function and Results.

Browse Decision Factors is the section of the website where the user can browse through factors, sub-categories and categories. These three types of organization provide a hierarchy for browsing and summarizing results.

> **Decision factors** are the fundamental attributes of line segments and routes that are relevant for the siting decision. Factors describe a characteristic of a discipline that has the potential to affect the project. For example, in the Biological Resources category in the I-80 test case, the Critical Habitat factor measures the acreage of designated Critical Habitat in the study area for a given segment or route. The siting goal of Critical Habitat is to minimize the impact of a potential line to Critical Habitat; therefore, segments or routes with more Critical Habitat in the study area are given a worse score. Each project contains many factors that can be summarized in the analysis section of the website. Factors can be calculated from GIS layers, graded by subject matter experts or modeled using defined equations. Factors that are measured using different units cannot be added up into summary levels until they are transformed. In the TAILOR ASSUMPTIONS feature, non-GIS factor measurements can be changed and saved into a new scenario. The list of factors and their measurements are prepared in a separate application, the PACT Web Builder. Factors are organized into sub-categories to simplify browsing.
>
> **Sub-categories** are groups of decision factors organized by content within a category. While categories represent disciplines, sub-categories are a more specific division of

factors. For example, in the I-80 test case, the Critical Habitat factor is in the Habitat and Land Elements sub-category of the Biological Resources category.

Categories are groups of sub-categories that represent a broad discipline, such as Engineering, Cultural Resources or Land Use. Some categories contain several sub-categories, while others may have only one sub-category. For example, the Biological Resources category in the I-80 test case has two sub-categories: Habitat and Land Elements, and Water Resources.

Function and Results is the section of the website that includes the analytical components that are modeled to produce a result. Each of these components and their interactions are described below. Further explanations of these concepts using Critical Habitat as an example are provided in the **Website Functionality: Analysis and Components** section. All results can be compared to other scenarios using the compare scenarios function.

The Transformation Curve converts all factor results into the same units, which allows factors with different units, such as one measurement in feet and another measurement in dollars, to be analyzed together. All factor measurements are transformed before analysis. The transformation curve normalizes the units of measurement for each factor into a 0-100 scale based on the shape of the curve. The transformed factor measurement is referred to as a 'score.'

Scores are the transformed measurements after the curve has been applied. Scores can be aggregated into broader groups of analyzed factors such as sub-categories, categories and the executive summary.

Weights are the user-specified relative importance of one factor compared to another using a scale of low (a numeric weight of 0.25), medium (a numeric weight of 0.5), medium-high (a numeric weight of 0.75), and high (a numeric weight of 1.0). Weights can be changed by the user at the factor and category levels and can be saved to form new scenarios.

Contribution is the website's name for the numeric weight of the factor.

Impact is the transformed score multiplied by the contribution.

Compare Scenarios is a feature on the website that allows the user to compare new scenarios to the default scenario that is built into the project. Users can edit scores, weights, the transformation curve and other select aspects of the analysis to form new scenarios for comparison.

Figure 9 provides a visual representation of how the key evaluation components produce the results found on the website.

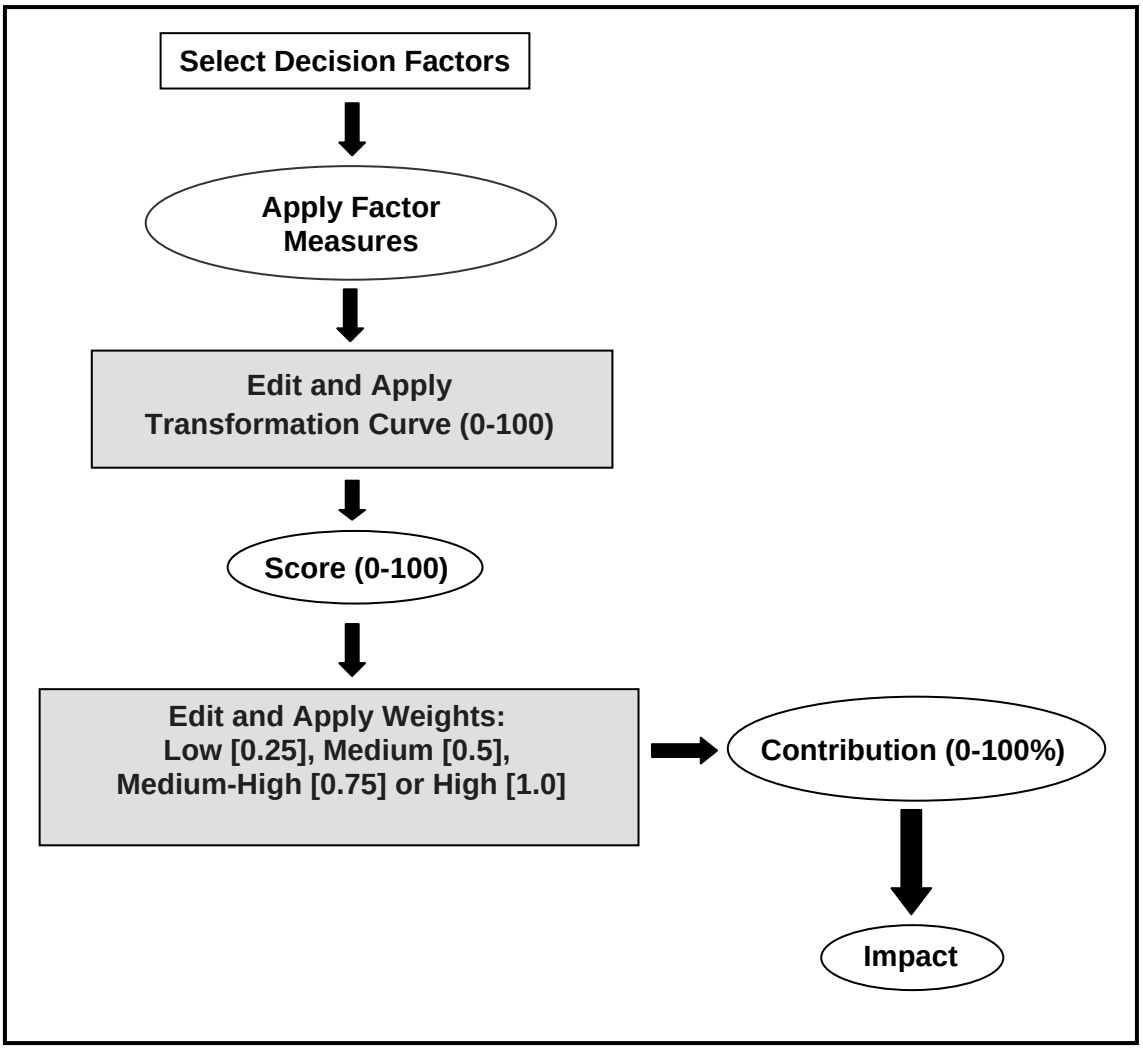


Figure 9. Key evaluation components.

3.2.5. Website Functionality: Analysis and Components

In the Website Functionality section the user is provided with a walk-through of the analysis and components on the website using *Critical Habitat* as an example.

Analysis

The analytical functionality in the website provides a high-level understanding of the project. Each of the three sections offers a different perspective of the project results. Summary-level results can also be used to compare scenarios.

> **Executive Summary** provides an aggregation of results by category. Using this level, the user is able to compare scenarios to determine how factors and categories impact line segments, contributing to different results.
>
> **Segment Summary** provides an aggregation of results by line segment.
>
> **Sensitivity Analysis** identifies those assumptions with the greatest influence on the results, and quantifies their relative influence. Scatter plots are used to illustrate the correlation between factors.

Figures 10, 11, 12, and 13 are screen shots from the PACT website.

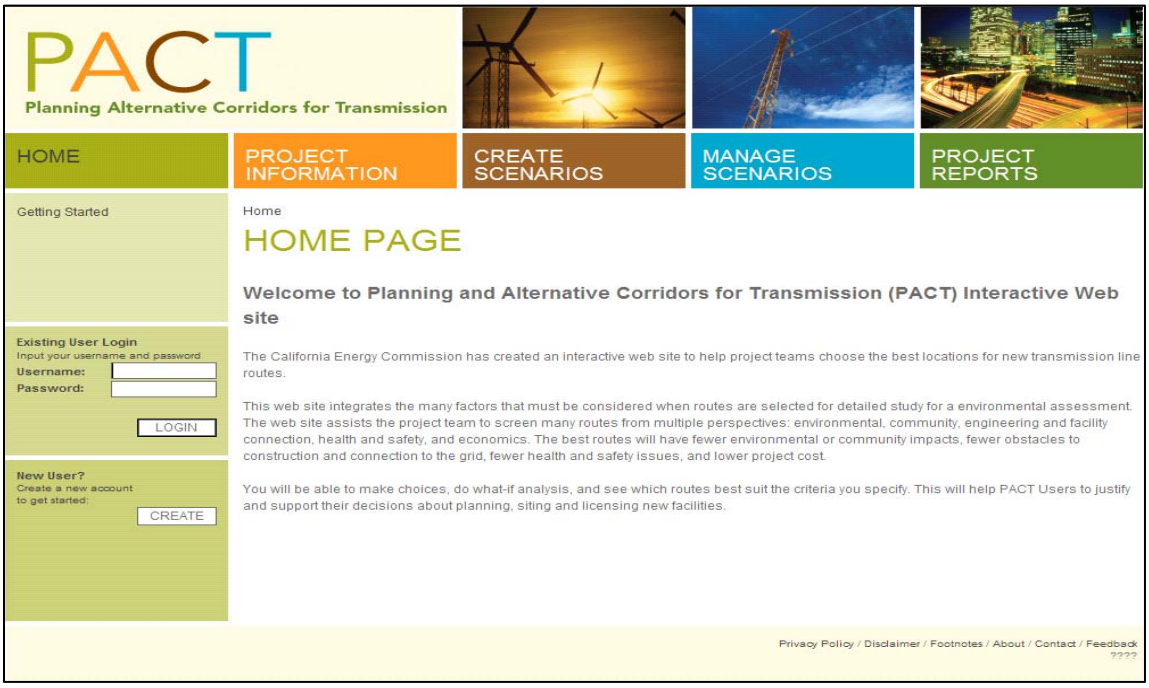


Figure 10. Screen shot of PACT website home page.

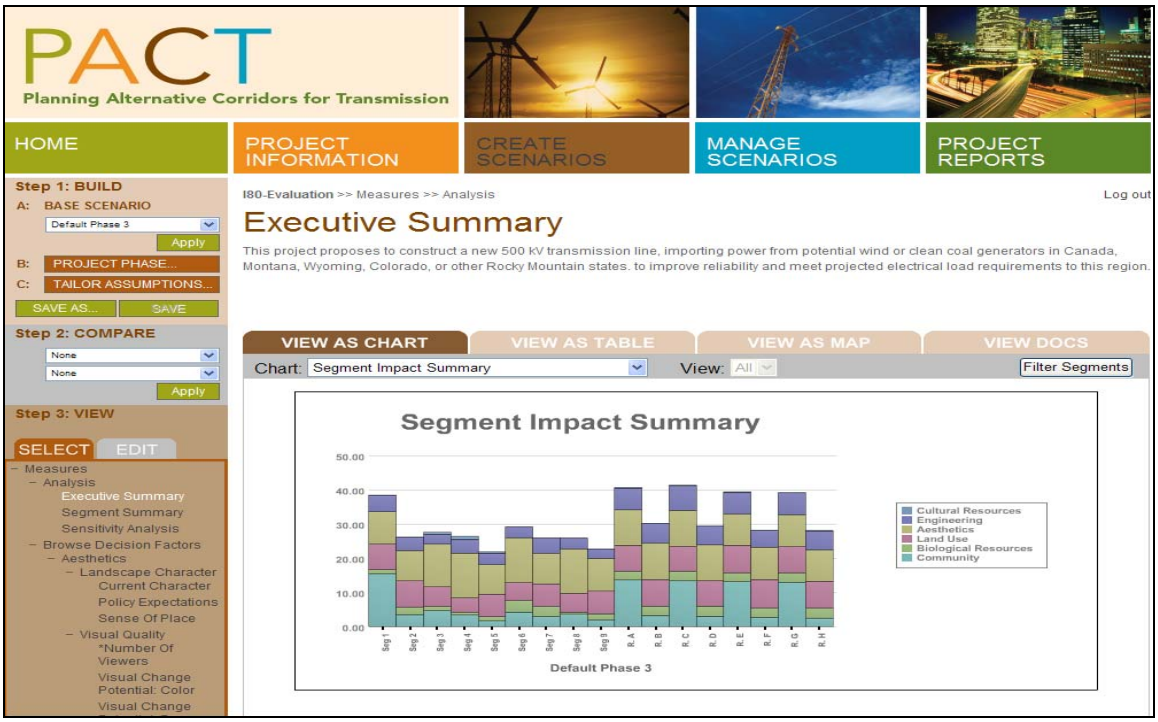


Figure 11. Screen shot of Executive Summary page.

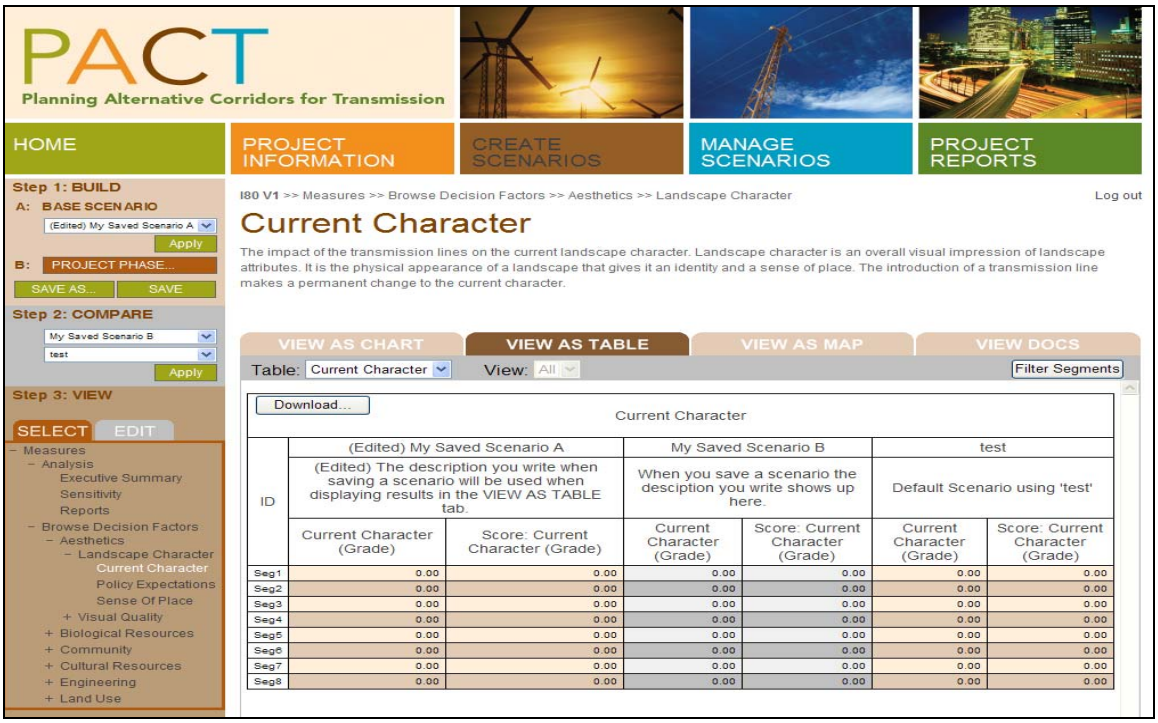


Figure 12. Screen shot of comparing alternative scenarios using 'Current Character' as a sample factor.

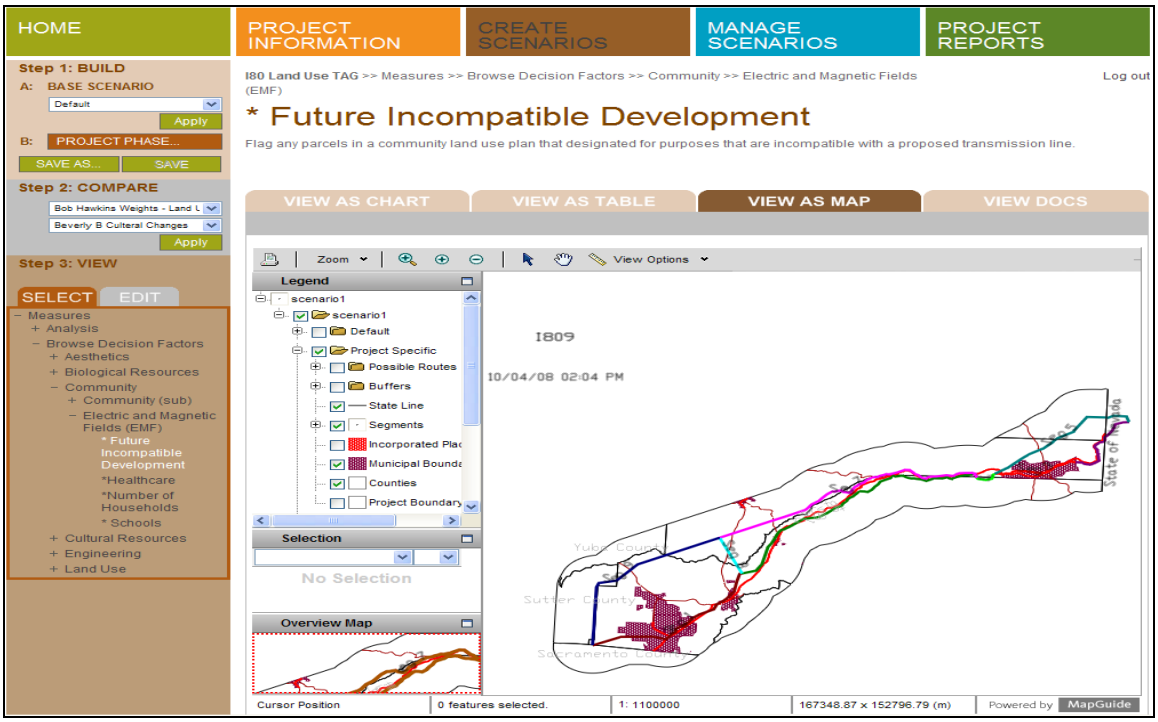
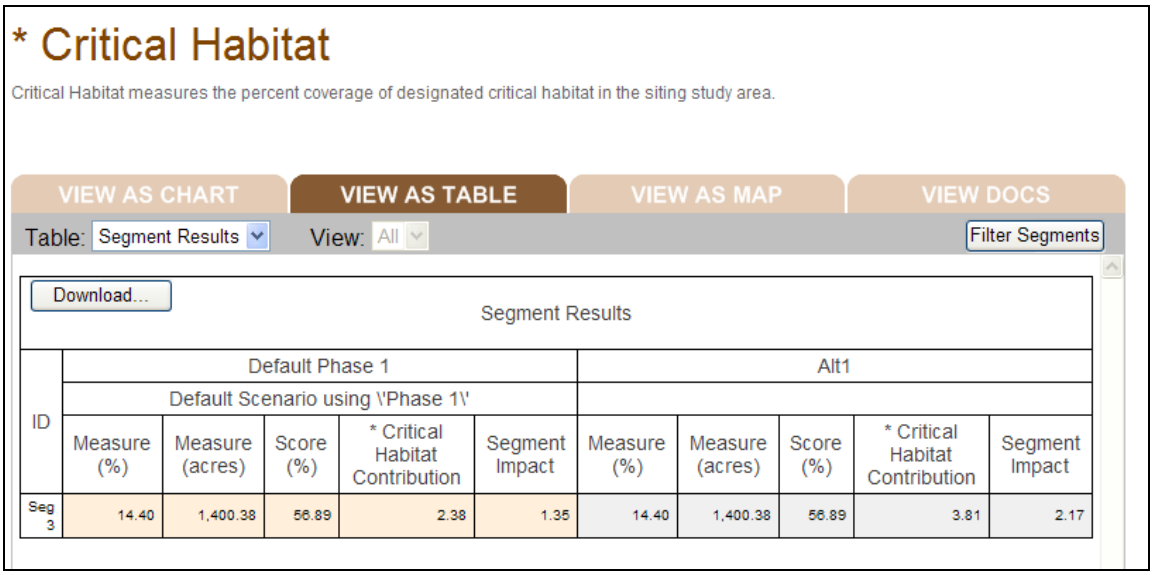


Figure 13. Screen shot of mapping capability using 'Future Incompatible Development' as an example factor.

Components

Factor Measurement

Factors can be measured using spatial data and defined equations or graded by subject matter experts. The Critical Habitat factor is measured using the percentage of cover for four critical habitat data layers within a half-mile buffer of the line. Figure 14 illustrates the measurement for Critical Habitat in Segment 3.



* Critical Habitat

Critical Habitat measures the percent coverage of designated critical habitat in the siting study area.

VIEW AS CHART | VIEW AS TABLE | VIEW AS MAP | VIEW DOCS

Table: Segment Results View: All Filter Segments

Download...

Segment Results

ID	Default Phase 1					Alt1				
	Default Scenario using \'Phase 1\'									
	Measure (%)	Measure (acres)	Score (%)	* Critical Habitat Contribution	Segment Impact	Measure (%)	Measure (acres)	Score (%)	* Critical Habitat Contribution	Segment Impact
Seg 3	14.40	1,400.38	56.89	2.38	1.35	14.40	1,400.38	56.89	3.81	2.17

Figure 14. Critical Habitat results table

Transformation Curve

The logarithmic curve is applied to show a steep increase in impact as the percentage of critical habitat within the half-mile buffer increases. The curve normalizes the units of measure for each factor into a 0-100 scale based on the shape of the curve.

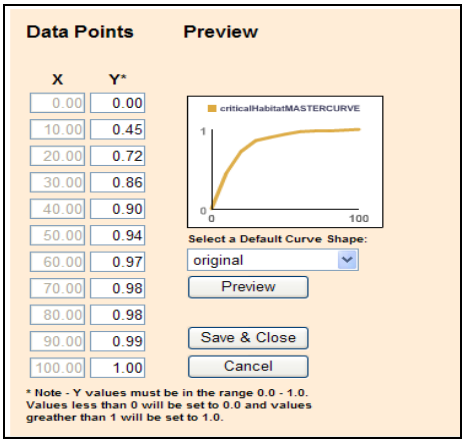


Figure 15. Transformation curve editing function.

Factor Score

Figure 16 represents the Critical Habitat scores showing that Segment 2 has a greater impact than Segment 3 with a score of 57. Scores are the transformed measures after the applying the curve. Scores can be aggregated into broader groups of factors such as sub-categories, categories and the executive summary.

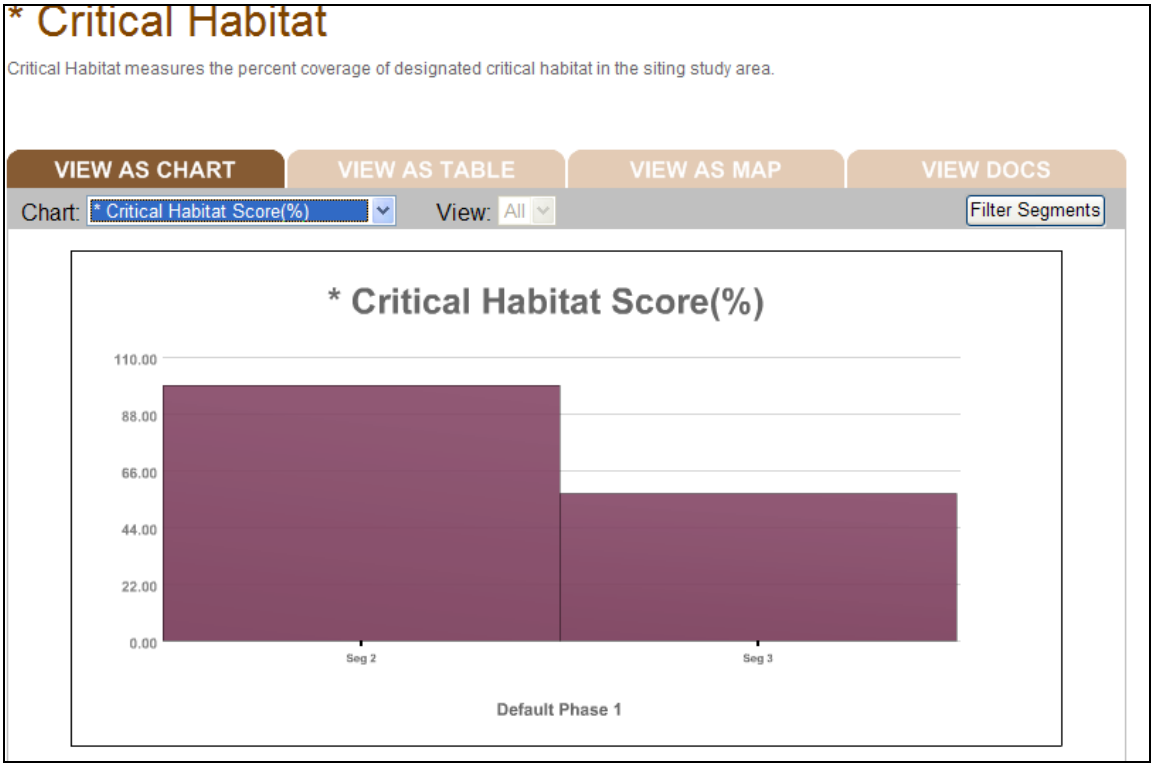


Figure 16. Critical Habitat score chart for Segments 2 and 3.

Factor Weight

Figure 17 shows the Factor Weights select/edit functions comparing the relative importance of one factor to another using a scale of low, medium, medium-high and high. Weights can be changed at the factor and category levels by the user and saved to form new scenarios. The weight of Medium for Critical Habitat establishes the relative importance of this factor in the roll-up analysis.

Figure 17. Factor weights

Category Analysis

Category analysis can be viewed as either impact or contribution. The transformed score multiplied by the measure is the impact. The factor and category weights are converted into a percentage and represent the contribution.

Figures 18 through 20 show the types of results that can be viewed at each organization level.

Sub-Category as the Organization of Factors

The Critical Habitat factor is located in the Habitat and Land Elements Sub-Category. There are two ways to view sub-category data, as Impact by Factor or Contribution by Factor.

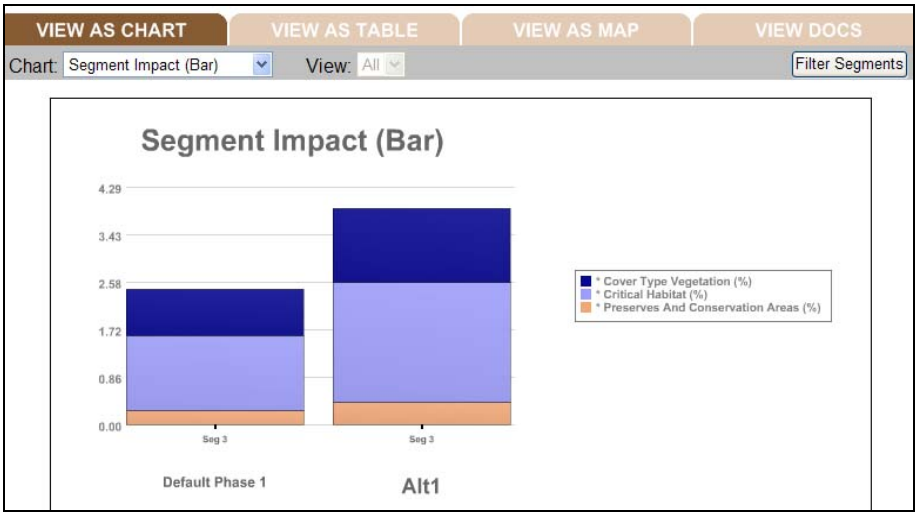


Figure 18. Segment impact by factor.

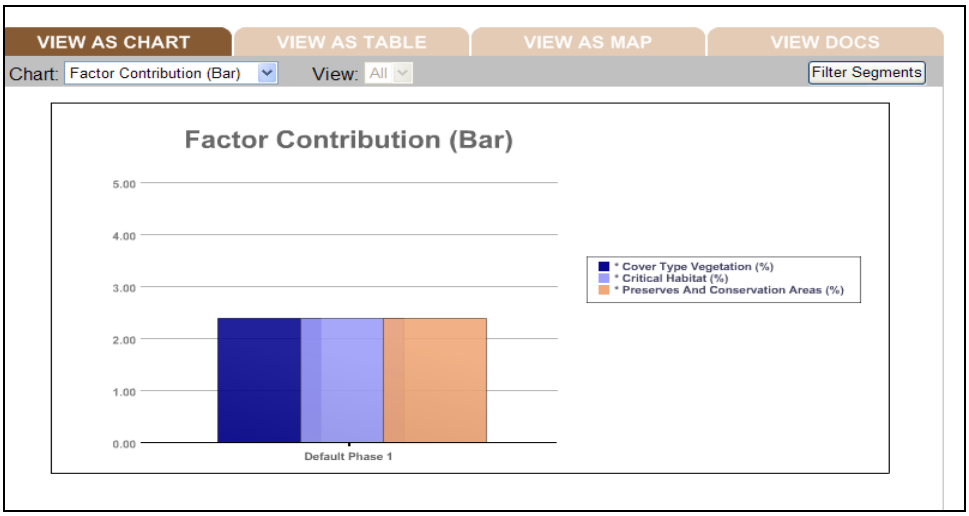


Figure 19. Contribution by factor.

Category as the Organization of Sub-Categories

The Habitat and Land Elements sub-category is located in the Biological Resources Category. At the category level, data can be viewed as impact by sub-category, contribution by sub-category and scores by sub-category. Figure 20 provides segment scores by sub-category.

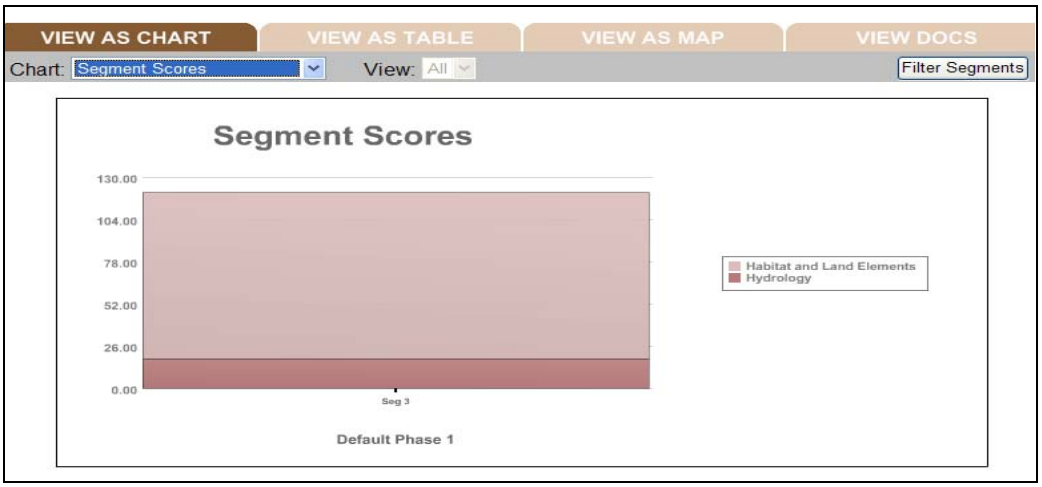


Figure 20. Segment scores by sub-category.

Executive Summary as the Organization of Categories

The Executive Summary provides an aggregation of results by category. Using this level, the user is able to compare scenarios to determine how factors and categories impact line segments, contributing to different results. Figure 21 shows the impact by category.

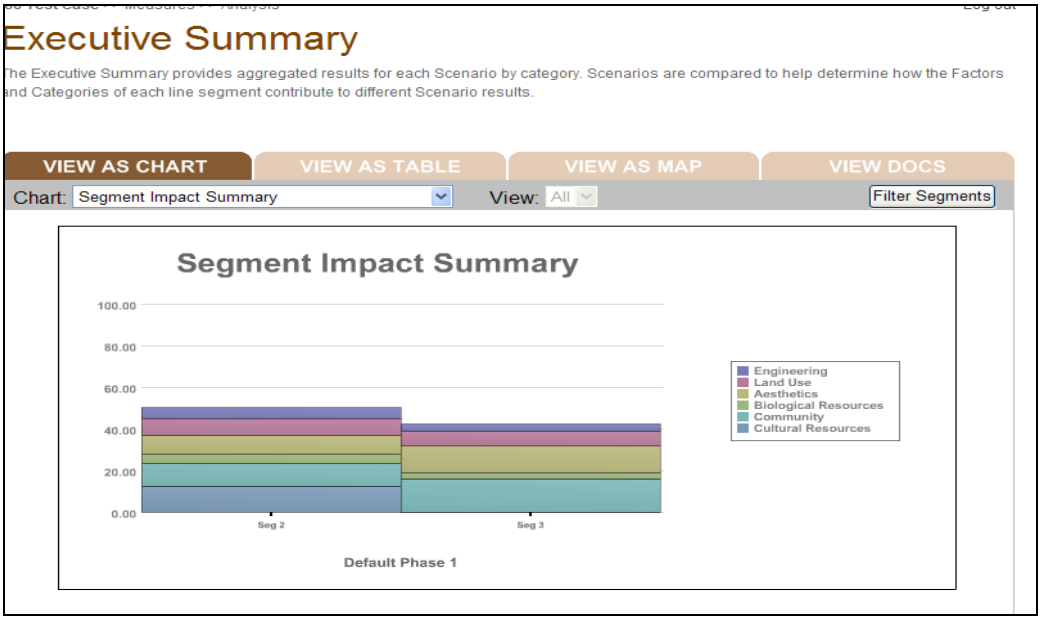
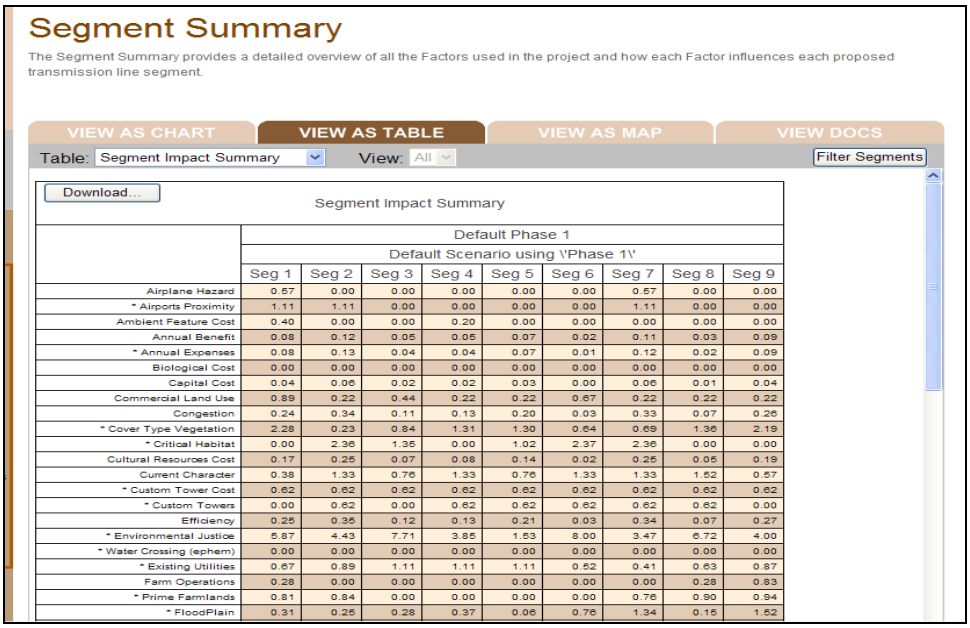


Figure 21. Comparison of two segments in the Executive Summary.

Summary Analysis

Segment Summary displays the results by line segment as shown in Figure 22.



	Default Phase 1								
	Default Scenario using \'Phase 1\'								
	Seg 1	Seg 2	Seg 3	Seg 4	Seg 5	Seg 6	Seg 7	Seg 8	Seg 9
Airplane Hazard	0.57	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00
* Airports Proximity	1.11	1.11	0.00	0.00	0.00	0.00	1.11	0.00	0.00
Ambient Feature Cost	0.40	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
Annual Benefit	0.08	0.12	0.05	0.05	0.07	0.02	0.11	0.03	0.09
* Annual Expenses	0.08	0.13	0.04	0.04	0.07	0.01	0.12	0.02	0.09
Biological Cost	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital Cost	0.04	0.06	0.02	0.02	0.03	0.00	0.06	0.01	0.04
Commercial Land Use	0.89	0.22	0.44	0.22	0.22	0.67	0.22	0.22	0.22
Congestion	0.24	0.34	0.11	0.13	0.20	0.03	0.33	0.07	0.26
* Cover Type Vegetation	2.28	0.23	0.84	1.31	1.30	0.64	0.69	1.36	2.19
* Critical Habitat	0.00	2.36	1.35	0.00	1.02	2.37	2.36	0.00	0.00
Cultural Resources Cost	0.17	0.25	0.07	0.08	0.14	0.02	0.25	0.05	0.19
Current Character	0.38	1.33	0.76	1.33	0.76	1.33	1.33	1.52	0.57
* Custom Tower Cost	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
* Custom Towers	0.00	0.62	0.00	0.62	0.62	0.62	0.62	0.62	0.00
Efficiency	0.25	0.35	0.12	0.13	0.21	0.03	0.34	0.07	0.27
* Environmental Justice	5.87	4.43	7.71	3.85	1.53	8.00	3.47	6.72	4.00
* Water Crossing (ephem)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
* Existing Utilities	0.67	0.89	1.11	1.11	1.11	0.52	0.41	0.63	0.87
Farm Operations	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.83
* Prime Farmlands	0.81	0.84	0.00	0.00	0.00	0.00	0.76	0.90	0.94
* FloodPlain	0.31	0.25	0.28	0.37	0.06	0.76	1.34	0.15	1.52

Figure 22. Segment Impact Summary.

Sensitivity Analysis identifies those assumptions with the greatest influence on the results, and quantifies their relative influence. Figure 23 shows the sensitivity analysis for the Impact as Contribution Summary viewed as a chart. Figure 24 shows the Correlation Chart with scatter plots illustrating the correlation between factors.

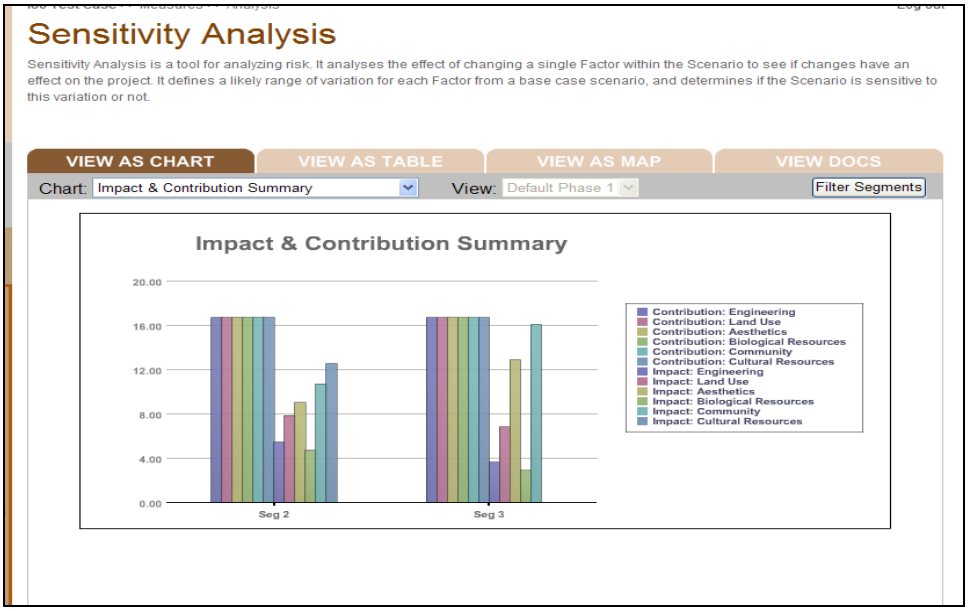


Figure 23. Impact and Contribution Summary in Sensitivity Analysis.

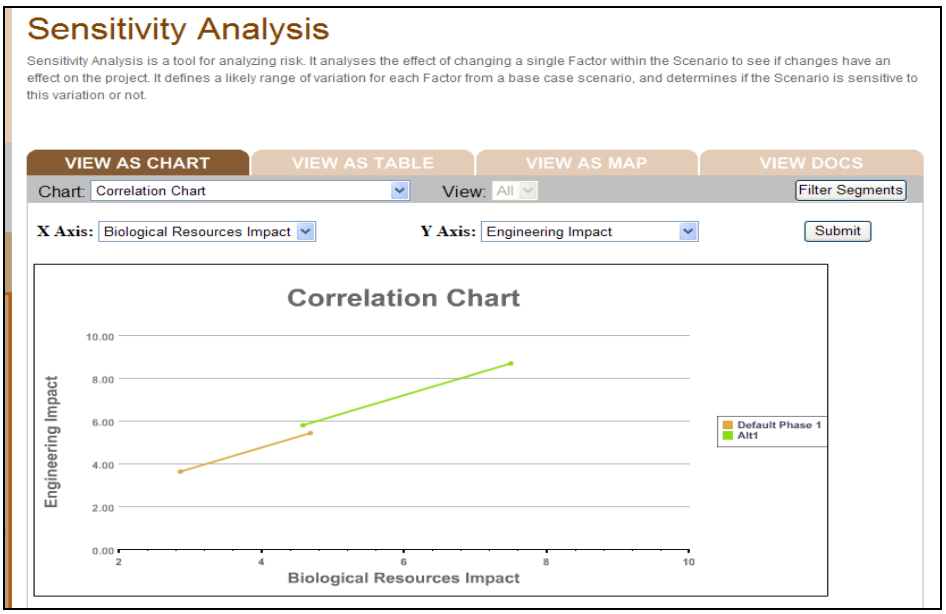


Figure 24. Correlation Chart in Sensitivity Analysis.

3.2.6. Test Cases

Three hypothetical test cases with geographically realistic characteristics were used to develop the PACT model.

Test Case #1 — Delta

The Delta test case was created in February 2006 and used until September 2006. SCE provided actual project data from a variety of sources for use by the Delta Project. This test case was used to develop the initial underlying model and begin the transformation from internal tools to web-enabled tools with user-friendly interfaces. Functionality was based on requirements of this test case as a simulated project. The proposed segments, landmarks and names were fictitious, as the area of study was hypothetical. The Delta Project test case was used for:

- Website creation
- Modeling Environment development
- Data Preparation tool development
- PACT application assembly and integration of components
- Technical Model development
- Web Generator tool development (later renamed as Web Builder tool)
- SVG Data Generator Model development

The Delta Project test case and tools were demonstrated for review at the first Project Steering Committee meeting on March 1, 2006 and a users manual was created for the project. Figure 25 is a screenshot showing a map of the Delta Project area. This is the first generation of the mapping tool used in the PACT application.

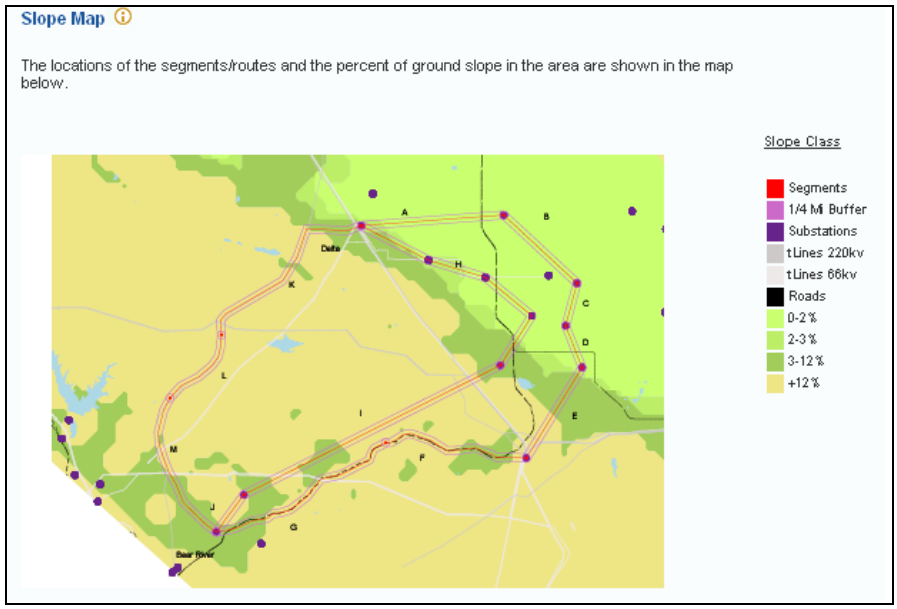


Figure 25. Slope map from the Delta test case.

Test Case #2 — Solano

The Solano test case was created in November of 2006 and used until September 2007.

Data from Solano County and PG&E were used to create the Solano Project test case, which was a hypothetical line connecting wind generation facilities to a substation in Solano County. This test case was used to improve, enhance and increase functionality of the initial underlying model and the three tools.

The Solano Project was used for:

- Website improvement and increased functionality
- Framework Manager application process creation
- Data Preparation tool improvement and increased functionality
- Web Generator tool improvement and increased functionality
- Technical bug testing and repair

Figure 26 is a screenshot of a map of the Solano Project test case area demonstrating a more sophisticated mapping tool.

Figure 26. Map features from Solano test case.

Test Case #3 — I-80

The final test case, the I-80 Project, is currently displayed on the project website for demonstration purposes. The I-80 Project test case was created in October 2007 to include all of the functionality recommended by the PSC. It was used for all technical transfer activities in 2008. This test case provides an ideal environment for correcting system errors, refining the planning structure and testing the interactions of the three components of the model.

The I-80 test case was created as an example of a project that could be used for transmission line evaluation. The data presently populating the website allows the user to understand what functionality is available. The test case assumes that a study area has been identified for the placement of a new transmission line and the siting goal of the test is to find the best route location for a new line within the defined study area.

This project was created as a 500 kV transmission line, importing power from potential wind or clean coal generators in Canada, Montana, Wyoming, Colorado, or other Rocky Mountain States. The general requirements of the 500 kV line for this test case were assumed to be:

- A 200-foot wide right-of-way or at least 150 feet of separation from existing transmission lines.

- A permanently maintained access road (approximately 20 feet wide) leading to each tower site.
- Lattice steel towers with an average height of 160 feet (range 100 to 170 feet) and base width of 40 feet located every 1000 to 1800 feet depending on topography.
- Conductor pull sites (graded pads for conductor reels) placed at intervals depending on line design and topography (temporary disturbance).

The I-80 Project is divided into the nine numbered segments and eight continuous routes depicted in Figure 27 and listed in Table 1.

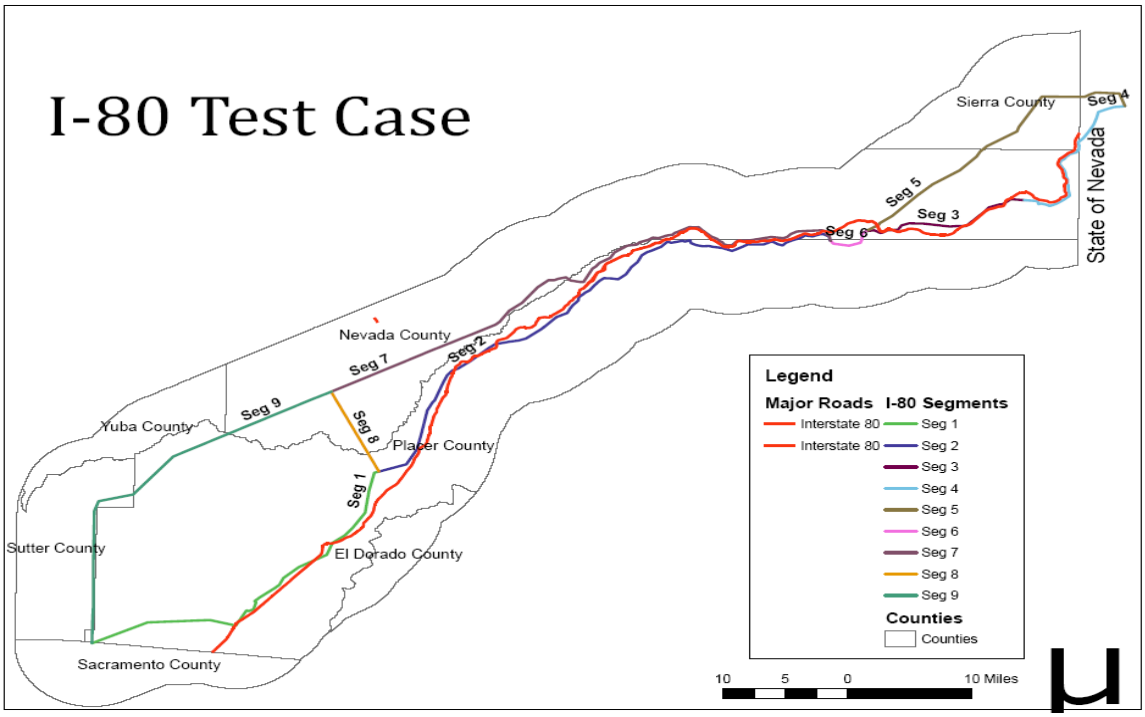


Figure 27. Map of I-80 Test Case.

Table 1. Segments and routes for the I-80 test case.

Routes	Southwest Segments	Common Segment	Northeast Segments
Route A	Seg 1, Seg 2	Seg 6	Seg 3, Seg 4
Route B	Seg 9, Seg 8, Seg 2	Seg 6	Seg 3, Seg 4
Route C	Seg 1, Seg 8, Seg 7	Seg 6	Seg 3, Seg 4
Route D	Seg 9,Seg 7	Seg 6	Seg 3, Seg 4
Route E	Seg 1, Seg 2	Seg 6	Seg 5
Route F	Seg 9, Seg 8, Seg 2	Seg 6	Seg 5
Route G	Seg 1, Seg 8, Seg 7	Seg 6	Seg 5
Route H	Seg 9, Seg 7	Seg 6	Seg 5

The I-80 test case allowed the technical team to upgrade the mapping software to complete the model. Figure 28 shows an example of one route, made up of Segments 4, 3, 2, 8, and 9, which are depicted by the green plot line.

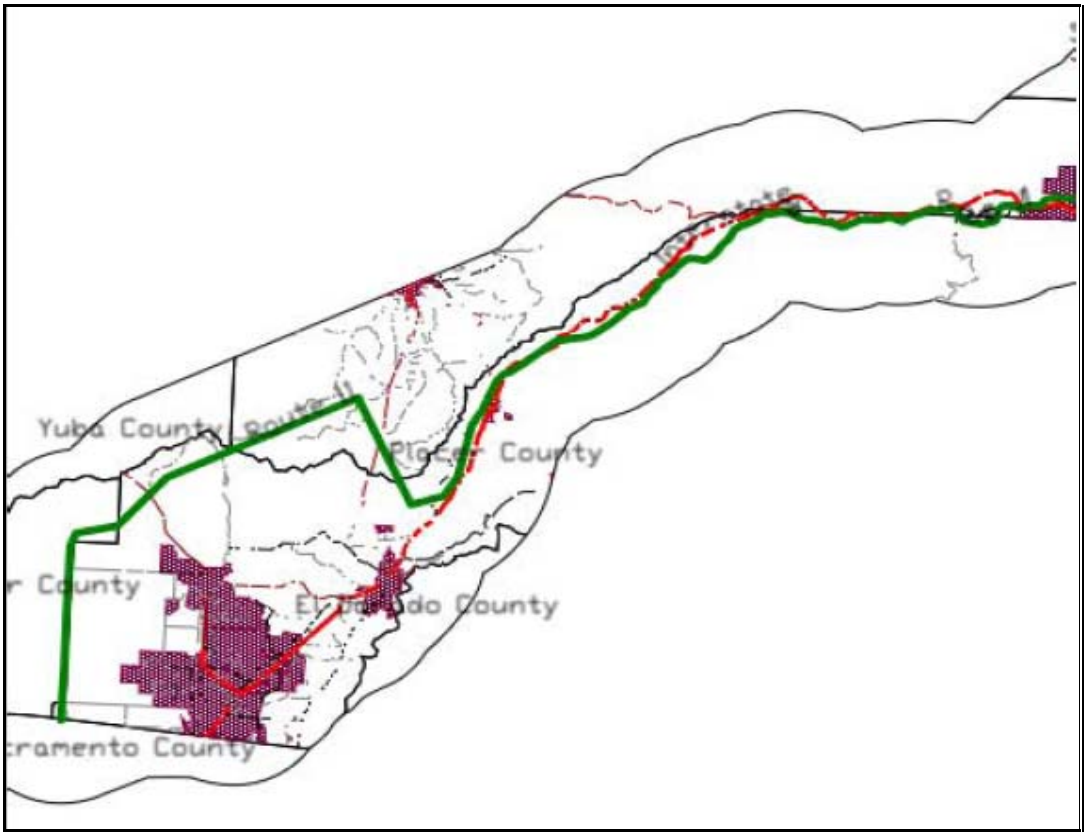


Figure 28. One route of the I-80 Test Case.

3.2.7. Deliverables

The PACT project was a large-scale development project that resulted in many end products. These products included three component applications: the Data Preparation tool, the Web Builder tool, and the website. Numerous meetings took place and documented the efforts of the PSC and the TAGs to share expertise on the siting inputs, the planning process, and desired analytical and visual outputs. A complete set of user guides and tutorials were created for the

three components of the model to teach potential users how to navigate through the project creation and analysis processes. Documents produced as part of the PACT project can be found in the appendices.

4.0 Conclusions and Recommendations

4.1. Conclusions

The project website was created and completed according to the PACT project objectives, with guidance provided by the PSC. The model successfully creates data libraries with the Data Preparation tool, defines decision factors with the Web Builder tool, and displays and provides an interactive environment for data and results on the website. The model was evaluated using three test cases. It can accommodate different project components such as alternative transmission line routes, generation facilities, and substations.

TAGs consisting of individuals from different organizations, created the categories, sub-categories, and factors for the test cases. They effectively built consensus around the planning process, siting inputs, and the trade-offs associated with meeting project objectives.

When this model is applied to actual projects it will improve communication among businesses, agencies and the public by providing clear documentation of the planning steps, the values underlying the project and the results of the analysis.

Users who attended the PACT model training workshops are equipped with a novice-level working knowledge of the functionality and potential application of the tool set, but most were not trained to the level of independent use. Users were given the opportunity to make recommendations to the project team and if appropriate, the recommendations were considered and incorporated into the final version of the model, user guides, and tutorials.

The PACT Project culminated with the launch of a website with a demonstration test case and a small number of proficient users. The PACT project requires further development to meet the full vision of the Project Steering Committee and management team.

4.2. Recommendations

The PACT model was developed using only three test cases and it is recommended that additional validation by a greater number of users be conducted. The website offers a flexible and powerful framework for a broad range of project types; therefore, it is recommended that the model be used and tested on as many different actual projects as possible to improve the content, functionality and ease of use of the model. It is also recommended that more steps be taken to demonstrate the model to more potential users, and in doing so, create opportunities for applying the model to increasingly complex cases.

In order to transfer the PACT technology from the project development team to more users, it is vital that extensive training opportunities are provided to potential users. Previous training workshops focused on introducing a small number of new users to the functionality of the tools, and additional training will be required to create proficient, independent users. Improved marketing of the training may also encourage more potential users to participate in future training workshops.

One function, corridor planning, was not evaluated using the I-80 test case and the corridor planning on the website would benefit from dedicated testing using an actual project.

Improvements should be made to the project reporting capabilities, and future work should be conducted to develop a user-friendly capability on the website that exports complete analytical reports.

Once the project tools have been validated and are ready for transfer to the public, a long-term web hosting solution must be identified to ensure that all users have equal access to the PACT suite of tools.

4.3. Benefits to California

Californians will benefit from the PACT project in terms of cost, efficiency, communication, and transparency. The PACT project model can simplify and expedite environmental analysis and project decisions, reducing siting and licensing costs. Data from each project is displayed efficiently in chart, tabular, and map form to ensure the results are accessible to different users. The planning process is made transparent by the model, and users are able to see how each decision variable is valued by the project team. The model also uses quantitative analysis to optimize facility siting to minimize the negative effects to the community and environment.

Additionally, the public-private partnership proposed for the Planning Alternative Corridors for Transmission Project will help to facilitate regulator reviews, independent analyses, public reviews and hearings, constructive feedback to proponents and the public, and the flexibility to rapidly adjust, edit and resubmit proposals.

A series of user manuals were created to guide new users through the PACT tool functionality, which includes specific instructions for creating a project website from start to finish. The user manuals allow broad accessibility of the PACT tools, which benefits Californians by opening potential use to those individuals or organizations without a technical background, and encouraging a collaborative, transparent process to a growing number of organizations in the future.

5.0 Glossary

BLM	Bureau of Land Management
CEC	California Energy Commission
CPUC	California Public Utilities Commission
GIS	Geographic Information Systems
LADWP	Los Angeles Department of Water and Power
PACT	Planning Alternative Corridors for Transmission
PIER	Public Interest Energy Research
PG&E	Pacific Gas and Electric
PSC	Project Steering Committee
RD&D	Research, Development and Demonstration
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
SMUD	Sacramento Municipal Utility District
SVG	Scalable Vector Graphics
TAG	Technical Advisory Groups

Appendices

Appendix A — PSC Rosters

Appendix B — TAG Rosters

Appendix C — User Manuals

Appendix D — EEI Conference Poster