Using Context Sensitive Solutions to Deliver Sustainable Projects

MEASURING CONTEXT SENSITIVE SOLUTIONS BENEFITS

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ABSTRACT

In recent years, Context Sensitive Solutions (CSS) has been promoted by both AASHTO and FHWA as a best practice for project development. CSS provides a systematic and comprehensive approach to project development from inception and planning through operations and maintenance. The ability to categorize and measure the benefits of CSS projects is vital to the long-term success of this approach. The objective of this project is to develop a guide for transportation officials and professionals that identifies a comprehensive set of CSS performance measures and quantifies the resulting benefits through all phases of project development. A fundamental aspect of this research effort is the identification of CSS action principles and their potential benefits. A matrix that correlates benefits to specific CSS principles was generated to allow for the development of appropriate metric indicators for each benefit. Guidelines for benefit analysis have been developed to provide transportation agencies with a set of recommended practices for assessing benefits. The guidelines emphasize the fact that CSS is a principle-driven, benefit-justified effort that can enhance an agency’s goals and interaction with stakeholders and the public. The need exists to analyze and measure the benefits of CSS and its impact on projects (e.g. cost and delay) in order to demonstrate a best use of agency resources. This need has been addressed with a guide that provides transportation agencies with a recommended method and appropriate tools.

INTRODUCTION

In recent years, Context Sensitive Solutions (CSS) has been promoted by both AASHTO and FHWA as a best practice. CSS provides a systematic and comprehensive approach to project development from inception and planning through operations and maintenance. Its goal is to achieve an outcome harmonizing transportation requirements with community needs and values. The ability to categorize and measure the broad scope of benefits within projects is vital to the long-term success of CSS in meeting livability and mobility goals. Transportation agencies currently lack the capability and tools that allow them to accomplish this. The development of performance measures will enable evaluation of the benefits and allow state and local transportation agencies to gauge the value of employing CSS and measure the progress they are making to improve project development and delivery processes.

A key factor in developing benefit evaluation tools is the recognition that transportation projects are unique in terms of the nature, scope and importance of issues addressed. These factors impact project purpose and need, community and environmental concerns, topographic and geometric conditions, traffic, safety history, and other public priorities. Moreover, there are guiding principles for CSS and a core of essential elements common to most projects. Those should be identified and considered when conducting project benefit evaluations, since such principles are the cornerstone of the unique project solutions to be developed. A range of measures must be examined to determine those most appropriate for assessing various types of project outcomes.

The objective of this research was to develop a guide for transportation officials and professionals that identifies a comprehensive set of performance measures of CSS principles and quantifies the resulting benefits through all project phases. This research effort provides transportation agencies with tools for identifying and quantifying the benefits of applying CSS principles.

To address CSS performance measures, a two-phased approach was developed. The first phase involved a review of literature, review of existing (documented) case studies; identification of potential examples, and the development of a methodology for data collection and analysis to be used. In the second phase, the selected example cases were evaluated and analyzed using measurement tools developed and applied to determine the benefits of CSS in a range of contexts.
This research envisioned the estimation of the benefits from the application of the CSS approach. The team accomplished this by first establishing the action principles required to accrue benefits and then by developing a procedure that allows transportation agencies to systematically collect needed data. This process is envisioned to be applied in all types and sizes of projects. The use of case studies to determine and estimate benefits resulted in a forensic approach, which proved to be a difficult process by which to obtain sufficient data to allow for a comprehensive estimation of such benefits. This paper presents the guidelines developed that form the foundation for a continuous performance evaluation and opportunity for process improvement for transportation agencies using CSS.

**LITERATURE BACKGROUND**

The seminal Context Sensitive Design workshop in Maryland identified several qualities that define excellence in transportation projects (Maryland SHA 1998). Based on the foundation set in Maryland, transportation agencies have associated Context Sensitive Design and Context Sensitive Solutions with the application of defined principles. The importance CSD/CSS principles was emphasized in the FHWA Flexibility in Highway Design Guide (FHWA 1997) and subsequently included in the AASHTO Guide for Achieving Flexibility in Highway Design (AASHTO 2004). A joint effort by AASHTO and FHWA also developed a set of principles that were reviewed and considered in this research (CTE 2007). State and other transportation agencies have also used the Maryland approach in developing independent Context Sensitive Design and Solution principles such as the Minnesota DOT (2007) and the Kentucky Transportation Cabinet (2004).

While much effort has been put forth to define the operating principles of CSD and CSS, no project has ever been undertaken to clearly define or quantify and measure the numerous benefits purported by CSS. A major finding of NCHRP Project 20-24(30) was that there is no systematic way to measure success from the application of a CSS process (Transtech Management Inc. 2004). This stems from the fact that little information exists that provides tools for transportation agencies interested in evaluating the benefits of CSS applications. A lack of formal benefit analysis may have contributed to skepticism among some transportation agencies reluctant to employ CSS due to concerns that CSS added costs and project development time without any substantiated benefit. In an era where many governmental decisions are viewed from a results-oriented business perspective, measures need to be established to evaluate the final product.

There have been few projects where benefits of CSS practices have been documented. A post-construction review of the Glenwood Canyon section of I 70 in Colorado was completed to provide a perspective of the benefits achieved through its innovative and collaborative design and construction process in the early 1990s (Stufflebeam et al. 2004). This widely lauded project was reviewed to determine whether it had met its stated goals, using a combination of quantitative and semi-quantitative metrics. This review indicates that benefits can be measured long after project completion if the appropriate data is available. Furthermore, some time must elapse after project completion to determine the success of certain outcomes such as safety improvements, environmental actions, multi-modal accommodation and recreational enhancements.

Several transportation agencies have formulated measures that could evaluate benefits of CSS. The Florida DOT has recently developed a guide for Measuring the Effectiveness of Community Impact Assessment (Ward 2005). This guide used the project qualities defined in the Maryland workshop to identify the key areas where measures could be used to assess the impact of the community involvement during project development. The Maryland State Highway Administration uses a performance measurement tool (a set of forms) to collect data for evaluating CSD&S projects (Maryland SHA 1998). Included are survey forms for both stakeholders and project team members. In a similar effort, the Kentucky Transportation Cabinet developed the Kentucky CSD Project Archive, which includes a benefits assessment obtained through lessons learned and project outcomes (Hartman and Mettill 2005).

NCHRP Report 456 sought to obtain a guide for assessing socioeconomic effects of transportation projects (Forkenbrock and Weisbrod 2001). The guide defined the effects of transportation projects and the means to measure them including the social and economic effects such as community cohesion, economic development, traffic noise, visual quality, and property values. The guide also provided information on determining the applicability of the measures to various scenarios, the steps to be taken for the analysis, and the appropriate methods for analysis. Though these metrics have been used to measure the benefits of CSS, they have not been applied in a consistent, comprehensive manner and thus their effectiveness has not been documented.

Transportation agencies have also focused on the mechanics of CSS considering it to be unique to the transportation sector. They have overlooked analogous practices that predate CSS that have existed in other sectors. These have sufficient similarity and function to be studied and, where applicable, adopted by transportation agencies. The quality management approach also has been extensively used in both business and by transportation agencies for other functions (pavement management). In part, quality management is used to determine goals and identify metrics used...
in performance measurement. The use of such an approach will improve quality, operational efficiency, and profits; in
the case of transportation agencies, it can create better use of limited (public) funds. Concerns about government
performance have led the National Center for Public Productivity (2007) to prepare a guide for developing performance
measurement systems. The GAO's long standing definition of public sector performance states that it includes
measures of productivity, effectiveness, quality and timeliness. Specific kinds or sets of performance measurement
indicators have been developed to focus on each of these performance types. The Center's guide also establishes the
criteria for "a good set of performance measures." State transportation agencies have not been immune to these
management improvement initiatives.

The literature review indicated that while some relevant research has been conducted, there have been few attempts to
develop metrics for quantifying the benefits from applying CSS before, during and after the project development.
However, there are models and tools that could be adapted from other customer-oriented processes and businesses
management approaches. "Customer" satisfaction is the goal for several of the processes examined and this could be
extended to the transportation agencies as well. To gauge such satisfaction, surveys or score cards are commonly
utilized and these will be the main tools for data collection in this research. Customizing these tools and then
standardizing their application for estimating the desired metrics is essential in obtaining useful information.

**PRINCIPLES AND BENEFITS**

CSS has been since its inception, a principle driven process aimed at increasing the quality and satisfaction of
transportation projects. In order to fully implement the CSS approach it is evident that benefits associated with CSS
must be identified and documented on all projects. By applying the CSS principles on a project and identifying the
achieved benefits, a direct link between project actions and benefits is identified. A proactive project approach uses
this linkage by setting benefit goals and determining principle driven actions that must be made throughout the project
development process. As a result the CSS principles provide the foundation for a systematic approach to project
development and benefit analysis. This two prong effort allows CSS to be summarized as a "principle driven, benefit
justified approach."

A fundamental aspect of this research effort is the identification of CSS principles. As noted previously, several efforts
have been completed to date that attempted to identify and document such principles. The project team felt necessary to
definitively identify CSS principles through a review of previous principles, the needs of the project development process,
and the ultimate evaluation needs. As a general guideline a principle should be concisely focused, self-explanatory and
capable of conveying intended actions. Based on this approach a set of 15 principles was developed (Table 1).

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<th>Table 1. CSS Principles.</th>
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<tr>
<td>1. Use interdisciplinary teams</td>
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<td>2. Involve stakeholders</td>
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<td>3. Seek broad-based public involvement</td>
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<td>4. Use full range of communication methods</td>
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<td>5. Achieve consensus on purpose and need</td>
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<td>6. Address alternatives and all modes</td>
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<td>7. Consider a safe facility for users and community</td>
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<td>8. Maintain environmental harmony</td>
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<td>9. Address community and social issues</td>
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<td>10. Address aesthetic treatments and enhancements</td>
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<td>11. Utilize full range of design choices</td>
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<td>12. Document project decisions</td>
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<td>13. Track and meet all commitments</td>
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<td>14. Use agency resources effectively</td>
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<td>15. Create a lasting value for the community</td>
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Some principles build on each other and have what appear to be hierarchal, cause-effect relationships. For example,
principles 2 (involve stakeholders) and 3 (seek broad-based public involvement) will have a significant influence on
principle 5 (achieve consensus on purpose and need) as well as shaping principle 4 (use full range of communication
methods). Understanding the principles and their interaction promotes knowledge of CSS fundamentals and process
relations and comprehension of how CSS projects are developed.
A good representation of these relationships is provided in Figure 1 showing the dependencies among principles as a building. The foundation of the building consists of the three Fundamental Principles of CSS. The floor is comprised of the four Basic Transportation Agency Principles that exist for every project. The six pillars of the CSS building are the six Agency Enabling Principles and Context-Sensitivity Enablers that provide for and ensure context-sensitivity:

**Context-Sensitivity Enablers**
- Maintain environmental harmony
- Address community and social issues
- Address aesthetic treatments and enhancements

**Agency Action Enablers**
- Utilize full range of design choices
- Document project decisions
- Track and meet all commitments

The lintel and roof of the building of CSS are the Long-Range Project Principles (Goals).

![Figure 1. The building of CSS principles.](image)

The three Fundamental Principles must be applied to have a CSS project development process. The four Basic Transportation Agency Principles are present regardless of whether or not a project employs CSS. The six enabling principles are the tools that enable a project team to create a lasting value for the community and use agency resources effectively, which should be the aim of all projects. While all principles will be present on any project, their relative intensity (as applied) will vary between projects. Similarly all benefits will be present; however, resulting benefits will vary accordingly.

Projects vary and the intensity with which CSS principles are used will vary as well. The three Fundamental Principles must be applied to have a CSS project development process. The four Basic Transportation Agency Principles are present regardless of whether or not a project employs CSS. The six enabling principles are the tools that enable a project team to achieve both create a lasting value for the community and use agency resources effectively, which should be the aim of all projects. While all principles will be present on any project, their relative intensity (as applied) will vary between projects. The relative intensity of each principle should be examined, since the magnitude of benefits to be realized will be affected. This relative intensity is to be determined by the scope, scale, and context of the project. For example, for a small project, there may be a limited number of stakeholders involved, which will affect the extent and type of communication methods employed and the level of public involvement required. Extensive public involvement efforts may not be necessary to provide measurable benefits. On large, complex projects affecting many parties, greater stakeholder public involvement may be required to achieve an equivalent level of benefits.
Potential benefits that could result from the application of each principle were identified (Table 2). The benefits were grouped in two basic categories based on who receives the benefits, i.e. the agency or the users/community. It is important to distinguish benefits based on the potential beneficiaries, since some of these benefits are internal to the agency’s operations and will have no clearly understood benefit to the users. This differentiation provides the agency with the ability to determine those other benefits and that the users will best recognize and use to judge the agency’s project development process performance. Benefits 1-11 are agency benefits and benefits 12-22 are primarily associated with users/community.

Table 2. CSS potential benefits.

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<td>1</td>
<td>Improved predictability of project delivery</td>
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<td>2</td>
<td>Improved project scoping and budgeting</td>
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<td>Improved environmental stewardship</td>
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<td>Optimized maintenance and operations</td>
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<td>6</td>
<td>Increased risk management and liability protection</td>
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<td>7</td>
<td>Improved stakeholder/public feedback</td>
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<td>8</td>
<td>Increased stakeholder/public participation, ownership, and trust</td>
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<td>9</td>
<td>Decreased costs for overall project delivery</td>
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<td>10</td>
<td>Decreased time for overall project delivery</td>
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<td>11</td>
<td>Increased partnering opportunities</td>
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<td>12</td>
<td>Minimized overall impact to human and natural environment</td>
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<td>13</td>
<td>Improved mobility for users</td>
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<td>14</td>
<td>Improved walkability and bikeability</td>
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<td>15</td>
<td>Improved safety (vehicles, pedestrians, and bikes)</td>
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<td>16</td>
<td>Improved multi-modal options (including transit)</td>
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<td>17</td>
<td>Improved community satisfaction</td>
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<td>18</td>
<td>Improved quality of life for community</td>
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<td>19</td>
<td>Improved speed management</td>
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<td>20</td>
<td>Design features appropriate to context</td>
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<td>21</td>
<td>Minimized construction related disruption</td>
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<td>22</td>
<td>Improved opportunities for economic development</td>
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Quantitative and semi-quantitative indicators were developed to capture and measure the impact of each benefit. Appropriate tools for collecting the data were developed and are presented in the guidelines (Stamatiadis et al 2009). Metrics have been developed for all benefits and therefore transportation agencies have the ability to customize the data collection and analysis.

**PRINCIPLES AND BENEFITS RELATIONSHIPS**

The application of a principle could, typically, result in several benefits. Even though this relationship may exist, performing such analyses may prove impractical due to the range and quantity of data required. To produce a useful and usable guide, it was deemed reasonable to identify those benefits that have a strong relationship to each principle, capturing the essence of each principle. However, some benefits may have multiple indicators or metrics that could be used to measure the entire breadth and depth of their impact and effectiveness. This approach allows for developing specific metrics for a smaller number of targeted benefits, limiting data collection and analysis requirements.

A matrix of principles and benefits was developed which identify benefits having a strong relationship to each principle. These relationships were based on the collective multi-disciplinary expertise of the team to identify the potential benefits for each principle using each team member’s discipline-specific perspective. Those benefits identified as having the strongest relationship among the majority of the team were identified as primary benefits. Other benefit-principle
relationships that had a lower level of agreement among team members were considered to have a moderate relationship to the principle and categorized as secondary benefits. Finally, all other benefits that could be realized from the application of the principle were considered as tertiary, i.e. having a weak relationship to the principle. These relationships were refined based on input received from the project panel, as well as data and knowledge from case studies. The matrix developed on these three levels of relationship between benefits and principles is provided in Table 3.

For each principle one primary benefit is designated fundamental providing a single indicator to capture the benefit of applying the principle. The fundamental benefit allows an agency to perform a focused evaluation of a CSS project in the event that resources are not available to complete a full-scale evaluation of all benefits.

**BENEFIT ANALYSIS PROCESS FOR CSS PROJECTS**

As CSS has been defined as a principle-driven, benefit-justified approach, any evaluation of CSS must consider both how the process should be applied (principles) and what the outcomes are (benefits). Furthermore, review of the case studies by the project team identified a significant challenge in evaluating project outcomes on a forensic basis, i.e., after completion of the project. Therefore, the recommended application procedures should begin at project conception in order to assure that all data needs are met as the project progresses. It is anticipated that the benefit analysis may be used for four distinct applications.

1. **Justification of CSS Project/Project Elements.** Benefits are measured to allow for the project team to justify specific project elements (design or activities) throughout the project development process. Direct measuring and quantification of benefits is used to address concerns about project outcomes. These measured outcomes allow for greater acceptance of the project and can be used as an example in future projects.

2. **Justification of Agency CSS Program.** Benefits are measured to allow justification and evaluation of the effectiveness of an agency wide CSS program. The use of agency wide measured outcomes allows for determining the appropriateness of CSS program and demonstration of benefits to the agency, legislature, and interested public parties.

3. **Continuous Improvement of Agency Process.** Benefits are measured for use in conjunction with the principle-benefit matrix as a tool for a continuous improvement of the agency’s project development process. The benefit analysis can identify where improvements have been made and opportunities for improvement. The measured outcomes are used to determine those benefits not accrued and to then initiate an action plan that directly beget those benefits.

4. **Continuous Improvement of the Project.** Benefits are measured in conjunction with the principles-benefit matrix as a tool for a continuous improvement of the project itself. Measured outcomes for benefits accruing throughout the project development process are monitored to identify problems in the project approach and/or outcome prior to completion of the project allowing for corrective actions before the completion of the project.

Benefit analysis may be used by the project team to justify project actions or to improve processes for the project. Transportation agencies can use the same benefit analysis to justify the agency program or use it as part of a continuous improvement process. For successful benefit analysis, the evaluation approach should be established from the outset of the project so that principles are properly applied, data is timely collected, and benefits are systematically measured. The application process can be described in the following five steps.

**Step 1. Principle Intensity**

A major emphasis of CSS is that all 15 principles shown in Table 1 should be applied to all projects. However, the unique project attributes allow the project team to adjust the intensity of each principle to meet the unique demands of the project. Project attributes can be generally expressed as the scope, scale and context of the project. Each of these can directly affect both the depth and the breadth or intensity (depth and breadth) of the principle application. The effect of these attributes is demonstrated for principle 1 “use an interdisciplinary team”.

**Scope.** As the scope of the project increases, the number of involved disciplines expands. A resurfacing project may only involve the contractor, construction engineer and maintenance engineer. On the other hand a new construction project would require expertise in planning, highway design, construction, maintenance etc.
Table 3. Principles and associated benefits.

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<thead>
<tr>
<th>Principles</th>
<th>Fundamental</th>
<th>Primary</th>
<th>Secondary</th>
<th>Tertiary</th>
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<td>1. Use of interdisciplinary teams</td>
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<td>2. Involve stakeholders</td>
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<td>3. Seek broad-based public involvement</td>
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<td>4. Use full range of communication strategies</td>
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<td>5. Achieve consensus on purpose and need</td>
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<td>8. Maintain environmental harmony</td>
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<td>9. Address environmental health, safety, and sustainability</td>
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<td>10. Use appropriate adaptive strategies</td>
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<td>11. Address transportation needs</td>
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<td>12. Minimize overall impact to human and natural environment</td>
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<td>13. Increased stakeholder/public participation, ownership, and trust</td>
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<td>14. Increased partnering opportunities</td>
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<td>15. Increased speed management</td>
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<td>16. Improved quality of life for community</td>
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<td>17. Improved multi-modality options including transit</td>
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<td>18. Improved speed management</td>
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<td>19. Improved opportunities for economic development</td>
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<td>20. Minimize construction-related disruption</td>
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<td>22. Improved opportunities for economic development</td>
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Benefits

- Improved predictability of project delivery
- Improved project scoping and budgeting
- Improved long-term decisions and investments
- Improved environmental stewardship
- Optimized maintenance and operations
- Increased risk management and liability protection
- Improved stakeholder/public participation, ownership, and trust
- Decreased costs for overall project delivery
- Increased partnering opportunities
- Minimized overall impact to human and natural environment
- Increased mobility for users
- Improved walkability and bikeability
- Improved multi-modal options including transit
- Improved community satisfaction
- Improved quality of life for community
- Improved speed management
- Design features appropriate to context
- Minimized construction-related disruption
- Improved opportunities for economic development
Scale. As the scale of the project increases, the demands increase as well, requiring additional expertise and multiple persons to perform the work. A major construction effort may require highway design engineers with expertise in drainage, geometric design, traffic control etc. Conversely on a small project, a single engineer may be able to address all issues.

Context. The varying context of the project has a direct impact on the project as well. As new constraints and resources are encountered or impacted the appropriate team members must be identified. This would include environmental specialists, historic preservationists, special user groups etc.

For each of the 15 CSS principles, a set of “criteria for application” are provided in the Guidelines to assist the project team in determining the appropriate intensity of the principle (Stamatiadis et al 2009). As an example, one of the criteria of application for principle 6, address alternatives and all modes, is stated as “Multiple alternatives including various modes, capable of addressing the issues in the purpose and need statement, are identified and developed.” This criterion directly references the purpose and need statement and as such is limited by the defined scope of the project therein. The scale and context of the project should also be considered in its application. A resurfacing project applying this criterion may only examine the feasibility of alternative construction phasing alternatives to reduce construction impacts. If the roadway is heavily utilized by cyclists, i.e. it has a different context, the addition of a bicycle lane may be considered. The expanded scope of a corridor planning study, however, requires that many more alternatives be considered to address the full extent of such a project. This may include: 1) the examination of multiple modal options along the corridor including transit, pedestrian and cycling; 2) roadway alternatives such as two or four lanes, divided or undivided highways; 3) as well as construction phasing alternatives.

Step 2. Selection of Benefits to be Measured

It is anticipated that not all benefits will be measured on all projects. Instead, the benefits to be measured should be selected specifically to include only those identified as beneficial to the project or agency. This type of selective approach will provide maximum utility to the user and limit unnecessary data collection efforts. Benefits should be carefully selected based upon the purpose of the benefit analysis, the availability of data to measure project outcomes, and the availability of data to establish benchmarks. Providing a distinct and focused evaluation plan will enable the agency or project team to measure pertinent benefits, collect all necessary data and provide meaningful input directing future CSS efforts.

Selected benefits will also vary based on the purpose of the evaluation conducted. For example in a CSS project Element Justification, benefits used may be more specific than when the same benefit is used as part of an agency wide or programmatic justification. In this case, the benefits to be measured should be tailored to the individual project.

Step 3. Establish Benefit Benchmarks

The most critical element of the benefit analysis is the establishment of benchmarks for judging benefit accrual. Traditional analysis may use as benchmarks the difference in the measured outcome between before and after conditions or between CSS and non-CSS projects. However, such an analysis is often impractical due to lack of available data (before or non-CSD&S project). Benchmarks also vary greatly among agencies and projects, as well as, the purpose for which the benefit is being measured. For instance, if benefits are being measured for use in the continuous improvement of the agency process, the benchmark will be the measured outcome from the previous iteration. For benefits being measured to justify a CSD&S project, the benchmark is established relative to the project goals. It is therefore impractical to establish a single benchmark for each benefit metric to cover these benefit analysis options.

For benefit analysis on a single project, measures of effectiveness and their benchmarks should be explicitly stated in the purpose and need statement or in a memorandum of agreement. This approach allows for collecting only the required data for comparison and reduces data collection demands. These benchmarks should be both specific and tailored to the project and its context. Specificity is achieved by stating the desired benchmark to be targeted. For example, if the purpose and need statement calls for improved mobility, the specific target of decreased travel time by 20 percent compared to the existing conditions should be stated. Customization is achieved also this way, since benchmarking is specific to the project and agreed upon by team members and stakeholders. In the same example, an agency-wide goal of reducing travel time by 30 percent may be inappropriate for the context of this project.

As part of the continuous improvement of the agency process, a moving benchmark is established which is related to the measured outcomes of the previous round of projects. The evaluation is therefore established by determining the relative improvement of the process as it compared to the “benchmark” established by previous projects.
Step 4. Data Collection, Maintenance and Accessibility

A data handling plan must be in place from the project outset. The plan identifies the data to be collected along with when is to be collected. In addition, how that data will be maintained and made accessible to users is also determined. Data needed to evaluate benefits is obtained throughout the project development process and often is available only for a short time. As an example, attendance level at stakeholder meetings is only available at the meeting. If pertinent data is not collected at that time, it may never again be obtainable. In addition, a system must be in place to maintain the data and make it accessible to those conducting the evaluation. For project specific benefit analysis, storage and accessibility may be less formal and available only to project team members. However, agency-wide efforts must have standardized data formats and provide a centrally located and catalogued data source so that others may access and analyze the data.

Step 5. Evaluation

Once the data is collected it should then be analyzed by several methods depending on the nature of the metric and its intent:

- Quantitative data allows for establishing benchmarks and making direct ordinal comparisons (using standard measures) and in some cases conversions to dollar amounts.
- Semi-quantitative data allows for making broad relational comparisons based on expert opinion and customer satisfaction. It can also be used to compare the views of the project team to the stakeholders/public. This information can be important as other data if, for instance, there is a goal to improve the public trust.

CONCLUSIONS

The primary outcome of this research effort is a practical set of guidelines for transportation professionals to use for assessing benefits of a CSS project. To achieve this goal, a set of principles was identified with associated benefits to which metrics can be applied to measure the outcome of CSS projects.

The guidelines developed provide a methodology for completing a systematic quantification of benefits of using the CSD&S approach for project development. It is apparent that a systematic approach needs to be undertaken where data will be collected periodically in order to provide the basis for evaluating individual projects and identifying areas for agency CSS improvement. The benefit quantification is a process that any agency can undertake in order to determine the effectiveness of their efforts on a specific project, conduct a program evaluation, and use the lessons learned to improve specific actions for future projects. This allows for a continuous improvement effort that could be undertaken to positively impact project development and delivery operations using agency resources more effectively.

The guidelines have also been designed with the realities of project scope, size and extent. A project team has the ability to identify and customize the principle intensity applied in the project based on the specific needs of the project. This provides the ability to vary principles applications in terms of magnitude and allows for a flexible project development process that creates the capability for the agency and project team to achieve desired outcomes. Moreover, the project team can also select the anticipated benefits and determine those that are to be monitored and measured. This allows for an evaluation procedure that provides flexibility to the agency and project team to achieve desired outcomes. To determine whether a benefit accrued, the project team can develop benchmarks that would be specific for the project developed and customize data collection to determine them. The evaluation and comparison of the collected data to these benchmarks allows for identifying successful application of principles and improvement actions for future applications of principles that were not successfully employed. These efforts could then be used by the agency to improve the development process of other projects.

The principle-benefit matrix provides an agency with a linkage of direct actions to improve both project and program performance as well as to determine future process improvement opportunities. Once the agency targets benefits to be measured by all projects, associated metrics could be determined and the agency-wide target threshold values could be established. The collected data could then be used to identify the remedial actions required to meet or exceed the thresholds set through an identification of the appropriate actions for improving each principle by examining the corresponding application criteria. For example, if an agency is experiencing an extreme lack of trust, then it can identify several actions, using the associations established by the matrix that it might take to remedy that situation. The use of the matrix in this fashion will allow agencies to improve their overall performance and project development and delivery process.
Conducting a targeted assessment of a specific project’s development process is difficult, but it could be accomplished if conducted in a real-time proactive manner. Using standardized surveys to acquire expert opinions and assess stakeholder/community satisfaction is possible and very informative. Project leaders can use this information during a project to determine effectiveness, and program managers can use the information from multiple projects to make procedural adjustments and determine possible improvement actions that may include, for example, improving process handoffs or training.

The most important aspect proposed is that a systematic and well organized data collection effort should be undertaken from the outset of the project. The forensic approach implemented in this research showed that it is almost impossible to identify and collect data after the completion of the project. Such data is likely to be incomplete, not adequately cover the required metrics, and not have the necessary statewide comparisons data available. The identification of the benefits to be monitored along with their metrics from the outset of the project is essential. This will allow for identifying the specific metrics to be monitored, allow for timely data collection, and the building of comparison data. It is important for an agency to identify data collection needs from the outset of the project and to include them in the project development process to ensure that critical windows of opportunity are not missed. Critical assessment data must be collected appropriately, maintained adequately, and be readily available.

Some benefits cannot be easily quantified and not all metrics can be converted to dollar values in order to determine the level of benefit accrual. Such benefits need to be compared to the goals set forth in the purpose and need statement of the project. For example, benefit 12 “Improved mobility for all users” is measured by identifying the extent of new or improved facilities included in the project. For some cases, this benefit will accrue once a bike lane is added for the entire length of the project or a new bus line is incorporated with bus stops along the route. The facility’s presence is a positive benefit of the project, since it was part of the purpose and need statement, but it does not allow for converting this to a value to be added to time and cost savings or for determining the extent of benefit accrual for the project.

The results from the study indicate that agencies do not systematically collect data to evaluate project performance and develop benefit-cost information for projects. It is apparent that data is collected only when individual project teams consider it appropriate for documenting their actions to possibly avoid future difficulties with either stakeholders or the community. This approach does not allow for the development of a systematic data collection effort across all projects for an agency nor for the establishment of a database that could be accessible to any interested party. Therefore, there is a need for commitment by agencies to systematically collect such data and maintain a database to allow for benefit assessment and/or establishing a continuous quality improvement effort.

**BIOGRAPHICAL SKETCHES**

**Dr. Nikiforos Stamatiadis** is a Professor of Civil Engineering at the University of Kentucky. He joined UK as an Assistant Professor in 1990 from Michigan State University, where he obtained a Ph.D. in Civil Engineering with emphasis in traffic safety and the older driver. Dr. Stamatiadis teaches several transportation courses at UK both at the graduate and undergraduate level and he has developed and taught various workshops. Dr. Stamatiadis has been actively involved in establishing a strong traffic and transportation teaching and research program at UK. His research interests include issues on traffic safety, highway design and operations, pedestrian and bicyclist transportation, and public transportation. He has completed research grants on safety issues of the elderly, safety analysis, license renewal alternatives, access management, speed management, effects of design element choices on roadway safety, impacts of inconsistencies between design and operating speeds, and safety consequences of design elements tradeoffs. He is currently conducting research dealing with evaluation of means to affect driver operating speeds, intersection design, and practical design and solutions.

Dr. Stamatiadis has published articles in several journals including Accident Analysis and Prevention, Journal of Applied Gerontology, Transportation Research Board Record, and Transportation Quarterly. Dr. Stamatiadis is a member of several professional organizations and he is a licensed Professional Engineer. He is actively involved as a member of several technical committees in the American Society of Civil Engineers, Institute of Transportation Engineers, and Transportation Research Board. He is currently serving as the TRB University Representative for UK and the Faculty Advisor to the ITE Student Chapter at UK. Dr. Stamatiadis is the Chair of the TRB AHB65 (4) Self Enforcing Contextual Geometrics (of the Operational Effects of Geometrics) and the Chair of AFB05T Task Force on Context Sensitive Solutions.

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Mr. Kirk has presented at national conferences including Transportation Research Board and the American Planning Association, and has been published in several journals including Transportation Research Record and Research Results Digest. He is also a primary author of a manual on Context Sensitive Solutions for practitioners, and served on the core team of NCHRP 15-32 Quantifying the Benefits of Context Sensitive Solutions. Mr. Kirk is a licensed Professional Engineer, Professional Traffic Operations Engineer and a member of the American Institute of Certified Planners. He is currently the Vice-President of the Kentucky Section of the Institute of Transportation Engineers.

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WILDLIFE CROSSINGS WITHIN THE CULTURAL LANDSCAPE OF THE FLATHEAD INDIAN RESERVATION: U.S. 93 FROM EVEARO TO POLSON, MONTANA

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ABSTRACT

The benefits of wildlife crossings have been predominantly framed in ecological terms: i.e. habitat connectivity and species fitness. The health and movement of wildlife is also intimately associated with cultures who revere wildlife as mythic characters, seasonal portents and as on-going sustenance. It is from a cultural perspective that decisions are made regarding transportation and wildlife crossings. We examine the formative process of the design and implementation of wildlife crossings in the U.S. 93 Highway on the Flathead Indian Reservation, comparing the perspectives of the Confederated Salish and Kootenai Tribes with the perspectives of the transportation engineers. In addition to improving safety of humans and non-humans, wildlife crossings are a symbol of the interconnectedness of the Tribes’ life-world.

INTRODUCTION

As the highway transportation community recognizes the ecological impacts of our vast road network, wildlife crossings have become a viable method of improving the ecological permeability of highways. Starting in Europe with crossings designed for multiple species (sometimes including humans) and continuing with crossings in Florida, Alberta and Montana in North America (Schrag 2003), crossing structures dedicated to wildlife have gained political support for the many benefits they provide. Wildlife crossings reduce the barrier effects of highways for large carnivores and ungulates, improving habitat connectivity and animal migration (Clevenger 1998). Through improved habitat connectivity, wildlife crossings may prevent populations of large and small animals from isolation, improving species fitness. Wildlife crossings reduce the number of wildlife-vehicular collisions, thus improving highway safety (Bissonnette and Cramer 2008). They are especially important in areas where large mammals occur.

Despite their benefits, crossing structures face impediments to installation on new and reconstructed highways, primarily due to the cost of the structures, constructability, and continued uncertainty about their value. Perhaps the greatest impediment is not related to the design and installation of crossing structures, but to how people value wildlife, habitat and the landscape. The benefits of crossing structures are often framed in ecological terms, i.e. habitat connectivity, species diversity, and wildlife mortality. However, wildlife crossings are also a cultural construct, designed to mitigate the impacts of our roads within a social and political environment.

By examining the decision-making process of wildlife crossing implementation on the Flathead Indian Reservation in Montana, we can see how two cultures view wildlife, highways and their place in the larger landscape. While the dominant culture views the installation of wildlife crossings as ecological concessions to an environmental process, other cultural groups see wildlife crossings as one expression of an interconnected life-world.

TRANSPORTATION AND THE FLATHEAD INDIAN RESERVATION

The Flathead Indian Reservation occupies an extremely varied landscape of forested foothills, rolling prairies, broad flat valleys, meandering streams and vast wetlands bracketed by the Mission Mountains to the east and the Salish Mountains to the west (see Figure 1). Flathead Lake forms the northern boundary of the Reservation. Just south of the
lake, sandy pinelands and a unique complex of prairie potholes have been transformed into an agrarian landscape. In the south, forested hills and meadows support rangeland populated by a few small towns.

A brief history of the Confederated Salish and Kootenai Tribes (CSKT), with a focus on the role of transportation, will be valuable to understanding the cultural perceptions of the Reservation’s landscape. The U.S. Government formed the Flathead Indian Reservation under political pressure from white settlers coveting the fertile valleys occupied by Native Americans. Three distinct tribal groups inhabited western Montana in the 1800s: the Pend d’Oreille in western Montana and Idaho, the Kootenai farther north and on into Alberta, and the Bitterroot Salish or “Flathead” in the Bitterroot Valley and surroundings. The Pend d’Oreille and Kootenai tribes moved into the new Reservation after signing the Hellgate Treaty of 1855.

![Figure 1: Context of the Flathead Indian Reservation in western Montana.](image)

The Bitterroot Salish opted to stay in the Bitterroot Valley to the south, some moving to the reservation under Executive Order in 1873, but most choosing to stay with Chief Charlot. In 1859, conflicts between the Bitterroot Salish and white settlers intensified over rights to grazing lands and timber with the construction of the Mullan Road providing better access to the valley (CSKT 2000). In 1883, the Northern Pacific Railroad completed a transcontinental line through Montana leading to the elimination of the wild bison, traditional hunting game of the tribes. At the time, tribal leaders opposed the establishment of the railroad running through the southern portion of the reservation recognizing it would lead to more white settlers and development (CSKT 2000). Soon after, a second railroad was built through the Bitterroot Valley. In 1891, Chief Charlot, faced with dwindling numbers and worsening conditions, finally led the remaining Bitterroot Salish to homes on the Flathead Indian Reservation.

While many reservations throughout the United States were opened up to white settlement following the Allotment Act of 1887, the Confederated Salish and Kootenai Tribes opposed Indian allotments. In the early 20th century, they lost the legal battle, and the state of Montana opened up the reservation to non-Indians. From 1910 to 1929, homesteaders flowed into the reservation and inhabited the agricultural lowlands, a development encouraged by the establishment of the Flathead Irrigation System using tribal funds. From then on, the history of the reservation is a history of two peoples with a complex relationship of both mutual and incompatible interests. While tribal members viewed an increase in transportation development as a threat to traditional life-ways, white settlers viewed the lack of
transportation as a problem. “Transportation on both land and water was a grave problem to a growing reservation (McAlear 1961: 68).” The development of more tracks and roads was the solution. A history of the early white settlement after 1910, by the Reservation Pioneers, is a history of transportation: the establishment of a stagecoach route between Ravalli and Polson (see Figure 1), the replacement of the stagecoach with the automobile, the linking of the railroads, and the eventual construction of “super-highways.”

Figure 2: Stagecoach route along the Jocko Trail near current highway, U.S. 93.

Throughout this history of people movement, the Jocko Trail formed the north-south link between Flathead Lake and points south. Portions of the Jocko Trail are now buried beneath U.S. Highway 93, which travels north out of Missoula through the Flathead Indian Reservation to Flathead Lake. U.S. 93 now serves as the primary north-south route in western Montana not only for residents, but for the thousands of outdoor recreation enthusiasts who visit this lake and mountain region every summer.

U.S. 93 WIDENING PROJECT

In response to increasing fatalities on U.S. 93, the Montana Department of Transportation (MDT) studied traffic patterns along the stretch of highway through the Flathead Indian Reservation, eventually proposing the highway be expanded to four lanes. MDT’s goals of the widening project were to increase capacity of the highway and improve safety (FHWA and MDT 1996: 2-1). Increased capacity was needed to accommodate population growth and more tourism for visitors driving to Flathead Lake and Glacier National Park beyond. Improved safety was needed because the highway’s accidents per mile of roadway were higher than the statewide average. A third goal, maintaining or increasing speed limits, was not directly stated, but fell under the heading of “roadway deficiencies (FHWA and MDT 1996: 4-3).” Various segments of existing road did not meet design standards for a 60 mph rural arterial highway. While the Environmental Impact Statement (EIS) for the highway widening describes existing speed limits set by the Montana Transportation Committee, no speed limit changes were suggested in the alternatives.

Engineering Perceptions of the Landscape

By focusing on the narrow highway corridor and its function of safe and efficient vehicular movement, these goals are straightforward and laudable. Essentially, the highway becomes a problem to be solved, i.e. how do we move as many vehicles as we can from Missoula to Flathead Lake with as few accidents as possible? MDT engineers perceived the highway challenges and problems in this way. The Reservation itself, the landscape of trees, hills, small towns and wildlife, was seen as a blank tableau for highway improvements. Where place was recognized, it was viewed on a map as a hill to be cut or a stream to be crossed: an indirect engagement with a simplified space. Each stream and town then was an obstacle, a challenge of design, i.e. how do we maintain a straight and level road through or around this obstacle?

The influence of this indirect engagement with the landscape can be seen in the way the dominant culture develops environmental impact statements. Transportation engineers develop highway design alternatives and then examine different, usually pre-determined, categories of impacts (i.e. air, noise, and wildlife), as if they are looking at different layers on a map. In the draft of U.S. 93 project’s EIS, a description of the history and current concerns of the
Confederated Salish and Kootenai Tribes occupies the cultural resources section of the report (FHWA and MDT 1996: 6-14). The cultural landscape then is space upon which layers of meaning have been placed by people. If tribal members believe a place is sacred, it is something they have added to the landscape, not something inherent, and so can be considered as one factor among many, that can be mitigated or even removed.

**Tribal Response to the Widening Project**

Given the history of transportation on the reservation, CSKT’s response to the proposed widening of U.S. 93 was predictable. The Tribes objected, eventually offering an alternate Preferred Alternative of a modified two-lane highway with access control. CSKT also threatened to legally challenge MDT’s project based on multiple federal statutes, treaty agreements and executive orders. According to Joe Hovenkotter, Attorney at the Tribal Legal Department, CSKT believed they would not necessarily stop the project, but delay it significantly.

The Tribes shared MDT’s concern for highway safety; many of the tribal members had family members who were killed or injured in traffic accidents on U.S. 93. Yet, tribal staff believed the safety issue could be addressed through access control, limiting the number of dangerous driveways opening onto the highway, and by slowing travel speeds. CSKT were also concerned with the proposed highway project’s 1) cumulative impacts to farmland, wetlands, fisheries and the rural qualities of the reservation; 2) increased residential and commercial development; 3) increased automobile emissions; 4) visual impacts to scenery; 5) greater barrier to wildlife; and 6) greater barrier to people crossing the highway, particularly in small towns (CSKT 1996). Those concerns, informed by their understanding of the history of transportation impacts to the Reservation, were specific elements of a larger concern about “cultural integrity” and “tribal identity.” The highway threatened the primary relationship between their people and the landscape (FHWA 1996: 6.14-3). The Flathead Culture Committee described it as:

> For our culture to survive, our people must live in a place that continues to hold a powerful sense of tribal identity, of community, of familiarity. The open spaces need to be kept open, the pristine places that nurture our bodies and souls need to be kept pristine, and the preponderance of tribal people in certain areas of the Reservation need to be protected...

> There are countless laws and regulations and agency guidelines on the books committing the U.S. Government to protecting Native American cultural integrity. If the Highway 93 project turns these valleys into an overwhelmingly non-Indian suburbia, we would see that as a serious violation of all of those promises (CSKT 1996: 7-15).

**Tribal Perceptions of the Landscape**

While it is important to note that Salish, Kootenai, and Pend d’Oreille Indians have distinct tribal origins, histories, language and values, they share a perception of the landscape as a web of interconnected relationships. If the place suffers, so do their “bodies and souls.” The Reservation (and other aboriginal territories) is a place filled with meaning inherently a part of that landscape, experienced by humans and non-humans alike. As one tribal member put it, “our history is written within our unique and specific cultural landscapes. These places hold the memories of our ancestors, speak to us in the present, and are crucial to our survival, as Indian people, into the future (Pablo 2001).”

This concept of interconnected relationships proved difficult to convey by the Tribes in negotiations with MDT and the Federal Highway Administration (FHWA). While one party discussed the place’s Spirit, the landscape and their stories, the other party was discussing traffic flow, lane configurations and driveways. While one party was loathe to reveal the location of specific sacred cultural sites, the other party was looking to identify specific sites they could avoid or “mitigate.” The parties agreed to use the existing highway alignment, reduce the number of unsafe driveways and develop a Memorandum of Agreement before construction, but they could not agree on the number of lanes (Moler 2002). MDT then hired an engineering firm, Skillings Connolly, Inc. to tackle the access control issue. They met with hundreds of landowners on the reservation to reduce the number of access points to the highway, a major source of traffic accidents. Soon after, CSKT explored successful built projects that used Context Sensitive Design, a collaborative approach to highway design that addresses the larger landscape setting and conditions. They asked MDT to hire Jones & Jones Architects and Landscape Architects, Inc. who designed the Paris to Lexington Road, a culturally-sensitive highway in the bluegrass country of Kentucky. The efforts of landscape architects and planners to mediate between the engineers and tribes and established a more understanding dialogue led to an eventual agreement that showcased wildlife crossings.
The Memorandum of Agreement (MOA) between the CSKT, the FHWA and MDT contains lane configuration, design guidelines on vegetation, materials, and place name signs, and a description of potential locations of 42 wildlife crossings of different sizes. It is the wildlife crossings location and design that captured the imagination of the tribes and the public. A discussion of how the wildlife crossings were included in the highway plans and how each party viewed the crossings will allow us to compare cultural perceptions.

The first and most important factor in the implementation of the wildlife crossings for U.S. 93 is the Salish, Kootenai and Pend de’Oreilles’ special relationship to animals. It is a complex relationship based on traditions, daily life, seasonal movement and ultimately, their identity. Animals play the primary roles in the Flathead Indian stories of creation. Animal “geniuses” who can speak and call on the power of song dramatically shape the landscape, providing a place for the people to call home (Jones and Jones 2004). There is the wise Fox, the vocal Meadowlark, the cruel Grizzly Bear, the fast Antelope, and the most important character, Coyote. Amotken, the Great Spirit, designated Coyote a special helper, assigning him to the welfare of Indians (Clark 1966). One story describes Amteep, the wicked chief of the lower world, putting blight on all berries and causing a famine. To provide the Indians with additional food, Coyote convinced the salmon and trout to move into fresh-water streams. Coyote also taught medicine men how to use healing herbs to treat illness and disease.

As tribal members meet wildlife in the landscape they are reminded of their origins and the shaping of the landscape. These meetings are not between two separate beings, but a continual forging of kinship, as fellow sharers of the Spirit of Place. Wildlife communicate with the Native Americans important information about their place, the seasons, and upcoming events. For example, the birthing of fawns and buffalo calves signaled the availability of edible plants elsewhere on the reservation (Bigcrane 2002). Wildlife can also bring portents of the future. Debra Magpie Earling, an author and Confederated Salish and Kootenai tribal member, reveals some of what this means to the Salish in a story told by an elder:

*If Rabbit appears suddenly and twitches his ears, we know to drop to the ground before lightning sizzles past us. Hummingbird turns red before he enters our lodges to signal a young person will sicken. Rocks soften beneath our feet when we pray* (Earling 2006: 28).

As part of these larger meanings and relationships, wildlife provide food, clothing and trade items to the people. While today, hunting and gathering is no longer their primary sustenance, the Tribes continue to practice their traditional subsistence activities. Tribal members continue to hunt in traditional homelands, relying on game to supplement their diet. In the CSKT Comprehensive Resources Plan, wildlife is one of four “sustaining resources (CSKT 1996).” This sustenance aligns tribal members with the daily rhythms and seasons of life. As told by Victor Vandenburg, a Bitterroot Salish tribal historian:

*March was called the “Moon when the wild Geese come.” The period around May was called “Moon in which Bitterroot was dug.” The “Mid-summer Moon” was around the middle of July, when the plants and grasses were about full-grown. Around September was the “Moon of wild Cherries,” when Chokecherries were gathered and dried (Hungry Wolf 1974).*

Due to the importance of wildlife and the overall ecology of the Flathead valleys, the CSKT have resource staff with backgrounds in wildlife ecology, wetlands, landscape restoration and ethnobotany. Resource staff were able to tap into ecological research on habitat connectivity that showed key linkages through the reservation. They combined wildlife research with their own knowledge of the landscape patterns of the Reservation, and communicated resource concerns to the Tribal Council and members. Wildlife crossings at Evaro and in Ninepipes were proposed in the early 1990s by CSKT, as a response to wildlife habitat issues voiced by the tribe during U.S. 93 scoping sessions (Becker 1996). The CSKT Preferred Alternative found in the 1996 FEIS includes wildlife crossings near Evaro (see Figure 3), at Mission Creek, at Post Creek and in the Ninepipes Wetlands (Swaney 1996:10).
Other factors in the implementation of wildlife crossings include contextual thinking and outside expertise. Contextual thinking acknowledges the broader landscape of forests and watershed. Rather than design limited to a narrow road corridor, Context Sensitive Design responds to the larger landscape, a landscape that includes grizzly bears, amphibians and owls. Soon after Jones & Jones joined the consultant team, they developed a series of graphic boards on the potential of wildlife crossings along U.S. 93 based on local research on grizzly bear migration and initial results of monitoring of the wildlife crossings under and over the TransCanada Highway in Alberta. By presenting these images and showing the effectiveness of existing working crossings to MDT and CSKT decision-makers, the consultant team was asked to pursue the idea and include them in the Memorandum of Agreement.

The authority of outside resources who had already implemented wildlife crossings for similar animal species also proved instrumental in their inclusion. Wildlife crossing case studies from the Linn Cove Viaduct along the Blue Ridge Parkway, North Carolina, Interstate 70 in Glen Canyon, Colorado, State Highway 58 in San Bernadino County, California and the Trans-Canada Highway near Banff, Alberta in Canada illustrate a range of practical possibilities (MDT 2000). The consultant team arranged a trip to Alberta to tour the crossing structures on the Tran-Canada Highway, tapping into the local expertise of Anthony Clevenger.

How did the engineering community among MDT, FHWA and the consultant team respond to the proposal of wildlife crossings? The reception was mixed. Many of the engineers immediately saw the value of the wildlife crossings, in terms of habitat, reduction of traffic accidents, and appeasing the Tribes. Some engineers expressed reservations based on increased costs, impacts to the schedule, and practical concerns with sight lines, additional grading, etc. Underlying these detailed concerns was a general view that wildlife crossings were outside the mission of highway development. Wildlife crossings were an “extra,” added to the road to promote habitat connectivity, but they were not a part of transportation engineers’ purview, the movement of vehicles as quickly and efficiently as possible. When the Director of MDT at the time, Martin Dye P.E., approved the inclusion of wildlife crossings, the engineering community gave its support to the overall idea and started to influence the design.

**U.S. 93 DESIGN DISCUSSIONS**

Initially, tribal staff and landscape architects located, sized and designed the wildlife crossings. They located the crossings based on the experience of the Tribes’ wildlife ecologist and other tribal members, MDT road kill data, development patterns and the natural drainages the highway crossed. For example, it was more efficient to convert a proposed stream culvert into a larger box culvert for wildlife passage, than it was to place a wildlife-only culvert in an area where the terrain meant raising the road. This would allow wildlife to use the natural riparian cover of the stream corridor to move through the landscape. Landscape architects drafted design guidelines for the crossings, including fencing, aesthetics, and materials, so the crossings would blend with the landscape. The crossing locations, sizing, and design guidelines were included in the Memorandum of Agreement signed by MDT, FHWA and CSKT leadership.

Later, the broader design team of engineers and planners got involved in the wildlife crossing designs through two sets of meetings. The consultant team and representatives from the three governments spent two weeks walking the road,
visiting each proposed crossing site and discussing its composition and landscape setting (see Figure 4). The meetings were also attended by Anthony Clevenger of the University of Tennessee, as advisor, and staff from the Western Transportation Institute, as scientists responsible for pre- and post- highway wildlife monitoring. The meetings had tremendous benefits to later design decision-making. They gave the design team direct experience of the highway and the landscape it crosses. Engineers were no longer looking at a map, an abstract vision of the place. Decisions were made in the field, using the combined resources and expertise of the team. The locations and sizing of wildlife crossings were adjusted to accommodate anticipated animal species (Jones and Jones 2002). It also became clear that the wildlife crossings were not going to existing in isolation, but would be a larger part of the landscape restoration that would happen as part of the U.S 93 project. Wetland restoration, revegetation, access control, and hydrology had to be carefully coordinated with the crossings to lessen the impact of the road (Price 2003). And according to tribal staff, the Site Analysis report based on this field work formed the basis of tribal decision-making long after the original consultant team had finished design.

![Image](image.png)

**Figure 4: Biologists, engineers, landscape architects and planners Meeting at a proposed wildlife crossing location.**

The second set of meetings addressed many of the engineers’ feasibility and cost concerns. Value engineering identifies the “value opportunities, which may relate to reduced impacts, improved design or functionality, reduced costs, or improved aesthetics and compatibility with the natural features (EMS 2002: 5).” Engineers use value engineering meetings to reduce the costs of a design and improve efficiency. As part of this process, each wildlife crossing was examined again for fit, alignment and size. The most important issue in terms of cost was the height of each crossing. The height of the opening is a key factor in whether ungulates will use the crossings (Clevenger 1998). The tallest of these species, moose and elk, determine the height of the crossing opening. A few of the crossings in the south and along large drainages were kept at 12’ or higher to accommodate elk and moose, while the rest were reduced to 10’, deemed adequate for deer and bears. This savings of two feet elevation had large cost implications, as an additional two feet of fill needed to bring the road over the crossing extended before and after for a large distance. Further adjustments to the wildlife crossings to fit with existing terrain yielded additional cost savings, but most of the cost reduction was due to the decreased height of the crossings.

As the design progressed, landscape architects and tribal staff handed the detailed design work to eight engineering teams, each responsible for designing a section of the 56 mile stretch of U.S. 93. As the design moved to completion and each segment was constructed, CSKT reviewed the design for compliance with the M.O.A. and cultural impacts. The first wildlife crossings were completed in 2005 (see Figure 5), and the overpass in the critical habitat area north of Evaro was completed in 2009. Pre-construction monitoring efforts based on deer and bear movement by Western Transportation Institute suggested that wildlife were crossing the highway in variable locations and patterns, primarily at night (Hardy et al. 2007). Initial post-monitoring efforts have suggested a decrease in animal-vehicle collisions since construction of the crossings in the Ravalli Hill and Ravalli Curves areas (Huijser et al. 2010). The study’s annual report identified substantial crossing activity, particularly among deer, coyote and to a lesser extent, raccoon, bobcats and black bear.
PUBLIC PERCEPTION OF WILDLIFE CROSSINGS

How were the wildlife crossings received by the public? The newspapers have prominently featured the crossing structures in their coverage of U.S. 93 from Evaro to Polson. The structures feature prominently in pictures, headlines, and in the lead-in paragraph of each news feature (i.e. Devlin 2010, Briggeman 2009). Pictures taken by monitoring cameras have been distributed to the public by MDT and CSKT as a sign of their success (see Figure 6). Although the wildlife crossings are the featured aspect of the project, the three governments’ decision to name this stretch of U.S. 93 the “People’s Way” suggests the ultimate value and benefit of a more permeable road is seen as the collaboration and cross-cultural communication that went into it.

Figure 5: Wildlife crossing just north of Polson on a divided portion of the highway: two 10' x 22' arched box culverts.

Figure 6: Young grizzly bear captured by a motion-sensitive camera during monitoring.

Note also that though the wildlife crossings along the “People’s Way” have received considerable press among the transportation field and in western Montana, the coverage of the Memorandum of Agreement was even more extensive. Newspaper articles trumpeted the agreement’s and the future project’s unique structures and
unprecedented collaboration (Stromnes 2001). The MOA received an FHWA award for Exemplary Ecosystem Initiative in 2002. It was the agreement between the three governments that included wildlife crossings that was seen as groundbreaking. While MDT has been committed to the monitoring of the crossings and determining their success, the perceived breakthrough was not their implementation, but the idea of their inclusion.

Tribal members have embraced the wildlife crossings. The CSKT Wildlife Program features the crossings prominently as important linkages in animal movements and the sustaining of animal populations. Throughout the design and implementation of the wildlife crossings, tribal members and resource staff expressed relief that their values were acknowledged, addressed and acted upon. The crossings and the associated restoration of wetlands and meadows allowed the Tribes to avoid publicly identifying sensitive cultural sites. By preserving and restoring certain sensitive ecological places, their cultural traditions, harvesting fields and story places could remain. For the Tribes, the landscape is not composed of separate layers of natural and cultural elements. Rather, the landscape is a place of mutual dwelling of people and wildlife.

While this case study provides insight into the cultural perception of wildlife crossings and their implementation, additional research is needed that addresses wildlife crossings from a different contexts, such as economics, policy as it relates to speed, hunting and human-wildlife interactions, and other cultures perceptions.

IMPLICATIONS

By looking at two cultures involved in the implementation of wildlife crossings on U.S. 93, tribal members and transportation engineers, we have shown how people can have very different views of the same thing. Divergent perceptions should be identified and addressed in future wildlife crossing design and implementation. Several lessons arise from the experience of U.S. 93:

1) Human safety is a strong motivation for implementation of wildlife crossings. For the people of western Montana, it was a shared concern among different cultures, something that everyone could agree upon.

2) On reservation lands, and to a lesser extent in aboriginal homelands, Native American tribes have a great deal of power to influence highway design. This influence comes directly from treaty rights; wildlife (game) is a treaty-protected resource. It also comes from the inspiration of tribal stories and ways of life. The rootedness of Native Americans in place provides a wealth of knowledge and understanding of the landscape that carries great weight in the decision-making process.

3) Wildlife crossings are integral to roads in the landscape, as part of a larger system of permeability and landscape restoration. Crossings do not exist independently of the restoration of streams, wetlands, habitat and larger land use patterns.

4) Cultural considerations are critical to crossing development. Not only critical, but integral. The health of the wildlife that lives on or travels through the reservation cannot be separated from the health of the Tribes.

It is this last challenging point that, with further exploration, would contribute most to the growing body of literature on wildlife connectivity. What do the millions of animals killed every year on our highways do to our landscape and communities? How does the paucity of living creatures affect our decision-making for those people groups who revere wildlife and for those people groups who see them as a secondary concern compared to the movement of cars and goods? Can these cultural concerns be addressed with wildlife crossings or do other cultural elements, such as traffic speed and movement, need to be examined?

Whether future highway projects occur on tribal reservations or elsewhere, the people who live in a place can be influential advocates for habitat connectivity and wildlife crossings if they approach the highway holistically. The road continues to be a symbol of progress of the dominant culture, but is balanced with wildlife crossings as a symbol of the interconnectedness of Native American life-world.

BIOGRAPHICAL SKETCHES

Dale Becker. Wildlife Program Manager for the Confederated Salish and Kootenai Tribes since 1989, has been a tribal wildlife biologist for 26 years. He has graduate and undergraduate degrees in wildlife biology from the University of Montana and has worked for the U.S. Forest Service and the University of Montana. He was the tribal liaison for all wildlife related issues during the design and construction of U.S. 93.

Whisper Camel is a current wildlife biologist in the CSKT Wildlife Program working closely with Western Transportation Institute in the wildlife crossing monitoring effort.
Cory Parker, ASLA is a landscape architect with Jones & Jones for the past 10 years. Cory approaches landscape restoration through the lens of “place.” He has a Master’s Degree in Landscape Architecture from the University of Washington and has worked in wetland and stream restoration and park design. He led the U.S. 93 site analysis effort and interfaced with the seven engineering teams to develop designs for the wildlife crossings.

Charlie Scott, ASLA is a registered landscape architect with more than twenty years of experience in complex planning and design projects, including municipal and regional parks, transportation facilities, corporate and university campuses, museums and civic facilities, and mixed-use developments. He has a Bachelor’s degree in Landscape Architecture from Ball State University. He was the project manager for Jones & Jones during the U.S. 93 design discussions.

David Sorey, ASLA is a Senior Associate at Jones & Jones and a Landscape Architect with fourteen years of experience. David has worked on a variety of projects, including roadway planning and roadway design projects. He has a Bachelor in Landscape Architecture from the University of Oregon. He offered landscape planning expertise to the design team throughout the duration of the U.S. 93 project.

REFERENCES


**SUSTAINABILITY AND THE COLUMBIA RIVER CROSSING PROJECT**

Heather Wills (360.737.2726, WillsH@columbiarivercrossing.com), Environmental Manager, Columbia River Crossing, 700 Washington Street, Suite 300, Vancouver, Washington 98660 USA

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**ABSTRACT**

Sustainability plays a critical role in transportation projects in the twenty-first century, and the Columbia River Crossing Project (CRC) is no exception. The CRC is a bi-state, multi-modal transit, bridge, and highway improvement project in the Portland, Oregon/Vancouver, Washington metropolitan region that, in June 2008, the governors of Oregon and Washington stated “can and should be one of the most sustainable transportation projects in the country.” The CRC sets a precedent within both states as the first transportation project to develop a “sustainability strategy.”

The CRC Sustainability Strategy (CRC, 2011) explains how this project will meet the challenge presented by the two governors and shared by many local leaders: to become one of the most sustainable transportation projects in the country.

This strategy is the blueprint for an enduring project that will serve generations of users, join surrounding communities, and integrate with the natural environment. It is intended to accomplish multiple objectives, including:

- Articulating shared sustainability principles and goals of the CRC partner agencies, and defining project commitments and other recommended future actions that support them
- Applying an integrated, holistic “systems approach” to view the dynamic relationships of project components and their effects, rather than considering the various parts of this project in isolation
- Promoting sustainable project components that are currently under development and/or will be incorporated into the design, construction, and operational phases of the project
- Functioning as a “living document” that promotes flexibility and adaptability to emerging and future innovations

The strategy builds on the policies and plans that already exist with the state departments of transportation, Metropolitan Planning Organizations, cities, and transit organization that are co-sponsors of the CRC.

The strategy was developed from a framework composed of aspirational principles as well as more strategic goals that lead to more specific tactical activities for implementation during subsequent project phases. The principles, goals, and activities framework provides the overarching guidance for implementing sustainable components and practices into the CRC project design, construction, and operations and maintenance.

For the purpose of the CRC Sustainability Strategy, principles are considered to be fundamental and unchanging tenets. The CRC Sustainability Principles describe the “rules” or criteria of the process for developing a sustainable project and therefore are descriptive, not prescriptive. Sustainability principles are derived from the Vision and Values Statement and reflect current direction in stakeholder sustainability policies.

The CRC Sustainability Strategy is the first of its kind for a transportation project. This strategy is where all the environmental benefits, whether mitigation commitments or aspirations, will be contained. It is meant to be a living document that can be amended as new technologies, policies, and information becomes available.

**WHAT IS THE COLUMBIA RIVER CROSSING PROJECT?**

The Columbia River Crossing (CRC) project is a bridge, transit, and highway infrastructure modernization project for approximately 8 kilometers (5 miles) of Interstate 5 (I-5) from State Route 500 in Vancouver, Washington, to approximately Columbia Boulevard in Portland, Oregon. The CRC project will replace the I-5 bridge over the Columbia River and extend light rail to Vancouver, Washington. The bridge will provide a 6.1 meter (20-foot) wide covered pathway for pedestrians and bicycles over the Columbia River. The purpose of the project is to address the transportation problems on I-5 in the project area including: growing travel demand and congestion; impaired freight movement; limited public transportation operation, connectivity, and reliability; decreasing safety and increasing vulnerability to collisions; substandard pedestrian and bicycle facilities; and seismic vulnerability. Please refer to the CRC project website (www.columbiarivercrossing.org) for further details of existing conditions, the proposed project, the project’s purpose and need, and the potential impacts of the project.
The CRC project is a collaborative, multi-modal, bi-state project with two lead federal agencies under the U.S. Department of Transportation (USDOT): the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA). The Washington State Department of Transportation (WSDOT) and Oregon Department of Transportation (ODOT) are joint sponsors of the CRC project. CRC project regional project partners include: Southwest Washington Regional Transportation Council (RTC), Metro, C-TRAN, TriMet, City of Vancouver, and City of Portland. CRC project staff coordinates with state and local agencies in both Oregon and Washington, and also collaborates with federal agencies and tribal governments.

WHAT IS THE PURPOSE OF THE CRC SUSTAINABILITY STRATEGY?

The CRC, in consultation with project partner staff, drafted a project sustainability strategy to explain how the project is connected to regional and state sustainability goals, including promoting quality of life and regional economic and job growth and reducing impacts on our environment. The CRC Sustainability Strategy is the “blueprint” for an enduring infrastructure project that will serve future generations, join communities, and integrate with nature. The strategy is the first of its kind for a major transportation project.

The strategy is built upon the eleven environmental, social, and economic principles listed below, and supporting goals and activities including project commitments and aspirations. The eleven principles that frame the strategy consist of:

1. Support enduring quality of life and community resources
2. Strive for fair distribution of benefits and impacts
3. Improve transportation reliability and accessibility for all types of travel and reduce reliance on single-occupancy vehicles
4. Enhance safety for users of all types of travel
5. Support a sound regional economy and job growth
6. Support cost-effectiveness in design, construction, maintenance, and operation including consideration of sustainable funding sources and life cycle costs where appropriate
7. Enhance and protect natural resources, fish, and wildlife habitat
8. Enhance water quality and minimize water consumption
9. Minimize air quality impacts, greenhouse gas (GHG) emissions, and effects of climate change
10. Minimize materials consumption
11. Minimize energy consumption and support renewable energy

The CRC Sustainability Strategy principles are considered to be fundamental and unchanging tenets. These principles describe the “rules” or criteria of the process for developing a sustainable project and therefore are descriptive, not prescriptive. The strategy also contains corresponding and supporting goals that are shared by the CRC partners, and more detailed activities to achieve these goals. The activities include CRC commitments to be incorporated into the project that were made through the environmental process, as well as recommendations and considerations for future phases of design, construction, and ongoing operations.

The strategy is intended to function as a “living document” that will be adaptable to future emerging innovations.

WHY DID THE CRC DEVELOP A SUSTAINABILITY STRATEGY?

The CRC developed a CRC Sustainability Strategy for several compelling reasons, including to:

- demonstrate the leadership and commitment of the states of Washington and Oregon, and the Portland-Vancouver region to a sustainable transportation system to promote livable communities;
- meet the Washington and Oregon governors’ challenge posed in June 2008 that the CRC “can and should be one of the most sustainable transportation projects in the country”; and
- respond to regional and local partners’ emphasis on sustainability as articulated in their Locally Preferred Alternative (LPA) resolutions for the CRC that they completed in the summer of 2008.

The leaders in the states of Washington and Oregon recognize that future transportation challenges in mature transportation corridors such as I-5 will require solutions beyond added highway capacity. The nation is looking to CRC as a model for multi-modal transportation planning, because the project is one of the first in the nation to bring highway, transit, and other elements together under the same design.
In their joint letter to the CRC project Task Force on June 19, 2008, the governors of Washington and Oregon asserted that:

*We firmly believe this can and should be one of the most sustainable transportation projects in the country; one that incorporates high capacity transit, strategies that reduce vehicle miles traveled, tolling, electronic safety technologies, and world class bike and pedestrian facilities. We also believe we must use construction materials and methods that would minimize environmental impacts.*

The CRC Sustainability Strategy explains how this project will meet the challenge presented by the two governors and shared by many local leaders: to become one of the most sustainable transportation projects in the country.

**HOW DID THE CRC DEVELOP THE SUSTAINABILITY STRATEGY?**

Starting with the LPA that the project sponsors approved in 2008, the CRC collaboratively initiated and then developed the CRC Sustainability Strategy with input from project sponsors and partners. The CRC formed a Sustainability Technical Committee composed of project partners and CRC staff representing various project task forces and working groups formed to advise CRC project staff on the draft sustainability strategy development. With input from the Sustainability Technical Committee, the CRC staff created a framework for identifying and highlighting sustainable practices already included in, or likely to become part of, the CRC project design refinement, management, and operations. The framework is contained in a tabular matrix format (see following section). The CRC project staff and Sustainability Technical Committee created the framework after completing the following tasks:

- Considered and applied the CRC Task Force Vision and Values Statement to derive sustainability principles
- Reviewed applicable federal, state, and local regulations and documented specific requirements for compliance in relation to each project principle
- Reviewed applicable state and local nonbinding plans, policies, and guidelines and documented specific language related to the project principles that are within the scope of the CRC project (e.g., implementing land use changes and decreasing childhood obesity in local jurisdictions are considered beyond the scope of the project)
- Considered and incorporated applicable regulatory requirements and federal, state, and local nonbinding plans, policies, and guidelines
- Considered and incorporated other ongoing CRC project commitments and development efforts that complement the CRC Sustainability Strategy

**WHAT ARE THE MAIN FEATURES OF THE CRC SUSTAINABILITY STRATEGY?**

The principles, goals, and activities framework provides the overarching guidance for implementing sustainable components and practices into the CRC project design, construction, and operations and maintenance. This framework is provided in the table (Table 1) on the following pages, and a more detailed description of proposed activities to support the principles and goals is provided in Section 3 of the CRC Sustainability Strategy.

The CRC sustainability principles describe the “rules” or criteria of the process for developing a sustainable project and therefore are descriptive, not prescriptive. Sustainability principles are derived from the Vision and Values Statement and reflect current direction in stakeholder sustainability policies.

Goals are more focused statements of outcomes to be achieved in support of each principle.

Sustainability activities describe how and when a particular goal or principle is accomplished. Activities provide an appropriate level of detail to sufficiently guide ongoing project development and implementation, while providing flexibility to adapt to changing system conditions.

For the CRC Sustainability Strategy, draft activities were developed based on information gathered from the policies and plans of existing stakeholder agencies, CRC project technical reports, sustainability literature and publications, and working group recommendations (as described in further detail in the Sustainability Strategy).

The activities were tailored to fit the CRC project, and are shown below in Table 1 on the remaining pages as either already incorporated as project commitments in the LPA described in the Final Environmental Impact Statement (FEIS) for the project (unshaded cells in the table), or as recommended to apply to the LPA through subsequent project phases (blue-shaded cells in the table).

Additional details of each activity shown in Table 1 are provided in Section 3 of the Sustainability Strategy. In addition to the activities outlined in Table 1, the project will comply with applicable regulations, policies, and permitting requirements from federal, state, and local agencies as the project proceeds to construction.
<table>
<thead>
<tr>
<th>CRC Project Sustainability Principles and Goals</th>
<th>CRC Project Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.1 Foster regional cooperation and planning</strong></td>
<td><strong>1.1.1</strong> Maintain interjurisdictional coordination and community outreach through project design and construction.</td>
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<td><strong>1.1.2</strong> Maintain coordinated engagement of regional and local land use and transportation planners based in Washington and Oregon through the design, construction, and operation.</td>
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<td><strong>1.2 Support growth management planning in both states</strong></td>
<td><strong>1.2.1</strong> Support RTC and Metro regional policies and plans, and Cities of Vancouver and Portland policies and plans in the project area through design and operation of the project.</td>
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<td><strong>1.2.2</strong> Support planned land uses and developments in Vancouver and Portland through design and construction of the project.</td>
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<td><strong>1.3 Support a healthy community</strong></td>
<td><strong>1.3.1</strong> Maximize physically active forms of travel, including walking and bicycling, by designing and prioritizing implementation of non-motorized and transit project elements.</td>
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<td><strong>1.3.2</strong> Encourage walking and bicycling to basic services and activities in the project area by removing barriers and enhancing system connectivity where practical.</td>
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<td><strong>1.3.3</strong> Substantially minimize the need to generate and use hazardous materials for construction, and operations and maintenance by developing and implementing a Construction and Demolition Waste Management Plan (Best Management Practices [BMPs], spill plan, disposal plan, etc.).</td>
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<td><strong>1.3.4</strong> Reduce urban “heat island” effect of the project components by preserving trees where practical and working with community members to incorporate street trees and other design features that improve water quality, increase carbon sequestration, and build community values.</td>
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<tr>
<td><strong>1.4 Improve community cohesion and avoid neighborhood disruption</strong></td>
<td><strong>1.4.1</strong> Enhance community cohesion by designing the project to increase connectivity across existing barriers in the project area.</td>
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<td><strong>1.4.2</strong> Continue to inform and garner input from citizens most affected by project impacts by refining solutions through design and construction of the project.</td>
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<td><strong>1.4.3</strong> Minimize disruption to neighborhoods through development of compatible construction methods, scheduling, and traffic routing.</td>
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<tr>
<td><strong>1.5 Support a vibrant land use mix and promote sustainable development</strong></td>
<td><strong>1.5.1</strong> Minimize conversion of existing and planned residential, commercial, and industrial land to transportation right-of-way by limiting overall project design &quot;footprint&quot; to the extent practical.</td>
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<td><strong>1.5.2</strong> Support compatibility between planned land uses and transportation facilities (function, design, and capacity) in the project area through project design and construction.</td>
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<td><strong>1.6 Minimize impacts of noise, vibration, light, dust, and glare</strong></td>
<td><strong>1.6.1</strong> Minimize noise, vibration, and dust impacts during construction by implementing construction BMPs and a traffic management plan.</td>
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<td><strong>1.6.2</strong> Minimize noise impacts from large vehicles by designating project area truck and bus routes within major through routes and commercial corridors and away from local neighborhood streets.</td>
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<td><strong>1.6.3</strong> Minimize noise impacts from new and modified facilities near noise-sensitive receptors through innovative and cost-effective design features and construction practices.</td>
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<td><strong>1.6.4</strong> Minimize stray light and glare for facility users and adjacent land by incorporating context-sensitive, innovative, and cost-effective design features and lighting systems.</td>
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<td><strong>1.7 Support aesthetic quality that achieves a regional landmark</strong></td>
<td><strong>1.7.1</strong> Protect and enhance scenic views and viewshed by incorporating design features that minimize obstruction of scenic views.</td>
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<td><strong>1.7.2</strong> Promote the unique contextual character and sense of place by incorporating distinctive natural and built design features.</td>
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<td><strong>1.8 Protect parks, historic and cultural resources, and green spaces</strong></td>
<td><strong>1.8.1</strong> Avoid fragmentation and degradation of parks, open spaces, trails, and greenways by carefully locating new and modified transportation and utility project components.</td>
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<td><strong>1.8.2</strong> Maintain character of unique areas by preserving, replacing, or enhancing vegetation associated with parks and green spaces, and historic properties and districts.</td>
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<tr>
<td>CRC Project Sustainability Principles and Goals</td>
<td>CRC Project Activities</td>
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<tr>
<td>2. Strive for fair distribution of benefits and impacts</td>
<td><strong>2.1.1</strong> Provide access for elderly and disabled people by designing and conveniently locating transit stations, bus stops, and pedestrian amenities.</td>
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<tr>
<td>2.1 Support fair distribution of benefits and adverse effects of the project for the region, communities, and neighborhoods adjacent to the project area</td>
<td><strong>2.1.2</strong> Maximize efficiency of operation, users’ ease, and access for disadvantaged communities by integrating technology to create a seamless, coordinated, and single point of entry for communications and customer information.</td>
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<tr>
<td>2.1.3 Encourage and support transit ridership and other travel options for disadvantaged people during construction by implementing a robust communications and outreach program.</td>
<td><strong>2.1.4</strong> Continue to inform and garner input from affected vulnerable communities (including children, elders, and people with disabilities) and Environmental Justice target communities (minority and/or low-income populations) by refining solutions through design and construction of the project.</td>
</tr>
<tr>
<td>2.1.1 Provide access for elderly and disabled people by designing and conveniently locating transit stations, bus stops, and pedestrian amenities.</td>
<td><strong>3.1.1</strong> Accommodate future mobility and access needs of all users through design.</td>
</tr>
<tr>
<td>3.1.2 Adapt to changing needs by developing transit system capacity, routes, and service with optimal reliability and flexibility.</td>
<td><strong>3.1.3</strong> Use active management in the corridor to monitor key performance measures and implement and adjust mobility solutions such as operational and small-scale physical improvements, and demand management strategies.</td>
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<tr>
<td>3.1.4 Maintain travel time reliability by adjusting tolling.</td>
<td><strong>3.2.1</strong> Improve reliability, mobility, and safety of the multi-modal transportation network through the use of coordinated Transportation System Management (TSM) and operational strategies.</td>
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<td><strong>3.2.2</strong> Reduce reliance on SOVs by utilizing Transportation Demand Management (TDM) strategies coordinated on a regional level.</td>
<td><strong>3.3.1</strong> Maximize travel mode choices by incorporating appropriate transit, bicycle, and pedestrian facilities and integrating linkages between modes in the project area.</td>
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<td><strong>3.3.2</strong> Address non-motorized system gaps and deficiencies in the project area through project element design and construction prioritization.</td>
<td><strong>4.1.1</strong> Continue to enhance safety for river traffic by maintaining navigation channel geometrics.</td>
</tr>
<tr>
<td><strong>4.1.2</strong> Continue to support air traffic safety by complying with Federal Aviation Administration (FAA) navigable airspace regulations.</td>
<td><strong>4.1.3</strong> Enhance safety for bicyclists and pedestrians by developing and implementing a project-specific Safety and Security Management Plan.</td>
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<td><strong>4.1.4</strong> Maintain life-line connections in the I-5 corridor across the Columbia River through design and construction staging.</td>
<td><strong>4.1.5</strong> Incorporate an enhanced incident management system.</td>
</tr>
<tr>
<td><strong>4.1.5</strong> Incorporate an enhanced incident management system.</td>
<td><strong>5.1.1</strong> Preserve and expand existing sustainable and disadvantaged businesses, and attract new businesses and industries by designing the project for sufficient long-term capacity and maintaining multi-modal access to businesses during construction.</td>
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<tr>
<td><strong>5.1.2</strong> Support the local and regional economy and encourage new jobs by procuring local and regional design services, construction contractors, and equipment.</td>
<td><strong>5.2.1</strong> Maintain or enhance multi-modal freight system interconnections (trucking, rail, marine cargo, air cargo, and pipelines).</td>
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<tr>
<td><strong>5.2.2</strong> Continue to maintain freight mobility and minimize delay and out-of-direction travel for freight traffic through construction staging.</td>
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<tr>
<td>6. Support cost-effectiveness in design, construction, maintenance, and operation including consideration of sustainable funding sources and life cycle costs where appropriate.</td>
<td>6.1.1 Extend the useful life of existing roads, bridges, structures, transit facilities, and other transportation assets by developing and applying operation, maintenance, and preservation strategies that would be more cost-effective than substantial expansion or retrofit actions, while supporting other project principles.</td>
</tr>
<tr>
<td>6.1 Maximize cost-effectiveness in design, construction, maintenance, and operation.</td>
<td>6.1.2 Minimize costs by identifying, protecting, and/or acquiring needed right-of-way as early as possible.</td>
</tr>
<tr>
<td>6.1.3 Account for life-cycle costs to the greatest extent practical by developing effective measures and prioritizing least-cost solutions benefiting the project.</td>
<td>6.2 Secure adequate and reliable funding for the project.</td>
</tr>
<tr>
<td>6.2.1 Maximize leverage of short-term capital intensive investments, long-term project operation investments, and federal funding eligibility by developing a sustainable financing and revenue plan.</td>
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<td>7. Enhance and protect natural resources, fish, and wildlife habitat.</td>
<td>7.1 Reduce barriers to fish and wildlife passage.</td>
</tr>
<tr>
<td>7.1.1 Enhance fish and wildlife habitat by designing and prioritizing implementation of project elements that remove blockages or barriers limiting fish or wildlife passage in the project area.</td>
<td>7.1.2 Avoid fragmentation and degradation of significant habitat, floodplain hydrology, and wildlife corridors by sensitively locating new and modified transportation and utility project components.</td>
</tr>
<tr>
<td>7.1.3 Maximize passage for fish and other aquatic species by appropriately locating and minimizing the number and size of new bridge support structures, where practical.</td>
<td>7.1.4 Enhance aquatic and other species passage by removing or retrofitting culverts that block or restrict passage (i.e., oversized or natural bottom culverts).</td>
</tr>
<tr>
<td>7.2 Strive toward an increase in suitable high quality wetland, aquatic, and upland habitat.</td>
<td>7.2.1 Protect and enhance habitat by developing and implementing a comprehensive habitat mitigation plan.</td>
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<tr>
<td>7.2.2 Enhance urban ecological habitat by increasing native vegetative cover through design and construction of the project.</td>
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<tr>
<td>8. Enhance water quality and minimize water consumption.</td>
<td>8.1 Improve water quality and manage/treat 100% of stormwater runoff from project area (or equivalent).</td>
</tr>
<tr>
<td>8.1.1 Reduce transportation-related stormwater runoff, impervious surface, and other project impacts by completing and implementing a stormwater management plan to guide project design, construction, and operations and maintenance.</td>
<td>8.1.2 Maximize management of stormwater by restoring existing unused impervious paved areas to natural, permeable, and vegetated conditions during the design phase to the maximum extent practical.</td>
</tr>
<tr>
<td>8.1.3 Enhance water quality by investigating opportunities to create stormwater management facilities that provide multiple beneficial functions during the design phase to the maximum extent practical.</td>
<td>8.2 Minimize water consumption required for project.</td>
</tr>
<tr>
<td>8.2.1 Minimize landscaping irrigation needs and potable water consumption by designing planted areas and facilities to capture stormwater and using native, drought tolerant plants.</td>
<td>8.2.2 Minimize potable water consumption by continuing to investigate ways to incorporate gray water into the design and operations and maintenance of the project, where practical and cost-effective.</td>
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<tr>
<td>9. Protect and enhance air quality and minimize GHG emissions</td>
<td>9.1.1 Increase use of low- or zero-emission modes of travel such as transit, bicycles, and walking through design, construction, and operations and maintenance of the project.</td>
</tr>
<tr>
<td></td>
<td>9.1.2 Maximize use of low- or zero-emission modes of travel such as biodiesel freight, telecommuting, zero-emissions vehicles, carpooling, and vanpooling, through design, construction, and operations and maintenance of the project.</td>
</tr>
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<td></td>
<td>9.1.3 Minimize long-term air quality impacts by collecting and reporting air quality data and using this data to inform toll pricing, or implementation of emissions reductions technologies.</td>
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<td></td>
<td>9.1.4 Contribute to meeting current and future state and regional GHG emissions reduction targets by incorporating or accommodating technologies to monitor and report air quality, GHG emissions, and air toxics within the project area.</td>
</tr>
<tr>
<td>9. Design, construct, maintain, and operate project to resiliently adapt to climate change</td>
<td>9.2 Design, construct, maintain, and operate project to resiliently adapt to climate change</td>
</tr>
<tr>
<td></td>
<td>9.2.1 Continue to reduce vulnerability and resilience (e.g., to water level rise and extreme storm events) through project operations and maintenance by integrating adaptive climate change features and performance mechanisms into the design.</td>
</tr>
<tr>
<td></td>
<td>9.2.2 Evaluate climate change analysis methodologies and related projections to assess probable outcomes for the CRC project area over the next 50 to 100 years, and consider opportunities for adaptive management and participation in the carbon market.</td>
</tr>
<tr>
<td>10. Minimize raw materials consumption</td>
<td>10.1 Minimize extraction and consumption of raw materials</td>
</tr>
<tr>
<td></td>
<td>10.1.1 Use high quality, durable materials. Reduce life cycle consumption of resources.</td>
</tr>
<tr>
<td></td>
<td>10.1.2 Use incentives and disincentives to reward quality at lowest life cycle cost.</td>
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<tr>
<td></td>
<td>10.2 Maximize reuse and recycling of materials</td>
</tr>
<tr>
<td></td>
<td>10.2.1 Provide incentives to contractors to reduce, reuse, and recycle through specifications based on true performance</td>
</tr>
<tr>
<td></td>
<td>10.2.2 Remove restrictions on viable materials and methods to encourage incorporating locally available reused and recycled materials.</td>
</tr>
<tr>
<td>11. Minimize energy consumption and support renewable energy</td>
<td>11.1 Minimize energy consumption and transportation demand during construction, operation, and maintenance of the project</td>
</tr>
<tr>
<td></td>
<td>11.1.1 Minimize energy consumption and increase energy efficiency through efficient, cost-effective project design and implementation.</td>
</tr>
<tr>
<td></td>
<td>11.1.2 Provide opportunities to incorporate innovative approaches to traffic operations and support use of efficient vehicle technologies.</td>
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<td></td>
<td>11.1.3 Minimize energy consumption through operations and maintenance of the project by monitoring and adjusting toll pricing.</td>
</tr>
<tr>
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<td>11.2 Use renewable sources to the maximum extent practical</td>
</tr>
<tr>
<td></td>
<td>11.2.1 Maximize use of the most cost-effective renewable energy applications into the project design by selecting the least-cost proposal upon performing a life-cycle analysis.</td>
</tr>
<tr>
<td></td>
<td>11.2.2 Maximize opportunities to increase use of renewable energy sources by designing the project to accommodate integration of future emerging technologies.</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

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- Ron Anderson, CRC Urban Design Advisory Group
- Katy Belokonny, C-Tran
- Carley Francis, CRC Communications
- John Gillam, City of Portland, Bureau of Transportation
- Bob Hart, SW Washington Regional Transportation Council
- Jeff Heilman, CRC Environmental
- Eric Hesse, TriMet
- David Parisi, CRC Bicycle and Pedestrian Advisory Committee, and Freight Working Group
- Michael Piper, City of Vancouver
- Mike Rosen, City of Portland, Bureau of Environmental Services
- Mark Turpel, Metro

BIOGRAPHICAL SKETCHES

Heather Wills has been the Environmental Manager for the Columbia River Crossing project for the last six years. She has ten years of transportation and NEPA/environmental permitting experience in both the public and private sectors. She received her Bachelor of Science degree in Environmental Science from Portland State University in 1997, and a Master's degree in Environmental Planning from Portland State University in 2003. Prior to her current position at the Oregon Department of Transportation, Heather has held positions with the URS Corporation in Portland, Washington Department of Transportation, and the US Geological Survey Water Resources Division.

Scott Richman, AICP, PMP is a Senior Associate and Senior Project Manager with David Evans and Associates, Inc. (DEA). He has 20 years of professional transportation and environmental planning, and transportation project development experience, including 12 years at DEA. He received his Bachelor of Environmental Design degree from the University of Colorado in 1990. Mr. Richman’s expertise includes management, coordination and production of transportation-oriented National Environmental Policy Act (NEPA) documents and transportation corridor, transportation systems planning, and community planning projects. His primary areas of interest include the integration of alternative transportation modes, local land use and development plans, and natural resource management into sustainable transportation improvement projects and planning processes.

REFERENCE

SUSTAINABILITY IN BRIDGES: THE ART AND COMMUNITY OF CELEBRATING OUR LANDSCAPE

Linda Figg (850-224-7400, LFigg@figgbridge.com), President, CEO and Director of Bridge Art, FIGG, 424 North Calhoun Street, Tallahassee, Florida 32301 USA

Editor's Note: The complete text of this paper was not available to be included in the proceedings. Please contact the author for additional information.

ABSTRACT

Bridges for the future are being achieved today using advanced materials and modern designs that respect the environment, embrace a community’s sense of place, and promote an enhanced quality of life. Sustainable success includes positive results with social, environmental, and economic benefits. This paper/presentation will evaluate several case studies to examine the sustainable benefits of modern bridges. Examples include the New I-35W Bridge in Minneapolis, US 191 over the Colorado River Bridge in Moab, Utah near Arches National Park, Four Bears Bridge in North Dakota for a Native American Community, I-280 Veterans’ Glass City Skyway in Ohio, Penobscot Narrows Bridge and Observatory in Maine and many others.

Social benefits for communities can be realized through proper planning and better use of land in our transportation corridors. The Selmon Expressway in Florida enhanced mobility and eased congestion, providing better land use and a better quality of life. The new I-35W Bridge in Minnesota expands on visual quality opportunities and increased public space below the bridge with long, open spans. Extensive public involvement and educational programs benefitted the community throughout construction.

Environmental benefits are numerous in bridges designed and built to fit with the landscape. The new US 191 crossing of the Colorado River in Utah was built from above, with long spans to protect and preserve the river environment, incorporating colors and textures to blend in the landscape as if the bridge is born from the earth. The Blue Ridge Parkway Viaduct in North Carolina respects nature through a minimal footprint on the mountainside and iron oxide in the concrete to blend the bridge into the mountainside. Mountainside bridges in Glenwood Canyon, Colorado, such as the Hanging Lake Viaduct, were constructed to respect nature.

Economic benefits of bridges are part of design decisions, impact construction and provide for long-term community enhancement. Sustainable designs use local labor, local materials and maximize innovation in low energy solutions. Bridges such as AirTrain JFK in New York and the New I-35W Bridge in Minnesota offer accelerated construction to save costs and time through using resources efficiently. Modular, precast concrete segments for piers and superstructure have proven time and cost savings. On all bridges, utilizing quality, local and recycled materials offers longer life-cycle cost benefits as well as local economic benefits. Features include using nano-technologies, smart bridge sensors, LED lighting, waste products from other industries recycled in materials, and many other innovations that advance the art of maximizing sustainability.

By studying a variety of bridges with a focus on sustainability including associated social, environmental and economic benefits, knowledge can be gained that will benefit future bridges and local land use planning for the benefit of communities throughout America.

BIOGRAPHICAL SKETCH

Linda Figg is President/CEO and Director of Bridge Art for FIGG, an international firm that exclusively specializes in bridges. FIGG bridges have received over 330 awards for customers, recognizing economy, innovation, sustainability, and aesthetics, including three Presidential Awards through the National Endowment for the Arts. Linda is past president of the Construction Industry Round Table, was named as one of Engineering News Record’s Top 22 Newsmakers in 1998 and was named as one of the 13 most influential people in the concrete industry in 2007 by Concrete Construction. In 2009 Linda was named to the Alabama Engineering Hall of Fame. Linda’s passion for creating environment friendly and functional bridge sculptures has led her to focus on improving the quality of life in communities with landmark bridges.
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