

Research Report
KTC -14-10/SPR447-12-1F

Green Infrastructure

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Research Report
KTC-14-10/SPR447-12-1F

Green Infrastructure

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16. Abstract The transportation industry has increasingly recognized the vital role sustainability serves in promoting and protecting the transportation infrastructure of the nation. Many state Departments of Transportation have correspondingly increased efforts to incorporate concepts of sustainability into the planning, design, and construction phases of projects and congruently adopted sustainability measures into their internal standard policies and procedures. Sustainably constructed highways foster economic development, promote stewardship of the environment, and solicit citizen involvement for an integrated, comprehensive approach to project planning. As part of an effort to understand the extent to which sustainable design and construction principles are being used, this report selects and analyzes three case studies involving previously completed KYTC projects and assesses their commitment to sustainable concepts. Specifically, this report examines the extent to which KYTC utilized sustainable concepts for each case study as described in FHWA's INVEST rating system. This research effort comprised three components. First, KTC researchers analyzed KYTC's policies and manuals for project planning, design, and construction and determined the extent to which INVEST criteria and related principles were incorporated into their standard processes. Second, KTC analyzed the individual case studies themselves, to include project plans and other relevant documentation. Finally, KTC conducted interviews with each of the KYTC district offices responsible for managing those previously completed projects and obtained feedback on the INVEST criteria used for each particular project. Following this approach, KTC validated and finalized the assigned scoring ratings for each case study in accordance with the INVEST scoring guidance. In summary, this report describes the sustainable concepts and corresponding INVEST scores for each project, presents a summary of the main findings, and provides recommendations for the way ahead.			
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Executive Summary

Executive Summary

This report represents the culmination of a three-year project conducted by the Kentucky Transportation Center (KTC) on behalf of the Kentucky Transportation Cabinet (KYTC). Having recognized a movement throughout the United States to improve the sustainability of road planning, design, and construction practices, KYTC commissioned KTC to examine recently completed highway projects to determine their level of sustainability. The Year 1 Report focused primarily on guidelines other states had put into place to enhance sustainable outcomes in road construction and maintenance. KTC researchers surveyed recent trends applying sustainability principles to critical highway projects, from the planning and design phases through implementation and onward across their lifecycle. In Year 2, the research team identified a scoring methodology appropriate to assess projects in the Commonwealth of Kentucky. A number of public and proprietary rating systems have been developed to evaluate highway projects' sustainability. This report offered an in-depth discussion and analysis of the available options, ranging from Greenroads, a proprietary rating system developed at the University of Washington, to INVEST, a rating system put together by the Federal Highway Administration (FHWA). Because of it being publicly available and open-source, KTC researchers decided that INVEST was ideal to use for project assessments. A secondary goal of the Year 2 Report was to propose a list of prospective projects that the KTC research team would evaluate during the final year's project work. After consulting with KYTC officials, KTC researchers selected three projects to score. This report summarizes KTC's methodology, findings, and suggestions to gradually bolster highway sustainability in Kentucky.

After reviewing the basic issues this study addresses, this report looks at the INVEST rating system and discusses its applicability for assessing the sustainability of highway projects. It discusses the different scorecards that are available to evaluate various kinds of projects as well as the criteria on which they are scored. Chapter 2 provides a treatment of the methodology used by KTC researchers during the scoring process. To assign points for different sustainability criteria, proper documentation is necessary to validate researchers' findings. As a starting point, the research team conducted a review of agency-wide policies and guidelines at KYTC that are applied to construction and maintenance projects throughout Kentucky. Once this phase of the research was complete, researchers knew what knowledge gaps had to be filled in by examining project-specific documents.

Following the review of project-specific documents, KTC researchers assigned a preliminary score to each case study. Even after considering agency-wide guidance and project-specific information, uncertainty remained over the accuracy over some of the scores. To validate scores and correct any errors or omissions, KTC researchers visited staff in the KYTC District Offices responsible for project implementation and oversight. Before conducting these visits, the research team developed a set of structured interview questions to facilitate data collection. During the research team's visits with district staff, they shared preliminary results and gathered salient data that answered questions that had previously been unaddressed. This collaboration between KYTC staff and KTC personnel was critical for generating objective evaluations for each project. Chapter 3 builds off this methodological framework and presents findings for each of the projects that we examined. Table ES.1 summarizes the scores for individual case studies. All projects attained a Bronze Rating using the INVEST system, indicating the Cabinet and its District Offices have guidelines and practices in place conducive to enhancing the sustainability of Kentucky's roadway system. For each case study, KTC also generated a project-capable score. This is the score a project could secure with modest additional investments (on the order of 5%-10%) – what is important to keep in mind is that these are *estimates*. They are in no way prescriptive, nor are they to suggest a particular course of action for KYTC.

Executive Summary

Table ES.1

<i>Project Name</i>	<i>INVEST Score</i>	<i>INVEST Rating</i>
Double Crossover Diamond (DCD), Lexington	38	Bronze
Elizabeth to Radcliff Connector (E2RC)	35	Bronze
12th Street Reconstruction, Covington	39	Bronze

These findings cast a positive light on KYTC's current design and construction practices. Whether or not achieving higher sustainability scores should be a goal on individual projects remains at the Cabinet's discretion. Project-capable ratings demonstrate that significant gains in sustainability can be obtained by making small increases in investment. If KYTC would like to pursue this route, the research team recommends, for each prospective project, developing a thorough cost-benefit analysis to decide if the potential return on investment (ROI) can justify additional up-front expenses. Identifying an ROI threshold that would merit additional project funding is beyond the scope of this project; arguably, this level would vary based on the larger context road projects are situated in. Given that current procedures lend themselves to sustainable outcomes, we suggest that, at a project's inception, KYTC officials look at strategies to improve sustainability that do not add to its cost. Consulting the INVEST criteria would be one way of accomplishing this, as it contains a number of practices that amplify project sustainability without requiring increased financial outlays. In the years to come sustainability is likely to increasingly shape our approaches to remaking the built environment so that it is a setting that facilitates economic growth in a manner that is environmentally friendly and socially just. Future research could look more closely at the specific economic benefits Kentucky would realize if it adopted more sustainable practices into the highway design and construction process.

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Chapter 1: Background

Chapter 1 – Background

1.1 Introduction

This research analyzes the Kentucky Transportation Cabinet's (KYTC) project development operations to gauge the sustainability of their efforts and highlight areas for potential improvement. The impetus for effort stemmed from the belief that KYTC's strides in the use and development of context sensitive design aligned with sustainable principles increasingly used in the transportation industry. To assess this, KTC performed an in-depth study of transportation sustainability metrics and practices, which informed the case evaluations of selected KYTC projects. The findings demonstrate that KYTC projects have been sustainable – according to INVEST sustainability criteria – even when they were not explicitly designed to bolster sustainability. The rest of this report synthesizes literature most applicable to this research and presents the findings of case study evaluations.

This chapter describes the project's research ambit as well as the previous findings made during earlier phases of research; these were a precursor to the final case study analyses. First, to introduce the concept of sustainability and the ways it has been applied within the context of transportation, this chapter attempts to define sustainability. Because of the subject's complex nature, there has been vigorous debate over what kinds of practices are sustainable and what activities are unsustainable – especially in the transportation industry. These introductory comments familiarize the reader with the key tenets of sustainability; their goal is not to exhaustively review debates about sustainability, or to resolve them. Rather, the emphasis is placed on illuminating ideas that have gained purchase among transportation planners and professionals. Further study of these matters can be found in the Year 1 and Year 2 interim reports. The appendices contain summaries of this previous work.

Defining Sustainability

Traditionally, the concept of sustainability has prioritized the human relationship with the environment, but has not engaged to the same degree with issues of economic development and social equity. Although the concept of sustainability did not receive a formal definition until the 1970s and 1980s, there has long been the recognition that natural capital is finite, and that human well-being depends on using those resources in a wise, economic, and conservative manner (Mebratu 1998). It is understandable that sustainability is most closely linked to questions about the health of ecological systems and the damage humans impart to them through day-to-day activities. During the 1960s and 1970s, in the United States, people became more acutely aware of the environmental degradation afflicting the landscape. This led to increased calls for policies to curb the human excesses that not only damaged the environment, but also threatened human health. The National Environmental Policy Act was passed in 1970 and served as a milestone insofar as it mandated that environmental considerations be taken into account when making policy decisions at a federal level. Although this was a landmark piece of legislation that represented a response to the burgeoning crises facing the environment, it did not explicitly call for more sustainable forms of development.

The idea of sustainable development gained widespread visibility after the release of *Our Common Future* in 1987, published by the UN's World Commission on Environment and Development (Daly 1996). Arguably, this was a decisive turning point as the report introduced a definition of sustainable development that is often cited even 25 years later: it is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, pp. 105). While this definition retains currency, there are numerous disagreements concerning

Chapter 1: Background

whether this statement offers any kind of practical guidance about how to achieve sustainability. The WCED report was important, however, because it shifted thinking about sustainability from an environmental-centric perspective to one more concerned with maintaining economic development into the future. Priority was given to sustainable growth. While the environment was not pushed into the background entirely, *Our Common Future* catalyzed a more expansive approach to sustainability, one not singularly focused on environmental matters – though they do remain central because of the integral role that natural capital occupies in opening up the possibility of economic development. Daly (1991) outlines what steps must be taken to label a set of practices and policies sustainable: rates of renewable resources use cannot exceed the rates of regeneration; the pace at which non-renewable resources are exhausted must not be faster than the rate at which renewable resources are developed; and pollution emissions must not be so overwhelming that they cause lasting and permanent harm to ecosystems or human health.

During the 1990s a revised understanding of sustainability emerged that sought to balance environmental concerns, issues of social equity, and economic growth. John Elkington (1998, 2002) coined the term “triple bottom line” to describe the appropriate purview of sustainability. The triple bottom line was originally meant to guide corporations as they sought to boost their sustainability. The triple bottom line thus focuses on the economic, environmental, and social value that is gained or lost by pursuing a set of practices or policies. Elkington targeted the private sector with his ideas, but they quickly took hold in governmental and institutional settings. For example, at the 2002 World Summit on Sustainable Development participants endorsed a vision of sustainability that stood on the three pillars of environment, economy, and society. The Johannesburg Declaration, which emerged from this conference, urged “a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development—economic development, social development and environmental protection—at local, national, regional, and global levels” (quoted in Kates et al. 2005). The triple bottom line served to counteract the reorientation of sustainability definitions that occurred following *Our Common Future* by highlighting that, while economic growth and development are needed, they cannot be neglected at the expense of other considerations.

The triple bottom line has become the dominant paradigm in institutional thinking about sustainability because avoiding questions of social justice and environmental protection (i.e. focusing only on economic sustainability) will lead to unsustainable policies. What remains to be seen is how well this approach encourages the implementation of sustainable policies across local, regional, and national scales. As Pawlowski (2008) writes, sustainable development has been driven mostly by stakeholders working at the local level to achieve the necessary buy-in. Sustainability is within reach at the local level, but it remains unclear whether policies oriented toward sustainability can be scaled up to have more far-reaching influence. This question may be unresolved, however, though the fact that sustainable policies have been most successful at local and state levels suggests transportation and infrastructure is a logical area in which to develop policy strategies to improve sustainability in a targeted manner. Even so, the daunting challenge for transportation planners is to adopt a flexible yet specific definition of sustainability that can translate into practical, actionable policies. Many agencies have used institutional definitions as a starting point to identify the attributes of sustainable roadways.

1.2 Green Infrastructure, Phase I & II

Research during Years 1 and 2 of this project produced two interim reports. Their content framed the final year of research and narrowed its focus. This document contains these reports in appendices – in their entirety. A brief summary of these reports follows.

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Phase I found State DOTs have latched onto the “triple bottom line” approach to operations. Examining a cross section of states revealed that many sustainability initiatives have been successful. The initiatives KTC researchers looked at targeted improvements in environmental and economic efficiency, whereas social considerations often received less attention. This is not to suggest, however, that all state DOTs found the same level of success with the “triple bottom line”. The ten state DOTs KTC studied only included those with recognized and stated commitments to enhancing infrastructure sustainability; but the level of commitment varied significantly among states. Although KYTC did not overtly express the aim of being more sustainable, many of its processes, policies, and practices yielded sustainable outcomes. This indicated that KYTC – through minor effort – had the opportunity to become a leader in sustainable transportation. The Phase I report recommended that KYTC move toward a sustainability initiative with a more comprehensive, in-depth research project and case study analysis to better identify other areas where sustainable initiatives can be implemented.

Phase II scrutinized a number of systems designed at the national and state level to measure roadway sustainability. Two systems were the primary focus: Greenroads and the FHWA’s INVEST tool. Phase II had three purposes: 1) familiarize readers with how ratings systems score sustainability; 2) discriminate between Greenroads and INVEST, with the aim of identifying their respective strengths and weaknesses; and 3) determine which system was appropriate to use to evaluate the sustainability of selected highway construction and maintenance projects in Kentucky. Although both rating systems have many similar features, and hew to similar definitions of sustainability, INVEST, KTC researchers concluded, provided a better option to score projects because of its flexibility. Unlike Greenroads, which primarily focuses on the design of Greenfield Construction, INVEST allows users to choose from a variety of scorecards depending on the scope of the project considered. Its customized scorecards give users the ability to score not only new construction or major rehabilitation projects, but also maintenance activities like resurfacing.

During Phase II, KTC developed a methodology to examine case studies using the INVEST system to highlight the sustainability of KYTC’s policies and practices. The Year 2 report outlined the required documentation to rate projects. The argument for scoring projects was twofold. First, researchers would determine whether a project qualified for a sustainability certification under the INVEST system. Second, scoring projects provided an opportunity to determine what kind of sustainable design and construction methods could be added to a project without introducing excessive costs. Phase II also involved the identification and selection of 14 newly completed road projects with the ultimate goal of scoring three to five. KTC researchers consulted with branch managers and the study advisory committee (SAC) to determine appropriate projects. After KTC developed an initial pool of candidates, the SAC prioritized the projects by ranking them. During the final phase of research, KTC researchers began at the top of this list and worked their way down until they had scored the targeted number of projects.

1.3 Green Infrastructure, Phase III

This report builds on the work completed during Years 1 and 2. While previous research focused mainly on the conceptual underpinnings of sustainability, ratings systems used to evaluate road sustainability, and initiatives emerging around the United States to increase the application of sustainability principles to the planning, design, and construction of highways, the current report provides a succinct assessment of three recently-completed projects in the Commonwealth of Kentucky and how well they incorporated strategies designed to bolster sustainability. Using the FHWA’s INVEST rating system as a baseline, this report qualitatively evaluates roadway sustainability. KTC researchers used a three-part methodology to

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accomplish this. First, they reviewed agency-wide guidance from KYTC, including manuals that inform project planning, design, and construction to identify what sustainability principles have been worked into its standard operating procedures. Pinpointing these policies up front expedited the project and let the KTC researchers focus their energies on the second and third methodological steps. The second part of this process entailed analyzing individual case studies to identify what design and implementation techniques unique to projects qualified as sustainable. To make this determination, KTC researchers examined project plans and other relevant documentation. Based on the first two parts of this method, they generated a preliminary INVEST rating for each project. To address lingering questions and validate INVEST scores, KTC conducted interviews with the KYTC district offices responsible for overseeing each project. These interviews were helpful because, while documentation revealed much of the information needed to make an accurate evaluation, knowledge gaps had to be filled in, and it was only by talking with officials involved with the projects that the research team could verify whether or not particular practices had been used. After working through these steps, researchers finalized the sustainability ratings for each project in accordance with the INVEST scoring guidelines. The scores for each project (see Chapter 3) reflect that KYTC already has a number of practices in place designed to enhance the road construction and maintenance sustainability. This report describes KTC's findings in an objective manner – although it advances recommendations that KYTC may want to consider to bolster roadway sustainability, they are not prescriptive, nor do they place into question the Cabinet's current practices.

1.3.1 Problem Statement

Currently there is no framework in place to evaluate the sustainability of infrastructure projects in Kentucky. Without a set of evaluation criteria used to assess the sustainability of roadway projects, the state cannot reliably determine whether transportation initiatives in fact achieve economic, environmental, and social sustainability. The Kentucky Transportation Cabinet aims to identify potential projects, either completed or in progress, that may qualify as sustainable using the sustainability standards identified by the Federal Highway Administration (FHWA), and rate their sustainability using the FHWA's assessment procedure.

1.3.1 Objectives

1. Review the concept of sustainability as it has been applied to environmental issues. Survey literature that focuses specifically on the extension of the sustainability concept to transportation/infrastructure projects to define what a sustainable highway is.
2. Distinguish between the assessment protocols of the FHWA Sustainable Highways Self-Evaluation Tool and Greenroads, a program established in Washington State that rates and certifies the sustainability of roadway projects.
3. Articulate the short- and long-term benefits of sustainable practices for transportation projects.
4. Evaluate 2-3 representative road projects in Kentucky using the FHWA Sustainable Highways Self-Evaluation Tool. Prepare a report summarizing the outcome of this assessment that discusses the results and determines the level of sustainability these projects achieve.
5. Determine whether Data Needs Analysis (DNA) Scoping Studies should be implemented on a statewide basis to evaluate the short- and long-term sustainability of roadway projects during their planning phase.

Chapter 2: Methodology

Chapter 2 – Methodology

2.1 INVEST Criteria

The FHWA released INVEST 1.0, a sustainability rating system for road projects, in October 2012 to help outside transportation project stakeholders, (e.g. state DOTs) improve highway sustainability. INVEST allows state DOTs to assess their current practices and policies to determine to what extent they are sustainable, identify additional measures and/or mitigation actions for potential use, and improve the overall state of sustainability of their transportation systems. Further, this tool lets state DOTs quantify benefits realized by implementing sustainability practices and subsequently evaluate any corresponding increases in performance over time.

The INVEST system consists of customized scorecards, each specific to road projects of different sizes and magnitudes. INVEST scorecards rate three project phases – System Planning, Project Development, and Operations & Maintenance. The Systems Planning module focuses on the entire system and lets stakeholders assess how changes or improvements potentially impact the overall transportation network. The Project Development module targets an individual project and examines its sustainability from project planning through the end of construction. Once a road project is completed, it requires some level of maintenance to keep it fully operational. As such, the Operations and Maintenance module appraises project sustainability from the completion of construction until the end of its lifecycle. Using this three-pronged approach, INVEST enables cradle-to-grave project planning. Similar to other rating systems, INVEST builds from the triple bottom line concept of sustainability, noting that “The goal of sustainability is the satisfaction of basic social and economic needs, both present and future, and the responsible use of natural resources, all while maintaining or improving the well-being of the environment on which life depends” (FHWA 2012). Sustainable highways, according to the FHWA, should also improve access to transportation, provide an efficient and dependable way to move people and goods, and give individuals a wide variety of transportation options. INVEST also goes beyond strictly focusing on “sustainable highways” themselves by incorporating multi-modal concepts into the tool’s framework, including the pedestrian, cyclist, and public transit dimensions.

INVEST aggregates a collection of sustainability best practices, presenting them to stakeholders in an easy-to-use format. Projects are awarded points for achieving specified sustainability benchmarks. Overall, INVEST includes 60 different criteria, divided into the three aforementioned phases, or modules. Modules have different target audiences and purposes. This report, however, is concerned with project development, which INVEST scores using 29 categories. Each of these categories is described further in Tables 1 and 2 and is listed in Appendix A.

Project scope and magnitude are important considerations with INVEST 1.0. Previous versions of INVEST utilized basic or extended scorecards; under this system, stakeholders were free to choose the appropriate scorecard for their project (with extended scorecards used to evaluate new construction projects while basic scorecards were used to evaluate minor repair and rehabilitation projects). However, with INVEST 1.0, stakeholders now have the option of choosing from among six different scorecards based on the nature of their project. Five of these have been designed by the FHWA, while a sixth custom scorecard gives stakeholders the leverage to score their projects if they do not fit into predefined categories. Table 2.4 lists the different types of projects INVEST is able to rate and contains brief descriptions of each.

Chapter 2: Methodology

Table 2.1.1 - INVEST 1.0 Scorecards

<i>Scorecard Option</i>	<i>Description</i>
Paving	Used on projects that are devoted exclusively to pavement preservation; restoration projects that extend the service life of existing facilities and enhance safety; or pavement restoration projects that restore pavement structure, ride quality, and spot safety. It can be used for projects in urban or rural locations.
Basic Rural	Used for small, rural reconstruction or rural bridge replacement projects that <i>do not</i> expand the capacity of the roadway.
Basic Urban	Used for small urban reconstruction or urban bridge replacement projects that do not expand capacity of the roadway.
Extended Rural	Used for rural projects for a new roadway facility; structure projects where nothing of its type currently exists; and major reconstruction projects that add travel lanes to an existing roadway or bridge.
Extended Urban	Used for urban projects for a new roadway facility; structure projects where nothing of its type currently exists; and major reconstruction projects that add travel lanes to an existing roadway or bridge.
Custom	Used for projects that do not fit any of the predefined scorecard options. This scorecard gives the user the ability to develop a unique set of criteria that is most appropriate for the project being evaluated. The Custom Scorecard starts with a core set of 19 criteria that must be included as part of the score. However, there are no achievement or “certification” levels associated with the custom scorecard.

Source: Federal Highway Administration, INVEST Compendium 1.0, 2012

Project scope dictates the type of module used. Each module is coupled with one of the scorecards (as shown above) and involves set criteria to use in follow-up scoring. As a result, projects are scored using varying criteria – fewer criteria are used to rate a paving project than Greenfield Construction, for example. Figure 2.1 lists the criteria used for each scorecard in the Project Development module. To take an example of how INVEST works, imagine a project requiring repaving or minor maintenance activities takes place on a road already in existence, which typically eliminates the need to pursue additional actions on matters such as historical preservation, vegetation composition, and habitat restoration, among others. In the past, project managers sometimes lacked sufficient resources to tackle these types of issues when the primary objective was merely to improve the existing roadway’s structural integrity and function without building an entirely new road. However, there are still methods project managers can use to improve road sustainability in these cases, such as repaving using warm-mix asphalt, which reduces air emissions, or relying on pavement that is formulated to have an extended lifecycle. To this end, one of the primary ways to increase sustainability for maintenance projects is to reduce the number of times a roadway needs to be repaved. Resurfacing pavements contributes to air pollution and requires large energy expenditures in the process. Taking action to reduce repaving frequency can increase a road’s sustainability.

Chapter 2: Methodology

Figure 2.1.1 - Summary of Criteria Used to Score Types of Road Projects

Project Development by Criteria Scorecard						
	Paving	Urban Basic	Urban Extended	Rural Basic	Rural Extended	Custom Core Criteria ¹
PD-1 Economic Analyses			✓		✓	
PD-2 Life-Cycle Cost Analyses	✓	✓	✓	✓	✓	✓
PD-3 Context Sensitive Project Development		✓	✓	✓	✓	✓
PD-4 Highway and Traffic Safety	✓	✓	✓	✓	✓	✓
PD-5 Educational Outreach	✓	✓	✓	✓	✓	✓
PD-6 Tracking Environmental Commitments	✓	✓	✓	✓	✓	✓
PD-7 Habitat Restoration		✓	✓	✓	✓	✓
PD-8 Stormwater		✓	✓	✓	✓	✓
PD-9 Ecological Connectivity			✓	✓	✓	
PD-10 Pedestrian Access		✓	✓			
PD-11 Bicycle Access		✓	✓			
PD-12 Transit & HOV Access		✓	✓			
PD-13 Freight Mobility			✓		✓	
PD-14 ITS for System Operations		✓	✓		✓	
PD-15 Historical, Archaeological, and Cultural Preservation		✓	✓	✓	✓	✓
PD-16 Scenic, Natural, or Recreational Qualities			✓	✓	✓	
PD-17 Energy Efficiency		✓	✓	✓	✓	✓
PD-18 Site Vegetation		✓	✓	✓	✓	✓
PD-19 Reduce and Reuse Materials	✓	✓	✓	✓	✓	✓
PD-20 Recycle Materials	✓	✓	✓	✓	✓	✓
PD-21 Earthwork Balance			✓		✓	
PD-22 Long Life Pavement Design	✓	✓	✓	✓	✓	✓
PD-23 Reduced Energy and Emissions in Pavement Materials	✓	✓	✓	✓	✓	✓
PD-24 Contractor Warranty	✓	✓	✓	✓	✓	✓
PD-25 Construction Environmental Training		✓	✓	✓	✓	✓
PD-26 Construction Equipment Emission Reduction	✓	✓	✓	✓	✓	✓
PD-27 Construction Noise Mitigation		✓	✓			
PD-28 Construction Quality Control Plan	✓	✓	✓	✓	✓	✓
PD-29 Construction Waste Management	✓	✓	✓	✓	✓	✓
Total Number of Criteria in Scorecard	12	24	29	21	25	19

1 – Indicates the core criteria that must be included in the custom scorecard. The user may choose as many additional criteria as desired.

Source: Federal Highway Administration, INVEST Compendium 1.0, 2012

INVEST rates the sustainability of projects based on the total number of points accumulated. Project stakeholders such as state DOTs can self-assess each of their projects and do not require a third-party to independently assess a project's sustainability, a feature of other sustainability rating systems. As such, users of INVEST enjoy the benefits of this tool with minimal external costs (i.e., no certification fee) while enjoying the flexibility of matching criteria against their known internal processes and procedures.

INVEST is concerned with guiding stakeholders through the process of deciding what sustainability practices might benefit them. Because it is entirely voluntary – with no possibility of outside award or certification – stakeholders can determine which practices fit their context. While stakeholders have the ability to informally score their projects, INVEST is a one-stop compendium that contains all of the construction and design practices that have proven sustainability benefits. It may

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potentially give Kentucky and other states a foundation to develop proprietary rating systems. These systems could then be used to score projects and encourage the use of sustainable practices; further, states could incentivize stakeholders if a particular rating level is achieved. Table 2.5 summarizes the different achievement levels specified by INVEST.

Table 2.1.2 - Achievement Levels for FHWA INVEST 1.0

<i>Achievement Level</i>	<i>Points Required</i>
Bronze	Earn at least 30% of total available points
Silver	Earn at least 40% of total available points
Gold	Earn at least 50% of total available points
Platinum	Earn at least 60% of total available points

Source: Federal Highway Administration, INVEST Compendium 1.0, 2012

To qualify as sustainable a project must earn at least 30 percent of total available points. Anything below this threshold constitutes an unsustainable highway project. As previously mentioned, all evaluation is informal and conducted by individuals directly involved with the project. INVEST is designed to prompt critical reflection from project managers about the sustainability of completed projects or those under design. It also provides a means of assessing various tradeoffs involved in the construction process. Achieving a perfect sustainability score is highly improbable because of the immense difficulty of ensuring that all criteria scores are maximized. For example, project planners may want to include pedestrian access and bicycle access in a new roadway project. However, they could discover there is simply not enough room available to accommodate both, forcing the planners to consider the costs and benefits of including one mode of transport in lieu of another. Deciding which option best meets the needs of the community, and the broader environmental and economic context, calls for decision-makers to sacrifice one element of sustainability to preserve another.

2.2 Selection of Case Studies

KTC researchers selected case studies by soliciting input from KYTC stakeholders. Once an initial list of prospective projects was in place, KTC used a tiered screening process to identify the three case studies chosen for analysis. At the beginning of Year 3, KTC researchers identified approximately 30 completed transportation projects across the state that had sustainable practices enfolded into their design and implementation. These projects warranted additional investigation through a more intensive study process. With this list in hand, KTC researchers asked for feedback from KYTC officials at the state and district level. When speaking with district-level personnel, KTC researchers explained the purpose of the research, provided them with the list of potential projects, and sought their opinion regarding which projects merited closer scrutiny. District officials were asked to consider INVEST criteria when suggesting projects. The end product of this work phase was a refined list of possible case studies.

After obtaining project recommendations, KTC provided the SAC with the final list. The SAC narrowed this list down to 13 viable candidates. SAC members ranked each project based on two considerations – 1) how effectively it included sustainable design features or construction practices, and 2) how easy it would prove for KTC researchers to obtain the documentation necessary to score it using the INVEST criteria. The second requirement was critical because, without the proper documentation or having the opportunity to interview staff responsible for project oversight, it would not be possible to objectively score projects. Once KTC had a final list that reflected the SAC members' priorities, we worked to identify the case studies.

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The projects selected for detailed INVEST scoring were: 1) the Double Crossover Diamond (Lexington), 2) E2RC Connector (Elizabethtown), and 3) 12th Street Reconstruction (Covington) (see Appendix B). SAC members ranked the Double Crossover Diamond at the top of their list. The E2RC Connector and 12th Street Reconstruction were each tied for third in the rankings. In addition to the SAC rankings, KTC researchers considered several other factors when choosing projects to score, namely spatial diversity and variety with respect to project type. Each project was constructed in different regions of the state (Districts 4, 6, and 7) and gave researchers the opportunity to use different scorecards. The Double Crossover Diamond used the Basic Urban scorecard; the E2RC used the Rural Extended scorecard, and the 12th Street Reconstruction let KTC take advantage of the Extended Urban scorecard. Although ranked second on the SAC members' list, the Newtown Pike Extension was not selected as a case study given that one of the projects already chosen, the Double Crossover Diamond, is located in District 7. Rating the Newtown Pike project would have entailed using the Extended Urban scorecard, however, the 12th Street project already served as a representative in this category.

It is important to keep in mind that KTC researchers focused on projects that deliberately incorporated some aspects of sustainability. Therefore, the goal of the research was not to evaluate a random sample of construction and maintenance projects in the Commonwealth of Kentucky. KTC did not omit projects based on speculation that they would perform poorly on the INVEST criteria. Once the evaluation process got underway, researchers scored the projects in an unbiased manner to ensure the final results reflected the current state of planning, design, and maintenance – and how well these phases take advantage of knowledge about sustainable highway development.

2.3 Analysis of Case Studies

Data analysis proved to be a complex task because, often, construction plans did not contain all of the information needed to score projects. Knowing that additional insights from KYTC officials would be needed, the research team developed a multi-dimensional approach to data collection and analysis. Early phases of this effort were thus focused on establishing a systematic methodology to score projects. On the one hand, this entailed adopting a wide lens to understand KYTC standards and practices that are implemented across all construction and maintenance projects. But on the other hand it also meant zooming into the scale of individual projects to identify unique design and building practices that were sustainable. By looking at Cabinet-wide standards and practices, the research team was able to construct a database of procedures that are necessarily included as part of all construction and maintenance projects. With this knowledge, researchers were able to determine under what criteria projects would qualify for points using the INVEST system. The research team drew information from KYTC's standard policy manuals and guidance, individual project documents (i.e. plans), and interviews with relevant staff at district offices. The purpose of these interviews was to assist researchers with scoring and validate findings; the interviews were also invaluable for collecting data not available in guidance or project documents. As specified by the INVEST criteria, interviewing stakeholders is an acceptable method to score projects when documents do not offer a clear indication of whether specific elements would qualify for sustainability points.

KYTC Policies & Manuals: Like most state transportation agencies, KYTC relies on standardized organizational practices and procedures to inform project planning, design, and construction. Many of these guidelines are contained in KYTC's policy manuals library. With this in mind, the research team sought out KYTC policy manuals and identified guidelines with the most relevance for sustainability and the purview of this study. By looking at policy manuals, the research team was able to determine what

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practices are implemented across *all* road maintenance and construction processes that are sustainable. Given that all the case studies focused on highway projects in urban and rural settings, KTC researchers focused on issues related to highways as well as pedestrian and bicycle usage. Highlighting, up front, guidelines that would earn points under the INVEST criteria reduced the amount of time researchers needed to spend investigating project-specific documents or talking with KYTC District Office staff. Issues left unresolved by the policy manuals served as a focal point during the follow-up investigations.

There are a number of manuals in use across different divisions of KYTC. Because this study is concerned with the INVEST Project Development module, the research team zeroed in on manuals and guidance that spoke directly to planning, design, and construction. Separate modules have been developed to analyze the sustainability of operations and maintenance. Although these are important for maintaining the sustainability of a road throughout its lifecycle, the research team did not score projects using these modules. Perhaps future research into the operations and maintenance of sustainability would offer a full profile of how KYTC implements sustainability practices across all phases of project development. But this remains beyond the scope of the current project.

The research team began its analysis by screening the KYTC Policy Manuals Library, which is accessible via KYTC's website (<http://transportation.ky.gov/Organizational-Resources/Pages/Policy-Manuals-Library.aspx>). During screening, researchers identified policy manuals that contributed to the design, planning, and construction phases of highway projects. Researchers also reviewed other portions of the KYTC website to access other supplemental standards, policies, and guidance that impact design and construction practices. Looking at these materials proved useful in pinpointing guidance going beyond the ambit of highways per se – a great deal of information on pedestrian and bicycle use was in this supplemental guidance.

After completing this search, the research team closely read policy manuals and supplemental materials to determine what aspects of sustainability related to the INVEST criteria were discussed in them. Most of the guidance including mentions of sustainability was found in a subset of policy manuals, including the KYTC Highway Design Manual, KYTC Drainage Manual, and the KYTC Pedestrian & Bicycle Travel Policy. Other policy manuals, guidance, and departmental websites also contributed to specific areas of sustainability and the overall analysis, however, they had limited impact – at least when compared to the aforementioned manuals. Table 2.6 (below) lists the policy manuals and guidance reviewed by KTC researchers. Appendix C summarizes the complete results of this investigation. Table C.1 highlights which policy manuals or guidance contains information that can be used to score INVEST criteria. Future efforts to assess the sustainability of highway projects can use Appendix C as a starting point to the macroscopic evaluation.

Table 2.3.1 – Review List of Policy Manuals & Guidance

Name	Date	KYTC Department
Permits Manual	Jun 2013	Division of Maintenance
Construction	Jan 2013	Division of Construction
Construction Procurement	Jan 2013	Division of Construction Procurement
Drainage Manual	Jan 2011	Division of Highway Design, Drainage Branch
Field Operations	Aug 2012	Division of Maintenance
Highway Design Manual	Jan 2006	Division of Highway Design
Maintenance	Feb 2012	Division of Maintenance
Pedestrian & Bicycle Travel Policy	Jul 2002	Division of Planning

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Traffic Operations	Jul 2013	Division of Traffic Operations
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Source: KYTC Policy Manuals Library

Preliminary Scoring: After conducting an agency-wide review of guidance and practices, the research team narrowed its focus to individual projects. Researchers developed a spreadsheet that listed the 29 criteria on the Project Development scorecard, arranging it to accommodate different levels of achievement. Each scoring column was labeled “Possible,” “Achieved,” or “Capable” – based on researchers’ assessment; numerical scores were assigned to each project component. Definitions for each of these categories follow:

Category	Description
Possible	The total number of points a project can earn for a given criterion
Achieved	The total number of points a project <i>actually earned</i> for a given criterion
Capable	The total number of points a project could achieve for a given criterion with modest additional investment. This would be on the order of 5-10% for the entire project.

For preliminary scoring, KTC researchers scrutinized project plans to identify sustainable design features, practices, or construction techniques that would fulfill different INVEST criteria. By examining project plans, the research team could determine what features of the project adopted sustainable components – like modified drainage systems, improved pedestrian and bicycle access, and vegetation planted to improve and restore habitat lost during construction. Not all of the preliminary scoring was validated by project plan or guidance manual review. Members of the project team additionally made contact with select KYTC employees who were knowledgeable in the details of programmatic processes not necessarily captured in guidance manuals. An example is pavement structure and its design life. These decisions are specific to sections within KYTC, and contact with those sections allowed for more accurate preliminary scoring.

A final source of information for preliminary scoring came from a project member’s previous work. One of the project team members had conducted a previous case study with KYTC using the Greenroads scoring metric (outside of this research project). The analysis of that project and corresponding notes also informed preliminary scores. However, all of these scores needed validation from the team that was responsible for designing and implementing the project.

Project Interviews: After obtaining preliminary scores for each project, KTC researchers contacted KYTC staff responsible for project implementation. Although the project documents often contained a wealth of information that let KTC researchers assign accurate scores, in some cases documents did not speak to specific criteria. The Double Crossover Diamond, E2RC, and 12th Street reconstruction projects came under the purview of Districts 7, 4, and 6, respectively. As such, KTC set up meetings with district staff to collect additional information. Because these interviews shed more light onto areas not illuminated by project documents, they proved invaluable for scoring each project. All interviews were conducted during the week of March 24-28, 2014. Researchers visited district offices and used a structured interview format during their conversations. Before these visits, KTC provided

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district staff with a list of questions likely to arise during the interview. By sending these questions out in advance, the research team hoped to give officials time to prepare for the interviews and locate additional documents or information that would improve its efforts to score projects. Appendix D contains a complete list of interview questions submitted to district staff.

Final Validation: Case study analysis wrapped up by validating and finalizing the project's findings. Each stage in the methodology – KYTC policy review, individual project review, stakeholder interviews – was instrumental for contextualizing the role that considerations about sustainability play in the planning, design, and implementation of highway projects. Interviews were a key component of validating the research team's preliminary scoring as it let them share findings with district staff and determine the accuracy of its findings. Also, the interviews helped fill information gaps left after the first round of analysis. In some cases, interviews merely reinforced the research team's findings, although there were several occasions where scores were significantly altered. Perhaps the areas interviews were most critical of were the social aspects of sustainability. Often it was not possible to unpack these elements of projects based on project documents alone. Mostly, the interviews provided key insights into the context-sensitive solutions used and public outreach efforts undertaken by project staff. Chapter 3 discusses each of the projects, their context, and the final INVEST score assigned by KTC researchers.

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3.1 Double Crossover Diamond (Lexington, KY)

Located at the intersection of Harrodsburg Road and New Circle Road, the Double Crossover Diamond has received national acclaim since it opened in 2011. The project, which aimed mainly to address safety concerns, incorporated features to enhance sustainability. Approximately 35,000 vehicles pass through this high-volume corridor daily. The previous road design consisted of a typical intersection, with two standard thru lanes running in opposite directions. Inbound (going in the direction of Lexington) traffic accessed New Circle Road using a single left-turn lane. However, this standard design resulted in a high numbers of traffic accidents, sparking concern among highway planners and safety officials. The accidents most frequently involved vehicles turning left onto the ramp of New Circle Road. Vehicles had to cut across two lanes of oncoming traffic to execute this maneuver. The interchange also experienced significant delays during rush hours, in part due to these turning arrangements. The motivation to do a redesign thus stemmed from the safety hazard and congestion imposed by the existing interchange. To address all concerns, KYTC officials sought to go beyond traditional intersection designs, proposing a solution that has been experimented with in a small number of cases throughout the country. The Double Crossover Diamond (DCD) interchange design was relatively new when KYTC officials decided to apply it to the New Circle-Harrodsburg interchange. The first DCD came online in 2009. The DCD makes simple yet sophisticated and significant changes to the geometric layout of the roadway. First, the DCD eliminates left-hand turns, which was the primary driver of high accident rates. Second, the modified design has worked to alleviate traffic congestion through the interchange. Figure 3.1.1 provides a visual representation of the DCD. Arrows indicate the path inbound vehicles take through the interchange. While traffic still enters New Circle Road by making a left-hand-turn, vehicles no longer have to traverse multiple lanes of oncoming traffic.

Figure 3.1.1 - Double Crossover Diamond Overview



Source: KYTC, US 68 Double Crossover Diamond Interchange Website

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With respect to sustainability, the INVEST criteria recognize that improving roadway safety enhances sustainability. To evaluate this project, the research team used the urban scorecard under the INVEST Project Development module. The project consisted of renovating and rebuilding an existing interchange located in an urban setting, which justifies using this scorecard. The project received high scores on the safety-related criteria, boosting its overall sustainability. It garnered high scores in a number of other areas as well. Throughout the planning and design phases, KYTC took every opportunity to involve the public. While this drove up scores for educational outreach, it also led to modest increase in scores related to context sensitive solutions. Public involvement was critical because the project led to a radical change in the geometric layout of roads – local residents, as such, needed to understand the changes being made, how they would work, and how traffic flows would be altered if the project was to roll out seamlessly. Another priority of project planners was to accommodate pedestrians and cyclists, which guided design choices, including the adoption of multi-use paths, median refuges, and ample lighting. The inclusion of multi-use paths offered another travel choice for pedestrians and cyclists throughout the community. Along with these features, the project implemented advanced Intelligent Transportation Systems (ITS) through the use of cameras that provide streaming video, the use of new and innovative signal systems, and novel data collection strategies. The intersection adopted CENTRACS Advanced Transportation Management System to collect data that help optimize traffic flow while also minimizing congestion through the interchange. Other criteria the project received points for included: tracking environmental commitments, planting onsite vegetation, reducing and reusing materials, and employing a long-life pavement design.

Using the methods outlined in Chapter 2, the research team concluded the project earned 38 points out of a possible 105. This qualifies the project for a Bronze rating under INVEST. Additionally, the research team identified other design and construction practices that, while not implemented, could have been added to the project with a modest increase in investment and effort to generate a higher score. These practices in some cases came from the study interviews when designers noted items that were feasible, would have added value, or even observed they should have been done. For the DCD a few examples include the following: 1) it was noted that adding a formal and covered stop for transit would have been a good addition in this location, 2) warm-mix asphalt was a consideration and could have easily been incorporated, and 3) improved treatment of runoff using grass-lined channels instead of concrete was also a consideration during design. It was noted that if sustainability was a project team goal, some of the design team decisions would have easily lead to additional credits. Had the project included these areas, it would have been able to earn a maximum score of 75 points, which equates to a Platinum rating. This demonstrates a higher rating is well within reach and that the planning, design, and construction practices used for the DCD, as they stand, are clearly sustainable. Table 3.1.1 summarizes the findings of this project evaluation.

Table 3.1.1 - Double Crossover Diamond Scorecard

INVEST Basic Urban Scorecard	Bronze	Silver	Gold	Platinum
Minimum Score Required:	32	42	53	63
INVEST Maximum Possible:	105		Project Score Capable:	75
Project Score	38		Assigned INVEST	Bronze

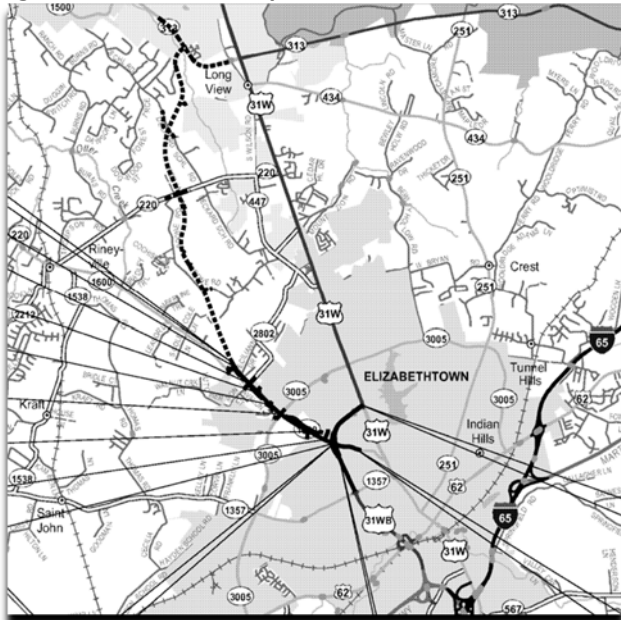
Achieved:			Rating:	
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Source: Kentucky Transportation Center, 2014

3.2 Elizabethtown to Radcliff Connector (E2RC)

The Elizabethtown to Radcliff Connector (E2RC) is an interchange connecting US 31 W to KY 313. It was designed to relieve congestion in an area that has undergone rapid growth and development. The project also reconstructed a one-mile stretch of KY 1600 and installed a new alignment at its junction with KY 313, near Radcliff. Figure 3.2.1 depicts the layout of the connector, which runs nearly parallel to the existing US 31 W.

Figure 3.2.1 - E2RC Map



Source: KYTC Project Plans, 2011

The only rural project in this study, the E2RC runs through sparsely populated areas and large tracts of agricultural land. One concern designers had to address was excess stormwater runoff, which can be problematic in areas that are sparsely vegetated. To accommodate potentially high levels of runoff, the project planners incorporated a grass-lined channel running alongside the roadway. The purpose of the channel is to enhance infiltration rates and prevent water from ponding on the road. Because of this, the project merited four points under INVEST's *Stormwater* category. Before construction, planners also analyzed corridor options and selected a path that would minimize disturbance to historically significant properties in the area. This mitigation contributed to the project receiving two points in the *Historical, Archaeological, and Cultural Preservation* category. Several advanced ITS solutions were incorporated to the project as well, including emergency signal preemption capabilities and an emergency passer-by warning system. The latter was located at a fire station along the E2RC. The project scored well in other areas as well. Included among these are: context sensitive design, educational outreach, tracking environmental commitments, site vegetation, reduce/reuse materials, and long-life pavement design. Using the INVEST's extended rural scorecard, the E2RC project received 35 points out of a possible 115. With this score, the project attained a Bronze rating. Further, KTC researchers identified a number of other opportunities for improving this score. Although not

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implemented, they could have significantly raised the score (up to 79 points) with modest additional investment. Examples of these areas included criteria such as highway safety studies (pre- and post) and using crash analysis as design criteria, adding pedestrian and bicycle access. The design team members commented that lifecycle cost analysis for the storm water system would have been a valuable addition as well. Table 3.2.1 contains summary information from the E2RC scorecard.

Table 3.2.1 – E2RC Scorecard

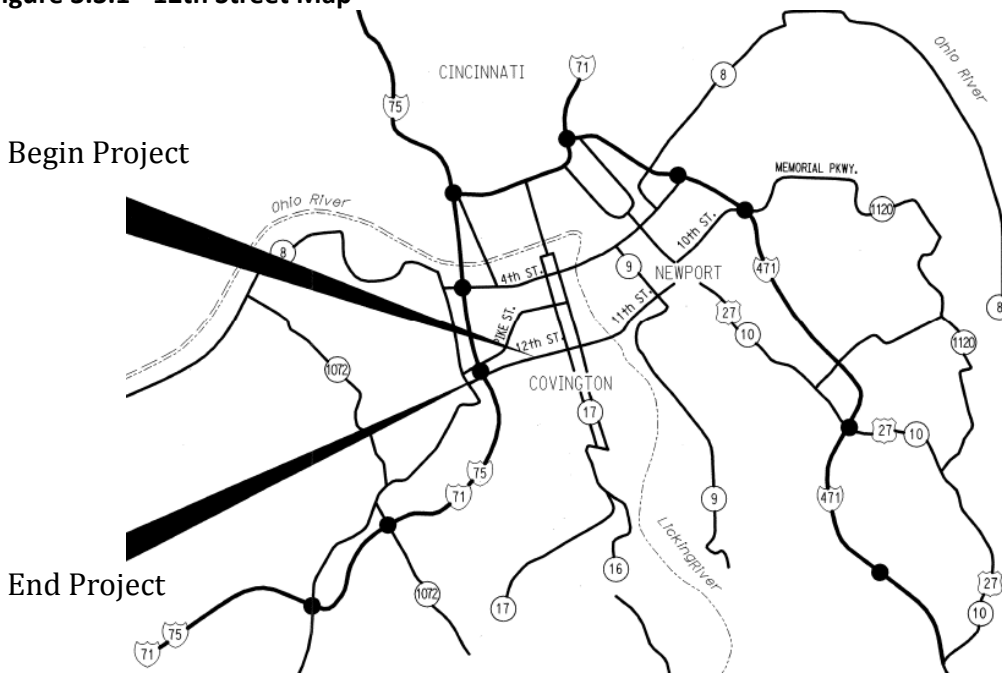
INVEST Extended Rural Scorecard	Bronze	Silver	Gold	Platinum
Minimum Score Required:	35	46	58	69
INVEST Maximum Possible:	115		Project Score Capable:	79
Project Score Achieved:	35		Assigned INVEST Rating:	Bronze

Source: Kentucky Transportation Center, 2014

3.3 12th Street Reconstruction (Covington, KY)

First surveyed in the 1880's, 12th Street is an east-west arterial that connects Covington to Newport. Northern Kentucky is undergoing rapid growth, and this road has experienced rising levels of traffic due to its intersection with Interstates 71 and 75. Reconstructing 12th Street entailed updating the non-functional street geometry. This involved building two 12-foot lanes along with curbs, gutters, sidewalks, and installing context sensitive landscaping. Planners also sought to preserve the historical ambience of the adjacent neighborhood. Discussions about reconstructing 12th Street began in the 1980's. Since then, the amount of traffic using the arterial has nearly tripled. Being connected to Interstate 75, the road also receives significant volumes of freight traffic. As such, the narrow lanes that characterized the original street – which also supported on-street parking – made vehicle accidents involving large tractor-trailers a common occurrence. Improving the safety of 12th Street was a primary consideration when planners retooled the road. Figure D depicts the portion of 12th Street redeveloped by this project.

Figure 3.3.1 - 12th Street Map



Source: KYTC Project Plans, 2009

Although first conceived in the 1980's, numerous delays beset the 12th Street reconstruction, and it was not completed until 2012. Many of the delays resulted from the large number of historic properties located in the construction zone; high-profile stakeholders also expressed competing viewpoints on the project, adding to the slowdown. To execute the planning, design, and implementation, KYTC partnered with key stakeholders and organizations, including the City of Covington, the FHWA, the Kentucky Heritage Council, and local homeowners. These efforts yielded high scores for context sensitive design; educational outreach; and historical, archaeological and cultural preservation. In addition to the historic preservation achieved by the project, it also dramatically improved freight movement. It received four points in two categories related to this – *Safety and Freight Mobility*. These high marks indicate the project met one of its key objectives. KYTC also used innovative strategies to manage stormwater. A highlight of the reconstructed road is that 100% of surface water runoff is treated; on-street planter boxes contribute to this (Figure 3.3.2). For these efforts, the project was awarded five points for stormwater management. Some of the other areas in which the 12th Street reconstruction excelled are: tracking environmental commitments, pedestrian and bicycle access, site vegetation, reducing/reusing materials, and opting for a long-life pavement design.

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Figure 3.3.2 - Historic Properties (L) & Planter Box (R)



Source: Federal Highway Administration, 2011

The research team used the extended urban scorecard to assess the 12th Street reconstruction. Overall, the project earned 38 points out of a possible 126. As with the other projects evaluated, this was sufficient for it to achieve a Bronze rating. With respect to project-capable points, KTC researchers have estimated the reconstruction could have netted up to 79 total points with some additional investments. Some areas in which sustainability could be improved at a reasonable cost include: documenting that concrete and cement supplied for the project was energy star compliant and requiring contractors to provide noise mitigation and quality control plans. Table 3.3.1 summarizes the 12th Street reconstruction scorecard.

Table 3.3.1 - 12th Street Reconstruction Scorecard

INVEST Extended Urban Scorecard	Bronze	Silver	Gold	Platinum
Minimum Score Required:	38	50	63	76
INVEST Maximum Possible:	126		Project Score Capable:	79
Project Score Achieved:	39		Assigned INVEST Rating:	Bronze

Source: Kentucky Transportation Center, 2014

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4 Conclusions and Recommendations

Calls to enhance the sustainability of planning, design, and implementation of road construction and maintenance projects have grown louder over the past 10 years. As this movement gains momentum, it is likely more states will seek out economic strategies to bolster the sustainability of transportation operations. While this makes sense from a financial standpoint, it will also produce social and environmental benefits difficult to calculate in purely monetary terms. Indeed, a number of states, in addition to devising new design and implementation practices, have developed proprietary rating systems that let officials impartially evaluate what level of sustainability their highway projects are achieving. Currently there is no movement at either the state or federal levels of government to legislatively mandate the use of more sustainable practices at DOTs. Whether this current thinking about sustainability holds is, at the moment, uncertain. As the effects of climate change, habitat loss, and land use/land cover changes compound, many states could introduce measures designed to reduce the environmental footprint of transportation-related projects. For now, this conjecture remains a mere possibility. However, it is worth reflecting on the current state of policies and guidelines that inform phases of project development and where sustainable principles fit in. This three-year study has scrutinized not just the theoretical and empirical lenses we use to understand sustainability within the context of highway maintenance and construction, but how successfully the Commonwealth of Kentucky has integrated sustainability into its current practices.

As outlined in Chapter 3, the case studies examined in this project – the Double Crossover Diamond in Lexington, the Elizabethtown to Radcliff Connector, and the 12th Street reconstruction in Covington – all performed well on the criteria used by INVEST to rate sustainability. Each project merited a Bronze rating. This reflects positively on the guidance and procedures used agency-wide at KYTC as well as the district-specific practices adopted for individual projects. There was no single area in which all of the projects excelled. As might be expected, context matters, and projects accumulated points under myriad criteria. The KTC research team observed that a Platinum rating was within reach for all the projects had modest additional investments been made upfront, which raises numerous questions. If KYTC wants to use the INVEST rating system with increased regularity to guide decision making, arguably it would need to develop an appropriate method of cost-benefit analysis that would let state officials and district staff determine what kind of investments are appropriate and will produce the greatest returns over the short- and long-term. Weighing costs and benefits versus the level of sustainability achieved is essential to consider – if significant cost increases yield a small bump in the sustainability rating, deepening the financial investment may not be warranted. An appropriate cost-benefit method would let KYTC personnel quantify the initial costs and the sustainability benefits a project would enjoy throughout its lifecycle. True, this does foreground the issue of finances, however in an era of tightening budgets it is imperative to look at projects from a monetary standpoint. Current practices suggest that KYTC has been proactive in pursuing ambitious sustainability standards at a reasonable cost. But what a cost-benefit analysis reveals is what sacrifices must be made to introduce more sustainable practices to a specific project. It is clearly not worth the tradeoff if being more sustainable would introduce financial obstacles insurmountable, preventing Kentucky from tackling other critical infrastructure projects. A proper balance is achievable, but understanding where this lies would require expanded research efforts and significant input from the Cabinet.

Another possibility, moving forward, is to look beyond INVEST. While general sustainability principles can be applied to a range of transportation projects, often sustainability is context sensitive. To think beyond INVEST would mean reflecting on what sustainability means for Kentucky, and how that idea may change from region to region. Potentially, Kentucky could follow the lead of states like Illinois

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and develop a proprietary scoring and certification system geared toward the Commonwealth. Creating this system would begin by closely studying what aspects of the INVEST approach work for Kentucky. The purpose of this analysis would be to identify either missing elements or criteria that are not relevant for Kentucky. Based on the Year 2 report, which briefly looked at state-based ratings systems, many of them overlap with one another in terms of their criteria. But differences are present, indicating that it is reasonable to tailor a rating system to the needs and geography of a particular state. Developing a new system would be a significant undertaking, but it is one that could offer benefits well into the future. Ideally, a new rating system would be the joint product of KYTC and an outside research agency – having an external organization assist with development would ensure the final rating system balances objectivity with a context-sensitive approach to the problem. Questions remain over how such a system would be administered and who would be responsible for evaluating projects. Solutions to these problems, however, would certainly emerge during system development, if that occurred. For now, it is worth reiterating that – as exemplified by the case studies presented here – Kentucky appears to be ahead of the curve on putting sustainability into practice on road construction and road maintenance projects.

Appendix A – INVEST Criteria

Table A.1 - INVEST Criteria and Required Documentation

Component	Component Description	Documentation Sources
PD-1	Economic Analyses	Results of a benefit-cost analysis or economic impact analysis, including: <ol style="list-style-type: none"> 1. Documentation of techniques used 2. Underlying assumptions of economic models
PD-2	Life-Cycle Cost Analyses	Any One of these three sources: <ol style="list-style-type: none"> 1. Calculations used for the LCCA – must include summary of inputs/outputs 2. Copy of the owner-agency policy on LCCA 3. Calculations for LCCA performed as part of a pavement management system to set best practices for pavement design
PD-3	Context Sensitive Project Design	Any documentation of CSS principles (or equivalent processes) used on the project
PD-4	Highway and Traffic Safety	One or More of the following sources: <ol style="list-style-type: none"> 1. Documentation of human factors considered during project development 2. Documentation of an RSA 3. Documentation of the project scoping process – must include data analysis describing how the existing facility’s safety performance was used to make project improvements 4. Documentation (project reports, technical memos) that show the application of HSM-quality evaluations of the project and alternatives considered 5. Design exception review and evaluation reports approved by the relevant agency – must include <i>quantitative</i> estimates of the expected safety performance of the design exception, specific mitigation measures, and <i>quantitative</i> estimates of safety performance resulting from proposed mitigation measures 6. Documentation that evaluates the project post-completion, which includes crash data from before and after implementation – must use advanced statistical methods that account for RTM
PD-5	Educational Outreach	One or more of the following criteria: <ol style="list-style-type: none"> 1. Public outreach materials that describe sustainability features incorporated into the project. 2. Brochures or other printed information that has been made publicly available 3. Website addresses and/or screen captures of the sites describing project sustainability

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		<ol style="list-style-type: none"> An agency guide, specification, or policy Copies of school or professional presentations and the date of the presentations
PD-6	Tracking Environmental Performance	<p>Both of these sources:</p> <ol style="list-style-type: none"> Documentation of environmental tracking system – must include instructions on what is included, and chains of documentation flows through different project phases Contract documents requiring contractors to assign an <i>independent</i> environmental compliance manager
PD-7	Habitat Restoration	<p>One of the following sources:</p> <ol style="list-style-type: none"> Contract documents that: a) measure baseline site conditions, and b) ecological improvements made during construction Technical reports or permitting documents that outline which species will benefit from site improvements Technical reports describing how impacts to habitat were minimized during the project development
PD-8	Stormwater	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> Project drainage report or other relevant calculations/studies Project contract documents
PD-9	Ecological Connectivity	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> Ecological study framed using NEPA documentation State permitting documents that includes consideration of ecological connectivity Contract documents illustrating improvements in wildlife crossings Documents attesting that efforts to minimize ecological impacts have been taken throughout the project development process
PD-10	Pedestrian Access	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> Planning documents that address pedestrian access, and how it fits with existing land uses and/or existing General and Transportation Plans Results of public input on proposed pedestrian facilities Contract documents illustrating enhancement of pedestrian access
PD-11	Bicycle Access	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> Documents addressing bicycle access within the project, how it fits with existing land uses and/or General and Transportation Plans, project analysis,

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		<ul style="list-style-type: none"> or a Bicycle Master planning process 2. Results of public input on proposed bicycle facilities 3. Contract of contract specifications and plans for proposed bicycle facilities 4. Total costs for new/improved bicycle facilities
PD-12	Transit and HOV Access	<p>One or more of the following sources:</p> <ul style="list-style-type: none"> 1. Description of purpose and need for HOV access on the project 2. Total costs to install new HOV facilities or upgrade current ones 3. Contract specifications and budget items that address transit and HOV
PD-13	Freight Mobility	<p>One or more of the following sources:</p> <ul style="list-style-type: none"> 1. Description of the purpose and need for freight access on the road project 2. Results of public input on proposed freight upgrades or installations 3. Contract documents showing freight facilities
PD-14	ITS for Systems Operations	<p>One or more of the following sources:</p> <ul style="list-style-type: none"> 1. Listing of ITS applications and their corresponding categories 2. Contract documents listing ITS applications that will be installed on the project 3. Photos or other documentation providing evidence of installed applications
PD-15	Historical, Archaeological, and Cultural Preservation	<p>One or more of the following sources:</p> <ul style="list-style-type: none"> 1. Documents showing the resource or location is eligible for the U.S. NRHP 2. Documents of relevant organizations indicating what tribal or other interests will be represented 3. Description of project features and policies that minimize adverse effects, in accordance with Sec. 106 of NHPA 4. Description of activities used to avoid impacts, improve, or enhance features
PD-16	Scenic, Natural, or Recreational Qualities	<p>One or more of the following sources:</p> <ul style="list-style-type: none"> 1. Documentation of national, State, or Indian tribe designation if byway designation is used to satisfy this requirement 2. Other documents showing the scenic, natural, or recreational values of the project 3. Contract documents illustrating where roadside access points are located, or other protection, preservation, or enhancement actions taken 4. Description of how impacts were minimized on the project site 5. Description of activities used to avoid impacts, improve, or enhance features
PD-17	Energy Efficiency	<p>One or more of the following sources:</p> <ul style="list-style-type: none"> 1. Documented energy usage evaluation and reduction plan

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		<ol style="list-style-type: none"> 2. Calculations documenting the amount of energy that would be used if the project was to be constructed with high-pressure sodium fixture, the expected energy usage after incorporating design improvements, and resulting energy savings 3. Contract documents and/or cut sheets of luminaires installed on the project 4. Sample cut sheets <i>and</i> specifications for each technology installed on the project showing expected wattage generated by each component 5. Documents for plans to audit energy use following construction
PD-18	Site Vegetation	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> 1. Vegetation or landscape plan that shows type, size, and location of all plant species 2. Specification sections relating to site vegetation 3. Copy of the policies or procedures used to select plan species 4. Design study report conducted by an appropriate agency that analyzes existing site vegetation, impacts, reuse of vegetation, references to assess invasive species, and planned vegetation species
PD-19	Reduce and Reuse Materials	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> 1. Calculations that show the remaining service life of pavements or bridges before and after the expected projects; there should be a clear demonstration that treatments applied will extend its service life 2. Calculation of the percentage of pavement area treated, which includes new and existing pavement 3. Approved mix design for pavement materials
PD-20	Recycle Materials	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> 1. Calculations showing the computed percentage of pavement and/or structural material recycled 2. Calculation of the percentage of pavement area recycled in-place 3. Calculation that shows the percentage of luminaires, signal poles, and sign structures reused
PD-21	Earthwork Balance	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> 1. A grading plan that reports <i>total</i> cut and fill quantities and <i>total</i> miscellaneous cut and fill quantities 2. Inspector or contractor's actual construction earthwork volumes or the project; this includes actual cut and fill, volume of unused embankment

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		materials, and the volume of material imported and exported to a site
PD-22	Long-Life Pavement Design	One or more of the following sources: <ol style="list-style-type: none"> 1. Calculations that demonstrate the total percentage of <i>trafficked</i> lane pavement surface areas with long-life designs 2. The recognized, adopted and documented pavement design procedure 3. Documents illustrating pavement was designed using a minimum 20- or 40-year service life
PD-23	Reduced Energy and Emissions in Pavement Materials	One or more of the following sources: <ol style="list-style-type: none"> 1. Calculations showing at least 50 percent of total project pavement material meets threshold criteria 2. Asphalt or concrete mix designs showing design criteria were met 3. Documents from the cement production facility, asphalt plant, or concrete mixing plant that provide evidence requirements were met
PD-24	Contractor Warranty	The following documentation sources: <ol style="list-style-type: none"> 1. Contract documents that include details of warranty
PD-25	Construction Environmental Training	One or more of the following sources: <ol style="list-style-type: none"> 1. Contractor documents demonstrating an Environmental Awareness Training Plan is required of project personnel 2. Contents of the Environmental Awareness Training Plan
PD-26	Construction Equipment Emissions Reduction	One or more of the following sources: <ol style="list-style-type: none"> 1. Signed letter from the prime contractor indicating that the total non-road construction fleet operating hours and the percentage of the operating hours meet one of the three specified criteria 2. Provide a list of all non-road construction equipment used on the project; the list should contain: a) the make and model of each piece of equipment; and b) operating hours associated with the project 3. Documents stating the contractor implemented a no-idling policy
PD-27	Construction Noise Mitigation	One or more of the following sources: <ol style="list-style-type: none"> 1. Contract documents specifying contractors develop a noise mitigation and/or monitor noise during construction 2. A copy of the noise mitigation plan 3. Relevant noise permits, or agency or local authority noise policies
PD-28	Construction Quality Control Plan	One or more of the following sources: <ol style="list-style-type: none"> 1. Contract document specifications requiring contractors to develop and

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		implement a project-specific Quality Control Plan 2. Contract document specifications requiring quality price adjustment clauses
PD-29	Construction Waste Management Plan	One or more of the following sources: 1. Contract documents requiring contractors to develop and implement a project-specific construction waste management plan (or its functional equivalent) 2. Documents showing when (including quantities) construction materials were diverted from landfills. This includes trucking tickets with weights, destinations, materials, and calculations of percentages diverted from landfills

Table A.2 - Brief Descriptions of INVEST Criteria

- 1) Economic Analysis (2- 5p) – *Cost benefit analysis* (including non-monetary transactions) and/or *economic impact analysis* (including indirect economic effects).
- 2) Life-Cycle Cost Analyses (1- 3p) – Perform LCCA on pavement structures, stormwater infrastructure, and/ or major features (i.e. bridges, tunnels, etc.).
- 3) Context Sensitive Project Development (1- 5p) – Use CSS guidelines for planning and training, including a multidisciplinary approach and cooperation with stakeholders.
- 4) Highway and Traffic Safety (1- 10p) – Use *Road Safety Audits* (RSA) and quantitative models to evaluate projects for safety; additional points for public awareness campaigns and post-implementation monitoring.
- 5) Educational Outreach (2p) – Promote public awareness of and involvement in sustainability features of project through point-of-interest displays, websites, stakeholder guides, and school and professional presentations.
- 6) Tracking Environmental Commitments (2- 5p) – Document environmental commitments during project and keep track of them throughout and after completion; have independent environmental compliance monitor reporting directly to regulatory agencies.
- 7) Habitat Restoration (1- 3p) – Demonstrate that project alignment and/or cross section was modified to minimize or avoid habitat impacts; implement habitat restoration projects, even if impacted species *not* on endangered species list.
- 8) Stormwater (1- 9p) - Manage water runoff on project site by using BMPs (Best Management Practices) to treat 80 percent plus for pollution; and controlling 80 percent plus of flow.
- 9) Ecological Connectivity (1- 3p) –Provide wildlife access across roadways, provide wildlife crossing structures on new alignments; assess and if necessary upgrade existing alignments.
- 10) Pedestrian Access (1- 2p) – Create or upgrade pedestrian facilities for safety, comfort, connectivity, and (optionally) aesthetic/social amenities.
- 11) Bicycle Access (1- 2p) – Create or upgrade bicycle facilities for safety, connectivity, aesthetics, convenience, and comfort.
- 12) Transit and HOV Access (1- 5p) - Promote public transit and HOV (high occupancy vehicle) by upgrading transit stations, signage, and park & ride lots; implement use privileges on roadways (i.e., car pool lanes)
- 13) Freight Mobility (1- 7p) - Improve safety, efficiency, and impacts of freight through regulations such as non-idling policies; expansion of rest area (especially electrified), delivery parking, and truck-only lanes; improvement of road design; and automated and virtual weigh-in-motion stations.

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- 14) ITS for System Operations (1- 5p) – Implement one or more ITS (Intelligent Transportation System) applications from a list of 15 categories (electronics payments/pricing, emergency management, enforcement, information dissemination, information management, ITS infrastructure backbone, lane management, ramp control, response and treatment, road weather management, surveillance, traffic control, traffic incident management, traveler information, warning systems).
- 15) Historical, Archaeological and Cultural Preservation (1- 3p) - document and protect historical or cultural assets, and promote public access.
- 16) Scenic, Natural or Recreational Qualities (1- 3p) – Provide access and stoppage for scenic or recreational spots along project route.
- 17) Energy Efficiency (1- 8p) – Reduce energy consumed by reducing lighting, installing energy-efficient fixtures, and/or using renewable power sources.
- 18) Site Vegetation (1- 3p) – Plant low-maintenance (i.e. not requiring mowing or mechanical irrigation), preferably native species for on-site vegetation.
- 19) Reduce and Reuse Materials (1- 8p) – Extend pavement service life; reduce amount of new pavement materials needed by incorporating portions of old pavement structures; preserve or retrofit existing bridges; repurpose rather than dismantle old pavement structures; and/or reuse industrial byproducts in new roadway elements.
- 20) Recycle Materials (1- 8p) – Use recycled asphalt or concrete in new pavement, granular base course, and/or embankments; recycle in-place pavement; and/or reincorporate old minor structure elements (i.e. lights, signs, and poles).
- 21) Earthwork Balance (1- 3p) - use as much cut (excavated) earthen material from project as possible for fill (embankment) material on same project.
- 22) Long-Life Pavement Design (5p) - 75 percent plus of new or reconstructed pavement meets approved design requirements to last 40 or more years.
- 23) Reduced Energy and Emissions in Pavement Materials (3p) – 50 percent or more of pavement material must be manufactured using low-energy processes (warm mix asphalt, Energy Star certified cement production, and various other certified standards).
- 24) Contractor Warranty (1- 3p) – Require 3- 5 year warranties from construction contractor.
- 25) Construction and Environmental Training (1p) – Require contractor to provide environmental awareness training for project personnel.
- 26) Construction Equipment Emission Reduction (1- 2p) – Use non-road construction equipment that meets EPA engine emission standards and/or have diesel retrofit devices for after-treatment of pollution; implement no-idling policy; and/or use larger non-road earthwork-hauling vehicles.
- 27) Construction Noise Mitigation (1- 2p) – Require contractor to have and to monitor NMP (noise mitigation plan).

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28) Construction Quality Control Plan (2- 5p) – Require contractor to have formal plan; use Quality Price Adjustment Clauses to link contractor payment to future performance of project.

29) Construction Waste Management (1- 3p) – Require contractor to have formal Construction Waste Management Plan (CWMP); divert 50- 75 percent of construction waste from landfills.

Appendix B – KYTC Project Consideration List

Table B.1 - KYTC Projects for Sustainability Evaluation and Project Ranking

<i>KYTC Item Number</i>	<i>Project Type</i>	<i>Project Name</i>	<i>Construction Estimate</i>	<i>Project Description</i>	<i>Potential Credit Alignment</i>	<i>Avg</i>
7-144.01	Major Widening	Double Crossover Diamond	\$6,237,711	Widen Harrodsburg Road at New Circle Road from Corporate Drive to Alexandria Drive by increasing capacity under the NCR bridges and intersection improvements.	PD4, PD10, PD11, and others	1.67
7-593.XX	New Route	Newtown Pike Extension	Not Available	Newtown Pike Extension from West Main St. to South Limestone St. in Lexington.	Various	4.33
4-8103.10	New Route	E2RC Section #1	\$32,796,400	New Connector Road, Section 1: From Elizabethtown Bypass to Cecilianna Drive including interchange with Elizabethtown Bypass.	PD2, PD5, PD6, PD8, PD10, PD11, PD15	5
5-397	Safety	Eastern Parkway	\$3,617,001	Traffic and safety improvements for the Eastern Parkway corridor near Third Street.	PD3, PD4, PD10, PD11, PD12, PD14	5
6-273	Major Widening	12th Street Widening in Covington	\$15,500,000	Reconstruct 12 th Street from Interstate 75 to Scott Street (ARRA).	PD10, PD11, and others	5
12-296	Major Widening	US 114 Middle Creek Battlefield	\$17,484,583	Salysersville-Prestonsburg; Mountain Parkway extension from 0.7 miles west of KY-404 to US-23.	PD3, PD15, PD16	7.33
3-110.00	Reconstruction	Warren County KY 185 Reconstruction	\$48,670,000	Reconstruct KY-185 from north of the junction with KY-263 near Richardsville (MP 6.29) to the Butler County line (MP 11.913).	PD7, PD15, PD21	7.67
7-####	"Road Diet"	US 25 Georgetown	Not Available	No Notes Available	PD10, PD11	7.67
4-154.00	Congestion Mitigation	US 31W/KY 313 Access Management	\$6,240,000	Operational Improvements on US-31W to improve the traffic flow.	PD2, PD4, PD5, PD8, PD19	8
5-####	"Road Diet"	US 42 Brownsboro	Not Available	No Notes Available.	PD3, PD10, PD21	9
12-####	"Road Diet"	Prestonsburg	Not Available	No Notes Available.	Various	9.67
5-####	"Road Diet"	US 60/2nd Street Frankfort	Not Available	No Notes Available.	Various	10
4-8103.50	New Route	KY 313 to Bullion Connector	\$11,450,000	New Connector from Veteran's Parkway (KY 1646) to KY-313.	PD2, PD6, PD8, PD19	10.7

Appendix C – Summary of KYTC Policy Manuals & Guidance

Table C.1 - Summary of KYTC Policy Manuals & Guidance

INVEST Requirements		Preliminary Notes on KYTC Policy Manuals	Achieved
PD-1	Economic Analysis	The two components of economic analysis, Benefit-Cost Analysis & Economic Impact Analysis, are not discussed anywhere within the Highway Design Manual (HDM) or other policy manuals.	No
PD-2	Life-Cycle Cost Analyses (LCCA)	The Pavement LCCA is discussed on pgs. 30, 60, 365 within HDM. Stormwater & Major Feature LCCA's are not mentioned within HDM or Drainage Manuals.	Yes - Partial
PD-3	Context Sensitive Project Development	Context Sensitive Design is briefly mentioned on pg. 18 of the HDM and not mentioned anywhere within other policy manuals.	Yes - Partial
PD-4	Highway and Traffic Safety	The HDM has several mentions of safety including pgs. 38, 65, 326, 330, 333, and 356. However, it does not discuss the quantitative analyses discussed in INVEST. Each case study will have to be examined on safety factors examined.	No
PD-5	Educational Outreach	KYTC conducts public hearings and utilizes outreach media as shown on HDM, pg. 293. However, it does not discuss all the components required by the INVEST sub-criteria.	Yes - Partial
PD-6	Tracking Environmental Commitments	Nothing listed within HDM (Environmental Considerations chapter) or the Division of Environmental Analyses website on these requirements.	No
PD-7	Habitat Restoration	Nothing listed within HDM (Environmental Considerations chapter) or the Division of Environmental Analyses website on these requirements.	No
PD-8	Stormwater	INVEST requires analysis of the following factors: Water Quality-Runoff, Flow Control, and Effective BMP's. The Drainage Manual (DR 200) discusses these 3 factors to varying degrees on pg 8, pg 5, and pg's 5/8/13, respectively.	Yes - Majority
PD-9	Ecological Connectivity	The HDM discusses many of these sub-criteria to include minimization of impacts (pg 122, 238), avoid impacts (pg 237), enhance features (pg 385), and restore features (pg 240).	Yes - Partial
PD-10	Pedestrian Access	The KYTC addresses pedestrian access on its HDM (pgs. 309-310, 338-339, 350) as well as its "Pedestrian and Bicycle Travel Policy" manual.	Yes - Majority
PD-11	Bicycle Access	The KYTC addresses bicycle access on its HDM (pg 350, 437-440) as well as its "Pedestrian and Bicycle Travel Policy" manual.	Yes - Majority
PD-12	Transit & HOV Access	The HDM does not discuss transit or HOV access as it relates to these criteria.	No
PD-13	Freight Mobility	The HDM does not discuss Freight Mobility as it relates to these criteria.	No
PD-14	ITS for System Operations	The HDM does not discuss most of these criteria although KYTC does employ a 511 system for traveler information.	Yes - Partial

Appendix C – Summary of KYTC Policy Manuals & Guidance

PD-15	Historical, Archaeological, and Cultural Preservation	The HDM, pg. 236 discusses these criteria as well as the KYTC, Division of Environmental Analysis website at "Cultural Historic" and "Archaeology".	Yes - Majority
PD-16	Scenic, Natural, or Recreational Qualities	The HDM does not discuss any of these criteria to any detail.	No
PD-17	Energy Efficiency	The HDM does not discuss this but KYTC has replaced many of their lights with LED versions to meet some of this criteria.	Yes - Partial
PD-18	Site Vegetation	The HDM does not discuss any of these criteria to any detail.	No
PD-19	Reduce and Reuse Materials	The HDM briefly discusses 2 of the 6 sub-criteria within the HDM (pg 74), Maintenance manual (pg. 44, 48), and the Field Operations Guide, section 300.	Yes - Partial
PD-20	Recycle Materials	The HDM does not discuss any of these criteria to any detail.	No
PD-21	Earthwork Balance	The HDM mentions striving for a "balanced" grade for its earthwork (pg. 90); however, it does not mention or require any hard-driven metrics as required by the INVEST criteria.	No
PD-22	Long Life Pavement Design	The HDM does not discuss any of these criteria to any detail.	No
PD-23	Reduced Energy and Emissions in Pavement Materials	KYTC uses warm-mix asphalt on some projects as discussed in the Kentucky Standard Specifications, 400 Asphalt Pavements.	Yes - Partial
PD-24	Contractor Warranty	The HDM does not discuss any of these criteria to any detail.	No
PD-25	Construction Environmental Training	KYTC appears to sponsor a Construction Management Academy which may cover some of these INVEST requirements.	Yes - Partial
PD-26	Construction Equipment Emission Reduction	The HDM does not discuss any of these criteria to any detail.	No
PD-27	Construction Noise Mitigation	Noise Mitigation efforts are briefly discussed within the HDM (pg. 238) and Construction Guidance Manual (137).	Yes - Partial
PD-28	Construction Quality Control Plan	The Construction Guidance Manual mentions quality control plans on pg. 295 but does not go into enough detail to truly examine whether it meets the INVEST requirements.	Yes - Partial
PD-29	Construction Waste Management	The HDM does not discuss any of these criteria to any detail.	No

Questionnaire on Kentucky Sustainable Highways

1. Economic Analysis
 - a. Was any type of economic analysis conducted on this project, to include benefit-cost analysis and/or economic impact analysis?
2. Life-Cycle Cost Analyses
 - a. Pavement Life-Cycle Cost Analyses are prescribed as standard practice in the Highway Design Manual. For this project, were any additional Life-Cycle Cost Analyses conducted, to include stormwater infrastructure or other major design features?
3. Context Sensitive Project Development
 - a. The Cabinet incorporates public involvement into its projects as a leader in Context Sensitive Design. For this project, were the following elements incorporated into this process:
 - i. Screen alternatives prior to selecting the implemented proposal as the solution?
 - ii. Use an external stakeholder/s who acted as Public “Champion” for promoting the project?
 - iii. Receive acceptance of the project from external stakeholders, to include the public, for addressing the underlying needs of the project and its final results?
4. Highway and Traffic Safety
 - a. Was a Road Safety Audit (or Road Safety Assessment) conducted for this project above and beyond the traditional safety review? For additional details, see the Highway Safety Manual (ch. 2) and NCHRP Report Human Factors Guideline for Road Systems.
 - b. Was a public awareness campaign instituted to address safety issues regarding the need for this project, most notably crashes?
 - c. Were quantitative, predictive statistical methods used to assess improvements in safety derived from the project? These methods are referenced in the AASHTO Highway Safety Manual, such as regression to the mean and to go beyond standard crash rates.
 - d. Was a statistically-reliable method used to assess the safety performance and effectiveness of the project post-construction, to include such methods as the Empirical Bayes method?
5. Educational Outreach
 - a. Were any of the following measures installed or performed during the planning, design, or construction of this project?
 - i. Included sustainability as a component within the project development process? Examples may include context sensitive solutions, neighborhood-aware design, complete streets, etc.
 - ii. Included sustainability as a component within the public involvement process?
 - iii. Installed point-of-interest displays, such as off-road kiosks, discussing the project and its sustainability features?

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- iv. Developed a project website for the public capable of receiving feedback and comments?
 - v. Executed sustainability features as developed within Cabinet guidance and policies?
 - vi. Performed school presentations regarding the project and its sustainability features?
 - vii. Performed professional presentations regarding the project and its sustainability features?
6. Tracking Environmental Commitments
- a. Did the principal project construction firm assign an independent environmental compliance monitor to provide quality assurance and report findings directly to the Cabinet on environmental compliance?
7. Habitat Restoration
- a. To minimize or avoid impacts to natural habitats (stream or terrestrial), were any of the following measures performed:
 - i. Modify project to minimize impact to natural habitat (must have been modified from original proposal or existing infrastructure alignment to reduce impacted region by a sq. ft. area of 50% or more)
 - ii. Modify project to avoid impact to natural habitat (must have been modified from original proposal or existing infrastructure alignment to reduce impacted region by a sq. ft. area of 75% or more)
 - iii. If this project was required to mitigate habitat impacts through restorative practices, was a restoration/preservation approach enacted to restore and/or preserve an upland buffer area surrounding the required stream or wetland mitigation site?
 - iv. If this project was not required to mitigate habitat impacts, was a habitat restoration effort implemented that mitigated habitat impacts for species not considered endangered?
8. Stormwater
- a. The KYTC Drainage Manual prescribes standard practices regarding stormwater runoff which relates to the INVEST sustainable highways criteria. For this project, do any of the following apply?
 - i. Were measures instituted to treat targeted pollutants from surface water runoff at the project construction site, to include sediments? If so, please describe the measure/s and the overall area treated.
 - ii. Were measures instituted to control runoff flows for the project site? If so, please describe the measure/s and the amount of runoff managed.
 - iii. Were any best management practice systems installed to treat runoff pollutants to include, but not limited to, the following: detention pond, wet pond, wetland, biofilter, and media filter?

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9. Ecological Connectivity

- a. Were any measures instituted to mitigate or improve ecological connectivity of the project? Examples of ecological connectivity can include minimizing transportation interference with wildlife crossings, establishing designated corridors for wildlife crossing, and retrofitting or upgrading existing culverts and/or fencing.

10. Pedestrian Access

- a. Pedestrian access scoring should reflect upgrades to previously existing facilities and go beyond minimum standards and requirements for all.
- b. Does this project promote pedestrian access by improving any of the following:
 - i. Enhancing safety through well-designed facilities that promote safe behavior?
 - ii. Providing comfort through allowing high volume of walkers, space for passer-by walkers, and be well maintained?
 - iii. Improving connectivity between homes and other areas (shopping, schools, etc.) through sidewalks, crosswalks, bridges, tunnels, and signage?
 - iv. Enhancing aesthetics and environment through landscaping, art, furniture, lighting, or social amenities (benches and gathering spaces) as appropriate to promote use of the facilities?

11. Bicycle Access

- a. Bicycling access requires bicycle facilities to foster use.
- b. Does this project promote bicycle access by improving any of the following:
 - i. Enhancing bicyclist safety through well-designed facilities that promote safe behaviors?
 - ii. Improving connectivity between homes and other areas (shopping, schools, etc.) through bike lanes, shared use paths, wide shoulders, bicycle parking, bridges, tunnels, and signage?
 - iii. Providing for Class I (separated) or Class II (bike lanes) exclusively for bicycle use?

12. Transit & HOV Access

- a. Does this project provide transit or HOV access?
- b. If yes, which of the following measures, if any, are specifically addressed:
 - i. Does the project provide new or improve existing transit shelters, transit stations, HOV signage, pedestrian or bicycle stations, and park and ride lots?
 - ii. Does the project provide new or improve existing HOV vehicle lanes or exclusive bus lanes?

13. Freight Mobility

- a. Does the project implement any of the following freight features:
 - i. No-idling policy with corresponding signage
 - ii. Construct new rest area or rest stop (or improving existing facilities)
 - iii. Provide safety improvements specifically for freight (e.g., additional safety signage, speed warning systems for hills, or other ITS solutions)
 - iv. Construct grade, alignment, or design adjustments specifically for freight trucks

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- v. Construct dedicated truck delivery areas (or repurposing of existing area to truck delivery)
- vi. Provide automated weigh-in motion stations
- vii. Provide virtual weigh-in motion stations
- viii. Construct or designate existing mixed-traffic lane to truck-only lane

14. ITS for System Operations

- a. Does the project include the use of ITS solutions, to include any of the following:
 - i. Electronic Payment/Pricing (Toll Collection)
 - ii. Emergency Management (Emergency Vehicle Signal Preemption)
 - iii. Enforcement (Speed Enforcement, Traffic Signal Enforcement, Ramp Meter Enforcement)
 - iv. Information Dissemination (Dynamic Message Signs, Highway Advisory Radio, Dynamic Parking)
 - v. Information Management (Data Archiving)
 - vi. Lane Management (Reversible Flow Lanes, Pricing, Lane Control, Variable Speed Limits)
 - vii. Ramp Control (Ramp Metering)
 - viii. Response and Treatment (Fixed and Mobile Winter Maintenance)
 - ix. Road Weather Management (Pavement Conditions, Atmospheric Conditions, Water Level)
 - x. Surveillance (Streaming Video)
 - xi. Traffic Control (Adaptive Signal Control, Advanced Signal Systems, Special Events, Vehicle Restriction)
 - xii. Traffic Incident Management (Call Boxes, Service Patrols)
 - xiii. Traveler Information (511)
 - xiv. Warning Systems (Highway-Rail and Intersection Collision Warning Systems, Animal Warning)

15. Historic, Archaeological, and Cultural Preservation

- a. Is any portion of the project within the project boundaries of the U.S. National Register of Historic Places (or thereby determined eligible)?
- b. Is any portion of the project along one of America's Scenic Byways (www.byways.org), a State Scenic Byway, or other route thereby designated as such?
- c. If either of the above answers are yes, then do any of the following measures apply:
 - i. For Part (a) (Historic Places), have efforts have been made to “minimize” impacts from the project as described in Section 106 of the National Historic Preservation Act
 - ii. For Part (a) (Historic Places), have efforts been made to “avoid” any impacts from the project?
 - iii. For both Parts (a) and (b), have efforts been made to “enhance” features with the goal of protecting and preserving historic, archaeological, or cultural resources? Examples of this include installation of informational or interpretive facilities (e.g., viewpoint, kiosk, sign, or other installation for visitors detailing historical, archaeological, or cultural significance).

16. Scenic, Natural, or Recreational Qualities

- a. Is any portion of the project along one of America's Scenic Byways, a State Scenic Byway, or other route thereby designated as such?
- b. Has any existing access to scenic, natural, or recreational qualities been removed as a part of this project? If yes, please describe
- c. If either of the above answers are yes, then do any of the following measures apply:
 - i. For Part (a), have efforts been made to minimize "adverse effects" related to these features?
 - ii. Have any areas been specifically designated to provide natural, scenic, or recreational access for vehicle traffic, to include viewpoints, overlooks, welcome centers, tourist activities, or other information or recreational areas?
 - iii. Have efforts been made to avoid "adverse effects" related to these features?
 - iv. Have efforts been made to "enhance" features with the goal of protecting and preserving the scenic, natural, or recreational qualities along the roadway? Examples of this include improvements to existing access points, signage, views, or to the scenic, natural, or recreational qualities themselves.

17. Energy Efficiency

- a. Did the project implement any of the following measures:
 - i. Evaluate energy needs and develop alternatives to reduce power consumption and still meet lighting and other needs?
 - ii. Reduce energy consumption through energy efficient lighting and signals, installation of renewable power sources, and/or other measures?
 - iii. Establish a plan to periodically audit energy use of the new project following its completion?

18. Site Vegetation

- a. Site vegetation includes all vegetation associated with a roadway project and its associated right-of-way (e.g., roadside vegetation, decorative planting, vegetation within stormwater facilities).
- b. Did the project employ any of the following measures:
 - i. Site vegetation consists of non-invasive, non-toxic species only and minimizes disturbance of native species?
 - ii. Use seeding that does not require consistent mowing for a viable stand of grass
 - iii. Require any mowing?
 - iv. Require use of irrigation after construction?
 - v. Use greywater or reclaimed water for vegetation during construction or post-construction period?
 - vi. Use native species for vegetation as defined by EPA's Level III ecoregion?
 - vii. Incorporate the use of a vegetation management plan to maintain the corridor?

19. Reduce and Reuse Materials

- a. This concept focuses on reducing, reusing, and recycling materials for a construction project.

Appendix D – Interview Questions

- i. “Reducing” reduces the need for new materials. Examples include soil stabilization methods, pavement preservation technologies (existing pavements), bridge preservation technologies, and retrofitting existing structures.
- ii. “Reusing” applies the reuse of materials from another industry for the project and can include such examples as coal ash, fly ash, sand, slag, shingles, and construction/demolition materials, among others.
- iii. “Recycling” utilizes the existing materials for use in the new construction project.
- b. This concept applies if any of the following measures were used:
 - i. Use of pavement preservation techniques such as crack sealing, chip sealing, slurry sealing, microsurfacing, or overlays to extend pavement life? If yes, what is the expected increase in service life?
 - ii. Reduced new pavement materials needed through soil stabilization methods? If yes, what percentage of the pavement area was treated in this manner?
 - iii. Performed bridge preservation activities such as deck overlays, crack sealing, joint sealing, removing channel debris, lubricating bearings, cathodic protection, electrochemical chloride extraction and cleaning, and painting to extend the bridge service life? If yes, what is the expected increase in service life?
 - iv. Retrofitted existing bridge structures to include such methods as stainless steel wire mesh composites, full height steel jackets, elastomeric bearings, steel restrainer cables, shear keys, fiber reinforced polymers wraps, shape memory alloy devices, metallic and viscoelastic dampers, or pipe seat extenders? If yes, what is the expected increase in service life?
 - v. Reuse existing pavements, structures, or structural elements for a new use by repurposing them? [Examples include using the existing pavement for a new use such as a frontage road, bike paths, or other similar uses] If yes, what percentage of the pavement is reused and repurposed?
 - vi. Reuse of industrial by-products as materials in new project to include foundry sand, coal ash, fly ash, slag, tires, shingles, and construction and demolition materials? If yes, which type of material is being reused?

20. Recycle Materials

- a. Did the project recycle existing asphalt pavement or concrete aggregate already in place at the site for use in the new project’s pavement, base, or embankments? If yes, what was the approximate weight of the recycled materials versus the approximate weight of the total materials used for project construction?
- b. Did the project recycle existing pavement materials using cold-in-place recycling, hot-in-place recycling, or full depth reclamation methods? If yes, what was the approximate percentage of existing pavement recycled versus the total amount of existing pavement?
- c. For rehabilitation of existing infrastructure, did the project relocate or reuse at least 90 percent of the existing onsite minor structural elements, such as lights, signal poles, and sign structures, for use in the new project?

Appendix D – Interview Questions

21. Earthwork Balance

- a. Balancing earthwork cut and fill reduces costs and increases sustainability. For the purposes of this criteria, did the project perform either of the following measures:
 - i. Balance earthwork cut and fill volumes such that the percent difference between the cut and fill is less than or equal to 10 percent of the total volume of material moved to/from offsite? For this calculation, only include soil stabilizer materials, soil additives, topsoil materials, and unused cut or imported fill materials discounting all others.
 - ii. If construction banking is used, did the project use construction banking from adjacent projects or other phases of the same project, truck this material less than 10 miles to jobsite, use banking stockpiles within a 24 month period, and ensure stockpiles had a temporary erosion and sedimentation control plan in place?

22. Long-Life Pavement Design

- a. Long-Life Pavement encompasses the following design traits:
 - i. Service life of 40+ years for new construction and major reconstruction
 - ii. Service life of 20+ years for small reconstruction and bridge replacement
 - iii. Pavement will not exhibit premature construction and materials-related distress
 - iv. Pavement will have reduced potential for cracking, faulting, and spalling
 - v. Pavement will maintain desirable ride and surface texture characteristics with minimal intervention activities, if warranted, for ride and texture, joint resealing, and minor repairs
- b. To meet this designation, the project must meet the following two criteria:
 - i. Design at least 75 percent of the total new or reconstructed pavement surface area for regularly trafficked lanes of pavement to meet long-life pavement design criteria.
 - ii. Pavement design is in accordance with a design procedure that is formally recognized, adopted, and documented by the project owner. Typically, this process is described in AASHTO Design of Pavement Structures or AASHTO Mechanistic-Empirical Pavement Design

23. Reduced Energy and Emissions in Pavement Materials

- a. The use of low-energy materials for at least 50 percent of the project is required to meet this category and can include any of the following options:
 - i. Use of warm-mix asphalt
 - ii. Receive hot-mix asphalt or cement from a production plant practicing fuel usage reduction techniques such as the burning of recycled oil, waste materials, or other fuel saving technologies
 - iii. Receive cement from an ENERGY STAR certified cement production plant
 - iv. Receive concrete from a concrete plant demonstrating a carbon footprint 15 percent below the national averages as shown in the National Ready Mixed Concrete Association's (NRMCA) Sustainable Concrete Plant Guidelines or meeting NRMCA Sustainable Concrete Plant Silver Certification
 - v. Use blended cement with limestone addition as shown in ASTM C 150/AASHTO M85

Appendix D – Interview Questions

24. Construction Environmental Training

- a. The Cabinet shall require the contractor to implement a formal environmental awareness training program during construction to stay in compliance with environmental laws, regulations, and policies.
- b. Does the environmental awareness training plan include the following elements:
 - i. A list of the types of project personnel to be trained?
 - ii. A description of the types, goals, and objectives of training to be given? If yes, please describe.
 - iii. A process to track training efforts, methods of training (online, classroom, field), topics, participants, and attendance numbers?
 - iv. A process to measure training effectiveness such as self-assessment, pre-test and post-test, and other measures?

25. Construction Equipment Emission Reductions

- a. Did the project use any of the following methods, to include:
 - i. Use non-road construction equipment with engines meeting EPA Tier 4 emission standards for at least 50 percent of the non-road construction equipment fleet by operational hours? If more than 50 percent, how much?
 - ii. Use non-road construction equipment with EPA verified diesel retrofit devices for after-treatment pollution control for at least 50 percent of the non-road construction equipment fleet by operational hours? If more than 50 percent, how much?
 - iii. Implement a no-idling policy for contract labor during construction
 - iv. Use non-road construction equipment with engines meeting EPA Tier 4

26. Construction Noise Mitigation

- a. Noise mitigation requires the contractor to plan and monitor noise control throughout construction beyond minimum regulatory requirements.
- b. Did the project use any of the following methods, to include:
 - i. Did the contractor establish, implement, and maintain a formal Noise Mitigation Plan during roadway construction? This plan should incorporate the following elements:
 1. Identify responsible party for noise mitigation activities
 2. List proposed construction activities for noise generation
 3. Provide dates and working hours of project construction activities
 4. List noise-generating devices onsite
 5. List noise-mitigating devices to be used onsite
 6. Describe noise monitoring standards, methods, and acceptable levels
 7. Describe correct procedures for non-compliant noise levels
 8. Describe complaint or feedback mechanism for public use
 9. Identify project location and its proximity to receptors of noise (e.g., commercial, residential, hospital, schools, parks, sensitive habitats)
- c. Did the contractor monitor noise and effectiveness of mitigation measures at the receptors throughout construction to ensure compliance with the Noise Mitigation Plan

Appendix E – Case Study Evaluations

SPR 12-447 Green Infrastructure Case Analysis						Project Description:
Case 1:	US-68 Double Crossover Diamond Interchange					WIDEN HARRODSBURG ROAD AT NEW CIRCLE ROAD FROM CORPORATE DRIVE TO ALEXANDRIA DRIVE BY INCREASING CAPACITY UNDER THE NCR BRIDGES AND INTERSECTION IMPROVEMENTS.
District:	7	County:	Fayette			
Project Type:	Major Widening	Const. Est	\$6,237,711			
INVEST Scorecard:	Basic Urban	Bronze	Silver	Gold	Platinum	
INVEST Max Poss.:	105	32	42	53	63	
	Project Achieved:	38				
	Project Capable:	75				
Credit	Description	Possible	Achieved	Capable	Status	Interview Comments
PD-1	Economic Analysis	0	0	0	Complete	Does not apply to Basic Urban Criteria.
PD-2	Life-Cycle Cost Analyses (LCCA)	3	1	3	Complete	Yes, pavement LCCA conducted on all projects.
PD-3	Context Sensitive Project Development	5	5	5	Complete	Yes, strong public involvement on this to address all CSS points.
PD-4	Highway and Traffic Safety	10	3	10	Complete	Public awareness campaign to address safety, considered historic safety performance for project scope, and conducted a pre- and post-crash rate study coupled with volume analysis.
PD-5	Educational Outreach	2	2	2	Complete	Included sustainability in project development and public involvement; project website; stakeholder guide; and conducted professional and school presentations.
PD-6	Tracking Environmental Commitments	5	3	5	Complete	KYTC has an environmental tracking system (Div of Env Analysis) and the means to communicate commitments to different sections (planning, construction, etc.).
PD-7	Habitat Restoration	3	0	0	Complete	Not Applicable
PD-8	Stormwater	9	1	9	Complete	Designed to treat 100% of sediment from surface runoff.
PD-9	Ecological Connectivity	0	0	0	Complete	Does not apply to Basic Urban Criteria.
PD-10	Pedestrian Access	2	2	2	Complete	Yes, Pedestrian access to a multi-use pathway reflects improvements to safety, comfort, connectivity, and aesthetics.
PD-11	Bicycle Access	2	2	2	Complete	Yes, Bicycle access to a multi-use pathway reflects improvements to safety, comfort, connectivity, and aesthetics.
PD-12	Transit & HOV Access	5	0	0	Complete	Not Applicable
PD-13	Freight Mobility	0	0	0	Complete	Does not apply to Basic Urban Criteria.
PD-14	ITS for System Operations	5	3	5	Complete	Project includes surveillance (streaming video), traffic control (advanced signal systems), and data collection (Centrac).
PD-15	Historical, Archaeological, and Cultural Preservation	3	0	0	Complete	Not Applicable
PD-16	Scenic, Natural, or Recreational Qualities	0	0	0	Complete	Does not apply to Basic Urban Criteria.
PD-17	Energy Efficiency	8	1	0	Complete	Project utilizes LED lighting.
PD-18	Site Vegetation	3	2	3	Complete	Roadside vegetation consists of native species grass (fescue) and does not require long-term irrigation.
PD-19	Reduce and Reuse Materials	8	6	6	Complete	Utilized pavement preservation by constructing an ACP overlay over the top of the pre-existing roadway alignment with an estimated increase of service life from 7 to 10 years minimum and conducted several bridge preservation measures of the existing structure.
PD-20	Recycle Materials	8	2	4	Complete	Project used Recycled Asphalt Pavement up to 20% per mixture.
PD-21	Earthwork Balance	0	0	0	Complete	Does not apply to Basic Urban Criteria.
PD-22	Long Life Pavement Design	5	5	5	Complete	Confirmed by KYTC Highway Design.
PD-23	Reduced Energy and Emissions in Pavement Materials	3	0	3	Complete	Not Applicable
PD-24	Contractor Warranty	3	0	0	Complete	Not Applicable
PD-25	Construction Environmental Training	1	0	1	Complete	Not Applicable
PD-26	Construction Equipment Emission Reduction	2	0	2	Complete	Not Applicable
PD-27	Construction Noise Mitigation	2	0	2	Complete	Not Applicable
PD-28	Construction Quality Control Plan	5	0	3	Complete	Not Applicable
PD-29	Construction Waste Management	3	0	3	Complete	Not Applicable

Appendix E – Case Study Evaluations

SPR 12-447 Green Infrastructure Case Analysis						Project Description:
Case 1:	E2RC Section 1					NEW CONNECTOR ROAD SECTION 1: FROM E'TOWN BYPASS TO CECILLIANA DRIVE INCLUDING INTERCHANGE WITH E'TOWN BYPASS.
District:	4	County:	Hardin			
Project Type:	New Route	Const. Est.	\$32,796,400			
INVEST Scorecard:	Rural Extended	Bronze	Silver	Gold	Platinum	
INVEST Max Poss.:	115	35	46	58	69	
	Project Achieved:	35				
	Project Capable:	79				
Credit	Description	Possible	Achieved	Capable	Status	Comments
PD-1	Economic Analysis	5	0	0	Complete	Not Applicable
PD-2	Life-Cycle Cost Analyses (LCCA)	3	1	3	Complete	Yes, pavement LCCA conducted on all projects.
PD-3	Context Sensitive Project Development	5	5	5	Complete	Yes, strong public involvement on this to address all CSS points.
PD-4	Highway and Traffic Safety	10	0	10	Complete	Safety was not analyzed by the INVEST criteria for this project.
PD-5	Educational Outreach	2	2	2	Complete	The project had a website and conducted professional and school presentations.
PD-6	Tracking Environmental Commitments	5	3	5	Complete	KYTC has an environmental tracking system (Div of Env Analysis) and the means to communicate commitments to different sections (planning, construction, etc.).
PD-7	Habitat Restoration	3	0	0	Complete	Not Applicable
PD-8	Stormwater	9	4	9	Complete	Project treats 100% of surface runoff (i.e., sediment) and included grass-lined channels for infiltration.
PD-9	Ecological Connectivity	3	0	3	Complete	Not Applicable
PD-10	Pedestrian Access	0	0	2	Complete	Does not apply to Rural Extended; however, the project does have sidewalks with lighting.
PD-11	Bicycle Access	0	0	2	Complete	Does not apply to Rural Extended; however, the project does have Class II striped bicycle lanes on roadway shoulder.
PD-12	Transit & HOV Access	0	0	0	Complete	Does not apply to Rural Extended.
PD-13	Freight Mobility	7	0	0	Complete	Not Applicable
PD-14	ITS for System Operations	5	3	5	Complete	The project has Emergency Vehicle Signal Preemption (adjacent fire station), emergency warning system for passer-by drivers, and 511 travel information capabilities (2 pts).
PD-15	Historical, Archaeological, and Cultural Preservation	3	2	0	Complete	The project contained historic properties in the original project scope and produced multiple corridor alternatives to avoid some of the properties.
PD-16	Scenic, Natural, or Recreational Qualities	3	0	0	Complete	Not Applicable
PD-17	Energy Efficiency	8	1	0	Complete	Project utilizes LED lighting.
PD-18	Site Vegetation	3	2	3	Complete	Roadside vegetation consists of native species grass and does not require long-term irrigation.
PD-19	Reduce and Reuse Materials	8	2	4	Complete	The project used asphalt shingles as a component within its pavement.
PD-20	Recycle Materials	8	2	4	Complete	Project used Recycled Asphalt Pavement up to 20% per mixture.
PD-21	Earthwork Balance	3	0	3	Complete	Not Applicable
PD-22	Long Life Pavement Design	5	5	5	Complete	Confirmed by KYTC Highway Design.
PD-23	Reduced Energy and Emissions in Pavement Materials	3	3	3	Complete	The project used warm-mix asphalt for its pavement mix.
PD-24	Contractor Warranty	3	0	0	Complete	Not Applicable
PD-25	Construction Environmental Training	1	0	1	Complete	Not Applicable
PD-26	Construction Equipment Emission Reduction	2	0	2	Complete	Not Applicable
PD-27	Construction Noise Mitigation	0	0	2	Complete	Does not apply to Rural Extended.
PD-28	Construction Quality Control Plan	5	0	3	Complete	Not Applicable
PD-29	Construction Waste Management	3	0	3	Complete	Not Applicable

Appendix E – Case Study Evaluations

SPR 12-447 Green Infrastructure Case Analysis						Project Description:
Case 1:	6-273 12th Street					
District:	6	County:	Kenton			RECONSTRUCT 12TH ST. FR I-75 TO SCOTT STREET.
Project Type:	Minor Widening	Const. Est.	\$7,586,554			
INVEST Scorecard:	Extended Urban	Bronze	Silver	Gold	Platinum	
INVEST Max Poss.:	126	38	50	63	76	
	Project Achieved:	39				
	Project Capable:	79				
Credit	Description	Possible	Achieved	Capable	Status	Comments
PD-1	Economic Analysis	5	0	0	Complete	Not Applicable
PD-2	Life-Cycle Cost Analyses (LCCA)	3	0	3	Complete	Project used concrete, not asphalt
PD-3	Context Sensitive Project Development	5	5	5	Complete	Yes, strong public involvement on this to address all CSS points (and State Senator as stakeholder).
PD-4	Highway and Traffic Safety	10	4	10	Complete	Project had a safety public awareness campaign and project engineer stated quantitative, safety analytical methods were used.
PD-5	Educational Outreach	2	2	2	Complete	They included sustainability in the project development process (moved historic properties) and conducted professional presentations regarding the project.
PD-6	Tracking Environmental Commitments	5	3	5	Complete	KYTC has an environmental tracking system (Div of Env Analysis) and the means to communicate commitments to different sections (planning, construction, etc.).
PD-7	Habitat Restoration	3	0	0	Complete	Not Applicable
PD-8	Stormwater	9	5	9	Complete	The project treats 100% of surface runoff for sediments and installed planter boxes as infiltration low-impact devices.
PD-9	Ecological Connectivity	3	0	3	Complete	Not Applicable
PD-10	Pedestrian Access	2	2	2	Complete	Yes, have sidewalks with lighting.
PD-11	Bicycle Access	2	1	2	Complete	Project has striped bicycle lanes for cyclist use.
PD-12	Transit & HOV Access	5	0	0	Complete	Not Applicable
PD-13	Freight Mobility	7	4	0	Complete	The project was designed to improve safety performance related to large freight trucks frequently moving along this corridor and improved the safety turning radius for large trucks as well as the railroad overpass.
PD-14	ITS for System Operations	5	0	5	Complete	Not Applicable
PD-15	Historical, Archaeological, and Cultural Preservation	3	3	0	Complete	The project actively sought to avoid impacts to some historical properties located within the site area while moving (protecting and preserving) other historical properties.
PD-16	Scenic, Natural, or Recreational Qualities	3	0	0	Complete	Project does not reside within an American Scenic Byway.
PD-17	Energy Efficiency	8	0	0	Complete	Not Applicable
PD-18	Site Vegetation	3	2	3	Complete	Roadside vegetation consists of native species grass and does not require long-term irrigation.
PD-19	Reduce and Reuse Materials	8	3	4	Complete	Project retrofitted an existing bridge's pier and foundations.
PD-20	Recycle Materials	8	0	4	Complete	Project material was concrete and currently lack details on original concrete supplier necessary for further assessment.
PD-21	Earthwork Balance	3	0	3	Complete	Not Applicable
PD-22	Long Life Pavement Design	5	5	5	Complete	Confirmed by KYTC Highway Design.
PD-23	Reduced Energy and Emissions in Pavement Materials	3	0	3	Complete	Not Applicable
PD-24	Contractor Warranty	3	0	0	Complete	Not Applicable
PD-25	Construction Environmental Training	1	0	1	Complete	Not Applicable
PD-26	Construction Equipment Emission Reduction	2	0	2	Complete	Not Applicable
PD-27	Construction Noise Mitigation	2	0	2	Complete	Not Applicable
PD-28	Construction Quality Control Plan	5	0	3	Complete	Not Applicable
PD-29	Construction Waste Management	3	0	3	Complete	Not Applicable

Research Report
KYSPR – 12 -477

Green Infrastructure

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February 2012

Executive Summary

Over the past several years, State DOTs have increasingly begun to embrace a new “triple bottom line” approach to business. This approach captures an expanded spectrum of values and criteria for measuring organizational success, encompassing the economic, the environmental, and the social. Ultimately, the central goal of the “triple bottom line” is sustainability and the results from the sample of states included in this review indicate that these sustainability initiatives have met largely with success. In all of the examples provided below, the initiatives discussed have been designed to increase environmental and economic efficiency and the results have been very encouraging. This is not to say, however, that all state DOTs are finding the same level of success in achieving the “triple bottom line”. Indeed, the ten state DOTs included herein represent those with the most recognizable commitments to sustainability, and some have a much greater commitment than others.

Further, this review was initiated under the auspice that in recent years the state of Kentucky has lagged in adopting sustainability initiatives. And, while there is certainly room for improvement, the state of Kentucky has shown to have initiated or be in the process of initiating, several programs that pay significant heed to the goals of sustainability. Combined with the realization that many states DOTs have very little in the way of significant sustainability achievements and few have singularly distinguished themselves there is certainly an opportunity for the KYTC to distinguish itself with respect to sustainability and the “triple bottom line”. To this end, this review makes the recommendation that movements toward these goals continue, beginning with a more comprehensive and in-depth research project and case study analysis to more acutely identify further areas where sustainable initiatives can be implemented. And further, that a process be developed to examine these case studies utilizing the Federal Highway Administration’s (FHWA) Sustainable Highways model in order to identify the areas in which KYTC’s standards and practices meet the criteria of the FHWA’s program. Additionally, KTC will investigate and recommend those programs which KYTC can adopt with little to no additional investment. More is discussed regarding these recommendations in the conclusion that follows this review.

The review itself proceeds in the following manner. First, there is a brief discussion of a sample of ten state DOTs across the country and some of their various sustainability initiatives. From there we move forward to a review of some of the more significant sustainability initiatives undertaken by the KYTC. Finally, the review concludes with a summary and assessment of its findings, a recommendation regarding a future work-plan, and an appendix containing the technical memos on each of the programs discussed in the KYTC section.

Green Infrastructure Applications / Sample of U.S. States

1.1 INTRODUCTION

The following section reviews green infrastructure and sustainability initiatives undertaken by the Departments of Transportation (DOT) across the U.S. in the following states; Colorado, Illinois, Maine, Massachusetts, Minnesota, Missouri, New York, North Carolina, Oregon, and Rhode Island. In each subsection the memo discusses the purpose of the programs implemented by each state and then follows with a brief report on the methods employed and the ultimate results of the programs.

STATE DOT INITIATIVES

1.2 Colorado – Statewide Sustainability Framework

Purpose: The development of a common language and framework for use in streamlining and enhancing statewide sustainability efforts.

Method: An outside consultant team assisted the Transportation Environmental Resource Council (TERC) with the development of 5 workshops from Sept. 2010 to April 2011.

Results: The five workshops resulted in the development and dissemination of eight tools to assist agencies with the integration of sustainability into their policies and projects. The tools developed by the workshops were: (1) an inventory program designed to create a baseline by which an agency can compare its efforts against future sustainability activities; (2) a handbook designed to explain how to effectively measure and manage sustainability performance; (3) spreadsheets to allow quantitative evaluation of sustainability projects; (4) spreadsheets for the development of long term and short term goals; (5) a decision flow chart providing paths to decision making at points of conflict among agencies or policies; (6) a matrix for choosing appropriate strategies among a variety of choices; (7) a worksheet that guides the process of determining key external partners for projects; (8) and a strategy plan for breaking down broadly defined strategies into smaller components (e.g. contracting, technologies, and risk). The results were deemed to be highly successful by the TERC and future meetings of the members of the workshops was recommended. Further, the building of a centralized resource (website / database) for the maintaining of the forward progression of sustainability throughout the state has been recommended.

1.3 Illinois – IDOT Environmental Initiatives and Partnerships

Purpose: General environmental programs designed to promote sustainability and preserve natural environments.

Method: The IDOT has constructed and maintained two wetland mitigation sites to help compensate for other unavoidable wetland impacts that have occurred as a result of various other construction projects. To this end, the IDOT reports that a total of 2506.7 acres of mitigation sites have been constructed to date. Further, IDOT has taken steps to maintain air quality for some of their newer construction projects. Specifically, the Dan Ryan Reconstruction Project has seen major air quality mitigation strategies implemented to control dust and other air pollutants. These steps include; street sweeping, dust suppression equipment, and engine idling restrictions. In addition, IDOT required contractors on the project to use ultra-low sulfur diesel fuel. Finally, there have been a number of partnerships between the IDOT and state environmental agencies which have seen the translocation of threatened plant life (the Forked Aster Translocation Project), the protection of endangered species (the Indiana Bat Blue Ribbon Study), and restoration of natural habitats (the IDOT Native Plant Program).

Results: The wetland mitigation sites have provided a demonstrably positive impact on water quality and flood retention, in addition to providing compensation for wetland impacts in advance of unavoidable losses. Further, the use of air quality control measures has resulted in 5-6% less particulate matter in the air at the Dan Ryan Reconstruction Site and continues to be monitored. Among the other programs listed above, all have seen some success. Since the implementation of the IDOT Native Plant Program, over 40,000 tree seedlings and hundreds of pounds of native grass seed has been distributed, and the translocation of the threatened Forked Aster was judged to be highly successful as well.

1.4 Maine – Waterway & Wildlife Crossing Policy and Design

Purpose: To develop effective ways to build, repair and maintain the transportation infrastructure, while protecting important aquatic, wildlife and surface water resources.

Reasoning: Research has indicated the integral role the DOT played in Maine's fishery resources and to sustaining coastal and inland ecosystems, which, in turn, provided commercial, recreational, and economic benefits to the state.

Method: The program develops strategies for the designing and implementing of fish and wildlife crossings that require passage through Maine's DOT transportation systems. Specifically, the program designed accommodations for three groups of species; fish, aquatic organisms other than fish, and land mammals. When conditions at a site indicate that a passage can and should be provided, appropriate criteria are employed to design an effective passage and ensure the long term sustainability of the site. In order to reach their goals of effective, efficient, constructible, and timely projects, the MaineDOT developed the following resources for the design of such passages. The guideline

incorporates; (1) information on all policies, (2) a design guide for various passages, (3) a data base with information on all current and previous projects, (4) an inspection protocol for coordinating inspection of passages, and (5) a program offering “In house” training for potential project directors.

Results: Each project, of which there are many, must be evaluated separately. But a review of a sample of wildlife crossing projects recently undertaken by the MaineDOT indicate that considerable resources have been saved by the development of a universal guideline. In two projects in particular approximately \$1.63 million dollars were saved.

1.5 Massachusetts – GreenDOT Initiative

Purpose: To make the MassDOT a national leader in promoting sustainability in the transportation sector by undertaking a wide range of activities, from strategic planning to construction and system operations. The three primary goals of GreenDOT are (1) reducing greenhouse gas emissions (GHG); (2) promoting the healthy transportation modes of walking, bicycling, and public transit; and supporting smart growth in development. All three goals are mutually reinforcing and aimed at the ultimate goal of reducing GHG emission.

Reasoning: Compliance with the Climate Protection and Green Economy Act signed into law in 2008, which requires a reduction in GHG emissions by 10-25% by 2020 and 80% by 2050.

Method: The methodology employed by the MassDOT for accomplishing the GreenDOT initiatives range from long-range planning solutions to system operation and maintenance programs. First, (1) with respect to long-term planning, statewide planning documents (including the Strategic Plan, Capital Investment Plan, and the Regional Transportation Plans) have been redesigned to integrate the three GreenDOT initiative goals. Second, (2) project prioritization has been reevaluated resulting in regional and state transportation improvement programs being redesigned. They now require the Metropolitan Planning Organization and MassDOT to balance highway system expansion projects with other projects that support smart growth and promote sustainability. Third, (3) the enactment of a “complete streets” initiative whereby all MassDOT projects were required to include accommodations for pedestrians and bicycles.

Aside from the above mentioned long term planning and operations initiatives, the following projects have already begun implementation. (1) MassDOT has initiated several projects with the Massachusetts Bay Transport Authority (MTBA) to increase the capacity of mass transit systems. One such project put to use \$70 million in federal funds from the FRA’s HSIPR program to upgrade existing railways to provide service to broader areas. Another utilized a

partnership with Pan Am Railways to rehabilitate 138 miles of track and increase its weight capacity. The \$47.5 million effort is one of the largest private investments in the Massachusetts rail system in decades. (2) To promote bicycle and pedestrian transportation MassDOT has begun mapping the 740 mile network of statewide on and off-road corridors known as the Bay State Greenway in order to promote a state bicycle network. It has also allocated 4.8 million in American Recovery and Reinvestment Act funds to enhance and expand bicycle parking facilities at MTBA stations. (3) Finally, MassDOT has begun using a range of recycled materials in pavement, including recycled asphalt, recycled tires, and warm mix asphalt. As well as replacing traffic signal bulbs with high-efficiency LEDs.

Results: The GreenDOT program is expected to result in a reduction in GHG by 7.3% by 2020. This is a full 30% below predicted unchecked GHG for 2020. Extrapolated for 2050, the expected reduction is in the neighborhood of 80%.

1.6 Minnesota – Integrated Roadside Vegetation Management (IRVM)

Purpose: A decision and quality management process for maintaining roadside vegetation. The IRVM serves as a guide to assist agencies with roadside vegetation management.

Reasoning: The IVRM projects are a proactive response by the MnDOT to several Minnesota Laws that protect plant life within the state. In addition, roadside vegetation provide a long list of safety and economic benefits, from keeping roadways clear of hazardous objects and snow to extending the life of pavement and roadside hardware.

Method: The project recommends implementing the program at the local level (either the township or town scale), as plans necessarily must be adapted to specific circumstances. In Minnesota, the program began with the organizing of a steering committee, the development of a long-term plan that outlined the program's direction, and the collection of pertinent data.

Results: The results of the program are all long-term and as a result the current level of evaluation is rather limited. One area in which data on result could possibly be obtained is from records of traffic accidents on Minnesota roads before and after they have had their vegetation rehabilitated.

1.7 Missouri – Comprehensive State Recycling Program

Purpose: To become a national leader in recycling, conserving, and environmental awareness.

Method: MoDOT has used a variety of methods to reach its recycling goals. The most effective of these have been warm mix asphalt, recycled roofing shingles,

recycled tires, and recycled building materials such as concrete and coal cinders. Since 2005, MoDOT has recycled 256,250 tires, enough recycled shingles to roof 36,474 houses, and over 500,000 tons of recycled concrete. In addition, 70% of Missouri's road signs are produced from recycled materials.

Results: The program has kept 8.4 billion pounds of waste from landfills by recycling materials back into road programs. Specifically, MoDOT has recycled 3.56 billion pounds of industrial waste from mines, steel furnaces, and power plants, and tires over the past five years, which equates to 89,000 truckloads of material that would have ended up in landfills. MoDOT has reported that the program has saved them approximately \$20 million on resurfacing projects and reduced their petroleum expenses by 20 percent.

1.8 New York – GreenLITES Sustainability Program

Purpose: GreenLITES (Leadership in Transportation and Environmental Sustainability) is a department of transportation project rating program similar to the LEED (Leadership in Energy and Environmental Design) system that the building industry has employed since the mid-90s. The purpose of the program is to increase sustainability of resources utilized by the NYSDOT.

Method: The GreenLITES program recognizes and increases awareness of the sustainable methods being used by the NYSDOT and promotes the use of these and new methods in the future. It awards points based on the following categories of (1) sustainable sites, (2) water quality, (3) materials and resources, (4) energy and atmosphere, and (5) innovation. Points are then tallied across these categories and certification is awarded based upon performance. These certifications are based upon where a project falls along percentiles. Those that are among the top 2% receive an evergreen rating; those in the 90-100% range receive a gold rating, and so on. However, those projects that fail to score at least a 33% rating are not certified. Projects are scored and certified before they go to bid and each Earth Day those projects that achieve the highest levels of sustainability are honored.

1.9 North Carolina – 3R (Reduce, Reuse, Recycle) Sustainability Program

Purpose: To employ recycling techniques in order to reduce waste and promote sustainability.

Method: As of 2009-2010, NCDOT has implemented the following programs: (1) top-down support for recycling programs, (2) a coordinating organization for waste reduction, (3) the setup of waste reduction and recycling opportunities at public facilities and rest stops, (4) and an educational program.

Results: Following the initiation of the 3R program, the NCDOT has reported that 80% of their office facilities have reduced paper waste by eliminating

unnecessary forms and converting to electronic formats. Further, changes made to their construction efforts have resulted in 2,365 tons of recycled metal, brick, and concrete. This “construction and demolition recycling program” has resulted in a dramatic reduction in landfill materials. In 2010, the NCDOT reported the savings it accumulated from its four pilot programs in this initiative. The savings across the four programs were approximately \$70,000 (The Halifax Prison Demolition Project), \$50,000 (The I-77 Visitors Center Renovation Project), \$30,000 (The NCDOT Wilson Annex Renovation Project), and \$5,000 (The U.S. 64 Visitor’s Center Renovation Project) respectively. In addition to the above, all NCDOT projects are now required to specify plans for 3R compliance. In total, the NCDOT estimates the program yielded \$155,000 in avoided hard costs; generated \$1.3 million in revenue; kept 2,371 tons of material out of landfills; saved \$5.4 million gallons of water and \$3.2 million kilowatt hours of energy; and saved 304,980 gallons of oil in 2009-2010.

1.10 Oregon – ODOT Integrating Sustainability Program

Purpose: A broad based recycling and sustainability plan for the entire ODOT department, extending from the use of biofuels and solar power to recycling programs and LEED construction standards. The goal is to integrate sustainability fully into all decisions made by ODOT.

Method: ODOT has integrated a large number of initiatives including (1) the retrofitting of equipment to reduce energy consumption, (2) an increase in the use of alternative fuels, (3) a comprehensive recycling and waste management program, (4) and the implementation of a new policy requiring that all new facilities must meet LEED Gold standards.

Results: As of 2010, ODOT’s assorted programs have resulted in a reduction in its use of electricity by 10%. This has been accomplished via the retrofitting of equipment and the development of new equipment standards, as well as a shift to solar powered trailer-mounted construction signs. The department has also shifted toward an emphasis on alternative fuels for its fleet of over 5500 vehicles. The ODOT now utilizes 71 hybrid vehicles and 31% of their fleet operates on biodiesel. Further, waste minimization and recycling programs have reduced paper usage by 20% and water usage by 25%.

1.11 Rhode Island – Green Equipment Incentive (GEI) & the East Coast Greenway (ECG)

Purpose: (GEI) - To provide an incentive for the owning and operating of snow clearing vehicles with AVL/GPRS closed loop spreader control systems installed in them; the purpose being to make more efficient use of salt and sand and reduce overall winter operations costs. **(ECG)** – To become a national leader in

Bike & Pedestrian programs and participate in the multistate East Coast Greenway initiative.

Method: The GEI project provides a flat 20% increase in hourly rates for private vendors who comply with the Green Equipment Incentive. The RIDOT also maintains a preferred vendor list for private trucks and those which comply with the incentive receive priority over those that do not. Inspections are conducted prior to each winter operating season.

Results: Results for the Green Equipment Incentive are not readily available as the project was initiated in October of 2011 and is ongoing for the remainder of the 2011-2012 winter season. RIDOT, however, has become the first state to have its portion of the East Coast Greenway completed and has an additional 40 miles of bike and pedestrian paths currently under construction.

Green Infrastructure Applications / State of Kentucky

I. INTRODUCTION

There has been concern, in recent years; that Kentucky may have lagged in adopting sustainability initiatives that could promote a more sustainable use of our state resources. The Kentucky Transportation Cabinet wished to identify program areas amenable to the implementation of sustainable or “green” initiatives, and the benefits that may be accrued. The following section lays out a list of programs currently being implemented by the state DOT. The results demonstrate a rather wide variety of initiatives and several promising avenues for continuing progress.

II. PURPOSE

The main purpose of this section is to identify initiatives taking place in the state that can be considered sustainable. Our working definition of sustainable is quite broad, incorporating environmental, social and economic sustainability.

Specific objectives include:

1. Perform a background review of selected state agencies and federal policy to determine potential areas of emphasis for sustainable or green infrastructure initiatives.
2. Identify and assess past and current environmental initiatives in Kentucky.
3. Provide a category (low cost, medium cost, high cost) listing of potential areas/topics of sustainable initiative implementation using secondary sources to determine expected benefits.
4. Prepare an initial Strategic Program Plan to identify future research (or case study) needs to determine the specific costs and benefits of selected initiatives.

III. LIST OF PROGRAMS

1. Threatened and Endangered Habitat

The goal of this project is to determine a better way for KYTC to anticipate the location of threatened and endangered habitats for purposes of

avoidance in transportation planning. The project incorporates a rules based spatial model of where one would expect species to be. The benefits of this project are that it helps biologists, planners and designers do their jobs more quickly and promotes informed decision making.

2. Kentucky Prehistoric Behavior Mapping

The goal of this project is to help anticipate the location of artifacts by landform features through a custom derivation of GIS layers. This project is currently in its fifth stage; the first four stages focused on specific Kentucky regions, including Woodford County, Inner Bluegrass, Hazard Hills, and Western Kentucky. One benefit of this kind of mapping is that it requires minimal cost when compared with other models (like that used in Minnesota). Kentucky's predictive model is also far superior and is applicable to the entire southeastern United States.

3. Stream and Wetland Mitigation

KYTC, in partnership with such groups as The Nature Conservancy, U.S. Fish and Wildlife Service and the Kentucky Waterways Alliance, has protected 4,982 acres of land from development, including more than 800 acres of preserved or restored wetland. The cabinet also has protected 49.3 miles of streams, including 17.1 miles of restored stream using natural channel design. The cabinet is currently working with The Nature Conservancy and the University of Kentucky to acquire 270 acres of the scenic Kentucky River Palisades in Garrard County.

4. Indiana Bat Conservation Fund

The Fish and Wildlife Service, Federal Highway Administration and KYTC completed a formal programmatic consultation in 2006 on the effects of minor highway projects on the endangered Indiana bat. This agreement streamlines Endangered Species Act consultation for minor highway projects due to the creation of the Indiana Bat Conservation Fund (IBCF). The IBCF allows KYTC to pay a mitigation fee for project effects on Indiana bats. The funds are then used to protect bat habitat areas, preserve hibernacula or conduct other important species recovery activities. The IBCF also accepts contributions from other organizations or individuals. The fund has been used to acquire critical habitat, place secure gates over cave openings and contribute to Indiana bat telemetry studies to locate maternity colonies.

5. Electronic Screening (NORPASS)

In this program, transponders on trucks enable safe trucks to keep moving on interstates, saving time, expense and emissions. In this program, trucks have their vehicle weighed and safety rating and credentials checked as they approach the port of entry. If all is in order they receive a green light and can proceed without stopping at the station. This program leads to less fuel consumption, time saved on transport, and ultimately savings on costs. After considering available Electronic Screening programs, Kentucky chose NorPass.

6. Department of Motor Vehicles (DMV) – (One Stop Shop)

The “One Stop Shop” is an office within the Department of Motor Vehicles (DMV) that has combined three separate divisions to help better meet transportation needs and increase efficiency. These three combined divisions were previously the Drivers Licensing, Motor Vehicle Licensing, and Motor Carriers offices. The “One Stop Shop” has been equipped with improved information technology which allows for the general public to now complete all of their vehicle related transactions at one location. As a result, costs are reduced due to increased efficiency and sustainability is improved via decreases in travel costs and a reduction in the redundancy of paper work. A similar program, an aspect of the “3R” initiative initiated in North Carolina, has resulted in a substantial reduction in paper waste production along with an ensuing reduction in costs.

(See Green Initiatives State Memo) Additional processes within the DMV are being moved to the internet as well; including payment of taxes, quarterly tax filings for transport trucks, and general information processing. The savings in employee time, mathematical error reduction, and paper waste reduction should save considerable resources.

7. Incident Management

Changes in state laws, policies, and practices increase traffic flow and safety by requiring vehicles involved in accidents to pull off roads when passengers are uninjured and implementing safe patrols.

8. Bike Miles

The Kentucky Bicycle and Bikeway Commission (formed by the state legislature in 1992) was created to represent the interest of cyclists at the state level, assist the bicycle and bikeway program within the cabinet, and promote the interests of the bicycling public. Through initiatives like this one, Kentucky has expanded its bicycle programs and services and now has nine bicycle tours: Ramblin’ River Tour, Bluegrass Tour, Midland Kentucky Bike Tour, Southern Lakes Bike Tour, Central Heartlands Bike Tour,

Mammoth Cave Bike Tour, TransAmerica Bike Tour, Mississippi River Bike Tour, and Underground Railroad Bike Tour.

9. Roadside Vegetation Management

This is a course designed to provide governmental roadway maintenance workers the basic knowledge necessary to safely and efficiently maintain Kentucky's highways. Changes such as mowing roadsides only three times a year and instruction on the safe use of chemical and mechanical techniques not only reduce costs but also provide environmental benefits.

10. Bridge Repair and Monitoring

The objective of this project is to retrofit P/C Spread Box Beams using carbon fiber reinforced polymer (CFRP) fabric to increase shear capacity. This strategy is cost effective, repair effective, limits traffic impacts, and reduces carbon emissions. To date, nine bridges have been strengthened with CFRP, and three bridges have been strengthened with steel FRP.

11. Signal system performance

The objective of this study is to develop and/or identify appropriate measures of effectiveness for roadway performance and efficient means of collecting pertinent data. This study will recommend performance metrics that are available from existing data sources and are sensitive enough to reflect changes to system timing and develop and deploy practical, cost effective systems and procedures that can measure traffic signal performance utilizing existing KYTC resources. These practices will be evaluated at several field locations as a proof-of-concept to assess the effectiveness of these methods to produce effective and meaningful performance measures and aid in optimizing the operational efficiencies of signal systems.

12. Traffic signal technician training

The objective of this project is to develop training and a certification process for traffic signal technicians. A practical and cost-effective training and certification program will be provided for the Transportation Cabinet's traffic signal technicians.

13. Adaptive Signal Systems

The objective of this study is to perform a comprehensive evaluation of an Adaptive Traffic Control System deployed along U.S. 60 (Winchester Road).

In addition, KTC will utilize hardware-in-the-loop micro-simulation to test and evaluate the ATCS under a wide range of conditions and develop preliminary guidance for ATCS deployments. The pilot project will also be used to increase interest and knowledge of ATCSs and encourage their use and implementation throughout the state.

14. Travel time analysis

Travel time analyses compare the performance on popular commutes using annually updated information. Via these analyses, the DOT can address bottleneck and safety concerns and ultimately reduce congestion. All of which leads to lower fuel costs, fewer greenhouse gas emissions, and reduced travel time.

15. LED Traffic Signals (CMAQ project)

This initiative is aimed at replacing traditional fluorescent bulbs in traffic signals with more efficient and durable LED bulbs. Such bulbs provide a 90% increase in energy savings, less maintenance, and a more reliable and extended lifespan.

16. Bridge Preservation and Sustainable Painting/Sand Blasting

The Bridge Preservation project focuses on techniques and materials used to repair, reinforce, and preserve bridges and related structures. One avenue of this research involves analysis of protective coatings for the bridges and also includes assessments of the environmental impact of such coatings as well as other potential surface contaminants. Studies have examined preservation and mitigation in state-maintained wetlands, prevention of volatile organic compounds during bridge painting projects, and developing improved maintenance safety protocol for Transportation Cabinet employees and contractors. Other research focuses on ways to develop infrastructure while minimizing the environmental impact of construction and materials. Further, the state has initiated a painting and sand blasting program that involves a switch from lead-based paint to solvent-based paint. More recently, other types of paints have been examined for potential use as well.

17. Building refurbishments

KYTC is pursuing an initiative providing for a move toward greater insulation of buildings and a switch to natural gas furnaces in lieu of traditional electric. These initiatives are part of a long term goal of reducing overall energy costs. Comparable programs in Oregon and North Carolina have resulted in substantial energy savings. (See Green Initiatives Sate Report)

18.511 Vehicle Information

A program created a computer program called CARS (Condition Acquisition and Reporting System) to provide notifications of incidents (including weather, accidents, construction, etc.) that could potentially affect traffic. The operation center also creates posts on its website and telephone system and sends notification emails to first responders.

19. Warm Mix Asphalt (WMA)

WMA is a technology that allows the producers of hot-mix asphalt (HMA) pavement to lower the temperature at which the material is mixed and placed on the road. The benefits of using warm mix asphalt include improved cost effectiveness, increased durability, and improved environmental sustainability. The pavement lasts longer which leads to fewer re-pavements and therefore lower costs and, by developing the product at a lower temperature, there is a direct decrease in fuel costs, plant emissions, and greenhouse gas production. There have currently been nine WMA projects completed in the state of Kentucky. These pilot projects were undertaken in Webster, Meade, Hardin, Mercer, Lincoln, Casey, Breathitt, and Lawrence counties. The results of these projects demonstrated that the WMA product was as good as or better than the HMA alternatives in terms of construction quality and proved to be more cost effective. Also, temperatures for the WMA were an average of 60 degrees cooler than those for HMA, which offers the additional benefit of mitigating environmental concerns. Visit <http://transportation.ky.gov/SASHTO/Warm%20Mix%20Asphalt.pdf> for more information.

20. Kentucky Erosion Prevention and Sediment Control (KEPSC) – classes provided by Technology Transfer

KEPSC training qualifies individuals for the inspection of erosion prevention and sediment control on construction sites in accordance with the Kentucky Pollutant Discharge Elimination System (KPDES) General Permit issued by the Kentucky Division of Water. Two training programs are being offered: KEPSC Inspector Qualification Training and Testing Course; and KEPSC Inspector Requalification Course.

21. Safety Circuit Rider – through Technology Transfer

The Safety Circuit Rider for the Technology Transfer Program uses crash data to locate high incident sites along roadways and assist communities in finding low cost roadway safety improvements. The Safety Circuit Rider

works with local governments to remove fixed objects such as trees, brush, stumps, etc. and to install signage per MUTCD guidelines. This free technical advice is helping communities across the state of Kentucky save lives every day.

22. Snow and Ice Removal – classes provided by Technology Transfer

This workshop covers safety practices, pre-trip inspection and maintenance of the truck, plow and spreader. Additionally, there is a discussion of vehicle operation, plowing and salting techniques, and identification of different snow conditions. This course is all classroom-based. The course is offered approximately four times each year.

23. Roads Scholar – classes provided by Technology Transfer

Employees working for local, state and industry agencies participate in the Roads Scholar Program. The benefits of becoming a Roads Scholar are that it provides the basic knowledge for anyone working, or wanting to work, in highway maintenance. This training series is designed to provide basic information on maintaining local streets and roads. Completion of this program leads to the designation of Roads Scholar. A variety of courses are offered, each being offered four to seven times per year. Visit <http://www.kyt2.com/training/course/asphalt-paving-best-practices-rs-asphalt-field-tech/roads-scholar-program> for the 2012 Training Calendar.

24. Division of Environmental Analysis

The Division of Environmental Analysis works to ensure that projects and activities undertaken by the Kentucky Transportation Cabinet are completed in an environmentally responsible manner, recognizing the importance of developing projects with sustainability in mind and the potential implications of Cabinet activities. KYTC then works to minimize resulting impacts to the human or natural environment that cannot be evaded

Conclusion / Recommendation

As the previous sections demonstrate there has been a great deal of emphasis placed upon sustainability within the transportation industry recently at both the local and national levels. There is also evidence that Kentucky finds itself in a position to move to the forefront of this movement. Further, while there has indeed been considerable progress toward the implementing of the “triple bottom line” into various programs, both nationally and locally, one aspect of these programs that stands out is their lack of cohesion. It is for this reason that this review recommends the development of a cohesive coordinating program that allows for the evaluation of all Kentucky state transportation projects under one rubric.

The model for this program recommendation is the FHWA’s Sustainable Highways Initiative. The program operates as a self-evaluation tool with a cohesive set of criteria. All of which operate under the understanding that sustainable highways should satisfy the “triple bottom line”. In other words, they must endeavor to satisfy the life cycle functional requirements of societal development and economic growth while also striving to enhance the natural environment and reduce the consumption of natural resources. The tool itself, designated the INVEST program, is designed to measure the sustainability of highway programs in order to track and assess progress, encourage broad participation, evaluate sustainability trade-offs, and communicate benefits and goals. INVEST operates by establishing a set of best practices for projects and disseminating tools for assessing a project against these criteria. It is not a mandate but instead only an evaluation. All of which falls well in line with the goals of the KYTC Green Initiatives Project. More details on the INVEST program itself can be found in its technical memo, which appears in the appendix attached to the end of this review.

To this end, the Kentucky Green Initiatives Project plans to move forward in the following manner. For year two the KTC project team will continue to examine completed KYTC

projects and evaluate them along the lines of the Federal Sustainable Highways criteria in order to determine where each program ranks in terms of platinum, gold, silver, or bronze certification. The KTC project team will investigate as many projects as possible in this phase in order to get a broad understanding of the results. Approximately seven projects will be reviewed and will be collaboratively chosen by the SAC committee members and the KTC project team. The focus of the year two phase of the project will be the identification of how current KYTC standards compare to the standards laid out by the Federal Sustainable Highways Initiative and in the year three phase the focus will move forward into revision to bring the two sets of standards into correlation.

Appendix¹

Warm Mix Asphalt

I. INTRODUCTION

Warm Mix Asphalt (WMA) is a technology that allows the producers of hot-mix asphalt (HMA) pavement to lower the temperature at which the material is mixed and placed on the road. The benefits of using warm mix asphalt include improved cost effectiveness, increased durability, improved environmental sustainability, and various direct engineering benefits. Several pilot projects in the state of Kentucky have employed the technique with largely successful results. Additional results from other states have echoed the positive results demonstrated in the Kentucky projects.

II. PURPOSE / BENEFITS / METHODOLOGY

The purpose of the WMA project is to create a more efficient, more sustainable road paving solution by lowering the traditionally very hot temperatures at which asphalt is produced and maintained prior to its use. Reductions of 50 to 100 degrees Fahrenheit have been documented. The technique is designed to create pavement that lasts longer and, therefore, leads to fewer repavements and lower costs. Such drastic reductions in temperature offer the potential benefits of substantially cutting fuel consumption, plant emissions, and the production of greenhouse gases. In addition, engineering benefits include better compaction on the road, the ability to haul paving mix for longer distances, and an extension of the paving season via the ability to pave at lower temperatures. The money saved on fuel costs can then be used to offset material costs and an extension of the paving season can directly impact efficiency. In addition, the lower laying temperature of WMA can lead to more rapid availability of surfaces for use, which is important for projects with critical time schedules, and fewer traffic delays for the public.

¹ Technical memos composed for the Green Infrastructure Study Advisory Committee Brochure. The individual memos provide more detailed information regarding some of the sustainable programs initiated by the KYDOT and will be presented at the KYTC sustainability conference in March 2012.

The methodology behind the warm mix asphalt extends from the need to “thin out” its binder. Essentially, traditional concrete asphalt pavement is composed of two quantities, a mineral aggregate and a binder. The common composition is 95 percent aggregate and 5 percent binder. The mineral aggregate is the portion of the pavement that makes up what the road is composed up. This is usually sand, stone, or gravel. The binder, in this case, is the asphalt mix. Due to its highly viscous nature, asphalt must be heated so that it can be mixed with the aggregate and turned into pavement. Traditional HMA is mixed at approximately 300 degrees and paving must be conducted while the asphalt is sufficiently hot. WMA can substantially reduce this mixing temperature by employing non-thermal methods to decrease the asphalt binder viscosity. These non-thermal methods typically included the adding of wax or chemical additives or an asphalt/water emulsion to the mix.

III. RESULTS / CONCLUSIONS

Recently there were 9 WMA projects reviewed in the state of Kentucky (5 chemical additive, 4 wax additive). These pilot WMA research projects were examined in Webster, Meade, Hardin, Mercer, Lincoln, Casey, Breathitt, Hickman and Lawrence counties. The results of these studies demonstrated that the WMA product was essentially as good as the HMA alternatives in terms of construction quality (density) and proved to be more cost effective. Specifically, for every 30 degrees in temperature reduction only a 1 percent reduction in density was noted. Further, temperatures for the WMA were an average of 60 degrees cooler than those for HMA; the offshoot being significant benefits in environmental sustainability and fuel savings.

On the federal level, the National Asphalt Pavement Association (NAPA) reports that, as of December 2011, 20 state DOTs have adopted WMA programs and 47 million tons of WMA was produced in 2010. Via that 47 million tons, the association reports that 30 million gallons of fuel were saved at a savings of more than \$80 million dollars. Extrapolating from these numbers, the NAPA projects a 2010 removal of 800,000 tons of carbon dioxide from the atmosphere. Further, they project that WMA saves between a half-gallon to a full gallon of fuel per ton of mix and, once fully deployed, will be the equivalent of removing more than 1.5 million vehicles from the road every year. An implication that is clearly substantial in terms of both cost effectiveness and environmental sustainability. With the Obama Administration’s prioritization of reducing dependence on fossil fuels and an ever-growing movement toward sustainability WMA appears to be a win-win for the transportation industry.

Division of Environmental Analysis

I. INTRODUCTION

The Division of Environmental Analysis works to ensure that projects and activities undertaken by the Kentucky Transportation Cabinet are completed in an environmentally responsible manner, recognizing the importance of developing projects with sustainability in mind and the potential implications of Cabinet activities. KYTC then works to minimize resulting impacts to the human or natural environment that cannot be evaded. Each of the described programs is designed to promote KYTC's larger goal of statewide environmental responsibility.

II. LIST OF PROGRAMS

1. Threatened and Endangered Habitat

The goal of this project is to identify a better way for KYTC to anticipate the location of threatened and endangered habitats so that these areas may be avoided in transportation planning and development. The initiative utilizes a rules based spatial model of where one would expect species and habitats to be. The benefits of this project are that it helps biologists, planners and designers do their jobs more quickly and promotes informed decision making.

2. Kentucky Prehistoric Behavior Mapping

The goal of this project is to help anticipate the location of artifacts by landform features through a custom derivation of GIS layers. This project is currently in its fifth stage; the first four stages focused on specific Kentucky regions, including Woodford County, Inner Bluegrass, Hazard Hills, and Western Kentucky. One benefit of this kind of mapping is that it requires minimal cost when compared with other models (like that used in Minnesota). Kentucky's predictive model is also far superior and is applicable to the entire southeastern United States.

3. Stream and Wetland Mitigation

Kentucky Transportation Cabinet, through cooperation with groups like The Nature Conservancy, U.S. Fish and Wildlife Service and the Kentucky Waterways Alliance, has endeavored to protect 4,982 acres of land from commercial and residential development, including more than 800 acres of preserved or restored wetland. The cabinet also has protected 49.3 miles of streams, including 17.1 miles of restored stream using natural channel

design. Currently, the cabinet is working in conjunction with The Nature Conservancy and the University of Kentucky to obtain 270 acres of the scenic Kentucky River Palisades located in Garrard County.

4. Indiana Bat Conservation Fund

In 2006, The Fish and Wildlife Service, Federal Highway Administration and Kentucky Transportation Cabinet finished a formal programmatic consultation on the effects of minor highway projects on the endangered Indiana bat. This agreement streamlines Endangered Species Act consultation for minor highway projects due to the creation of the Indiana Bat Conservation Fund (IBCF). The IBCF allows KYTC to pay a mitigation fee for project effects on Indiana bats. The funds are then used to protect bat habitat areas, preserve hibernacula or conduct other important species recovery activities. The IBCF also accepts contributions from other organizations or individuals, and since its beginning, the IBCF has been given over \$4 million, \$1.5 million (35%) of which has come from KYTC. The fund has been utilized to identify and obtain crucial habitat areas, arrange secure gates over cave openings susceptible to human and animal interference and help with Indiana bat telemetry studies used to locate maternity colonies.

5. Environmental Viewer

This program allows construction project coordinators to determine whether potential projects will impact environmentally susceptible areas. When such impacts are deemed likely, project representatives can contact the district environmental coordinator or the Division of Environmental Analysis. The viewer can be accessed at <http://maps.kytc.ky.gov/environmentaloverview/>. The interactive viewer allows users to view geographic areas at varying degrees of specificity, including city, county, route number and name, USGS Quads, districts and degrees of latitude and longitude.

III. CONCLUSIONS

This brief summary of current KYTC programs illustrates the diligence of the cabinet in its goal of promoting environmental responsibility in planning and development projects across the state, through education, funding, information accessibility and model research and development.

Prehistoric Behavior Mapping

I. INTRODUCTION

Analytic predictive archaeological models can have great utility for state Departments of Transportation, but it is difficult to model the likelihood of

prehistoric settlement using geographical proxy predictor variables because of the complexity of how settlement choices were actually made, and the complex interaction between these variables using GIS. In many cases classic statistical modeling approaches require too much data to be useful. This research reports on a preliminary predictive model that combines spatial analysis and fuzzy logic modeling to capture expert archaeological knowledge and convert this into predictive surface.

II. PROJECT GOALS

1. Develop GIS tools for archeologists to use to better understand the likelihood of encountering archaeological resources (in this case, prehistoric lithic scatters)
2. Capture and model basic settlement pattern relationships to landforms, using GIS data and tools
3. Express output as comparative likelihood: very low, low, moderate, high, or very high

III. PROCEDURE

The project was divided into 4 phases, each with a different test area.

Phase 1: Woodford County

Phase 2: Inner Bluegrass

Phase 3: Hazard Hills

Phase 4: Western Kentucky

A test area was defined in each of these regions, and five influencing factors were defined and calculated using the ArcGIS platform. Points were sampled and probabilities estimated using both small and large group structured processes from a broad range of archaeologists that fed a forward-backward fuzzy logic induction process. It was used to generate and refine a knowledge base that mapped all inputs to an output probability function. These data were extracted from the fuzzy logic model to a lookup table and then geocoded into the ArcGIS platform, generating output surfaces showing the probability of encountering artifacts across the entire study area.

Landscape properties that interact to influence prehistoric settlement decisions:

1. ***Slope in degrees of the surface.*** It is difficult to maintain a habitation on ground that is too steep, and increasingly difficult to impossible as slope reaches certain values.

2. ***Walk in minutes to nearest walkable water (including springs) using Tobler’s algorithm for computing walking time.*** Access to water promotes the likelihood of settlements.
3. ***Walk in minutes to nearest walkable confluence on streams with a Strahler order of 3 or higher.*** The confluences of larger streams are an attractive factor for habitation location.
4. ***Elevation difference to nearest walkable water (not direct line) in feet.*** There is a risk of flooding at very low elevations and there are various attractive landforms high above river bottoms.
5. ***Stream size.*** This factor helps mediate the relative impact of distances to water by the size and reliability of the water source.

IV. RESULTS / CONCLUSIONS

The tested results for models other than those for the Western Kentucky portion currently meet or exceed the performance of the most extensive and expensive models in the United States. Implementation of the model outputs is underway, so that KYTC archaeologists can begin to use the models to enhance their analysis of the potential locations of prehistoric sites. Work continues on customizing the modeling process to the unique landform properties of Western Kentucky and to explore the potential benefits of forthcoming high-resolution aerial (LIDAR) photography.

Technology Transfer Training Programs

INTRODUCTION

The Technology Transfer Program (T2) has delivered technical assistance and training to transportation agencies across Kentucky for over 30 years. The program promotes efficiency in Kentucky’s transportation system by providing workshops and training events, newsletters, how-to manuals, new and existing technology updates, legislative and regulatory news, on-site technical assistance; and access to the only transportation library in the Commonwealth.

Kentucky’s T2 Program is designated a Local Technical Assistance Program by the Federal Highway Administration or LTAP. Similar centers exist in the 50 states, Puerto Rico, and centers have been established to serve Native American Tribal governments (TTAP). These centers share a common mission to “foster a safe, efficient, and environmentally sound surface transportation system by improving skills and increasing knowledge of the transportation workforce and decision makers.”

T2 provides several programs specifically designed to cut transportation costs and provide effective and environmentally beneficial solutions to transportation

problems. These programs include Warm Mix Asphalt (WMA), Kentucky Erosion Prevention and Sediment Control, Safety Circuit Rider, Snow and Ice Training, and Roads Scholar.

One Stop Shop

I. INTRODUCTION

The “One Stop Shop” is an office of the Department of Motor Vehicles (DMV) that has combined three divisions to help better meet transportation needs and increase efficiency. These three combined divisions are; Drivers Licensing, Motor Vehicle Licensing, and Motor Carriers. The “One Stop Shop” is equipped with state of the art technology which allows for the general public to now complete all of their vehicle related transactions at one location. As a result, costs are reduced due to increased efficiency and sustainability is improved via decreases in travel costs and a reduction in the redundancy of paper work.

II. PROGRAM DETAILS

All of the services offered previously by the three separate departments of Driver’s Licensing, Motor Vehicle Licensing, and Motor Carriers are now provided by the “One Stop Shop”. These services include the scheduling of traffic school, judgment satisfactions, discretionary hearings, driver’s licensing, and title processing, among a variety of other services. By providing all of these services under the auspices of one office, the “One Stop Shop” aims to, not only become more cost effective, but also further the state’s sustainability initiatives. To this end, the program should produce less paper work due to increased efficiency and decreased redundancy between offices. The office has also received a major overhaul in technology, which further greatly reduces the need for paper transactions as many such transactions are now processed electronically. Also, the combining of all three offices under one roof should have a small but non-negligible impact on the reduction of greenhouse gas emissions by reducing travel for customers.

III. RESULTS

To date, the One Stop Shop has begun initiating several programs to streamline various processes and steer them away from traditional paper transactions and toward online transaction. First, several tax forms were brought online in the past two years, among these were; the International Fuel Tax Agreement (IFTA) forms, Kentucky Interstate Tax (KIT) forms, and the Kentucky Highway Use (KYU) forms. Second, the One Stop Shop also integrated with the International Registration Plan (IRP) in 2013, allowing fleets to register their trucks online. Third, on interstate and major highway systems there are no overall length restrictions, however, on these highways the trailer is limited to 53 feet in length by 8 feet 6 inches in width. Carriers with non-divisible loads exceeding these

dimensions are required to purchase an overweight/over-dimensional permit. Those permits became accessible online in the summer of 2012. In addition to moving these permit and tax forms online, various drivers' licensing procedures are also moving to the net. License reinstatement, changes of address, and registration, since 2014 are all conducted electronically. Also, temporary permits and field trip permits will similarly be handled online which will provide customers with 24/7 access to these service as opposed to the current 9-5 availability.

Traffic and Safety Programs

I. INTRODUCTION

The Kentucky Transportation Cabinet has undertaken several new initiatives in the interest of driver safety and smoother traffic flow on state roadways. These programs include Signal System Performance Measures, Traffic Signal Technician Training, Adaptive Signal Systems, Travel Time Analysis, and LED Traffic Signal Bulbs.

II. PROGRAM DETAILS

1. Signal System Performance Measures

The objective of this study is to develop and/or identify appropriate measures of effectiveness for roadway performance and efficient means of collecting pertinent data. This study will recommend performance metrics that are available from existing data sources and are sensitive enough to reflect changes to system timing and develop and deploy practical, cost effective systems and procedures that can measure traffic signal performance utilizing existing KYTC resources. These practices will be evaluated at several field locations as a proof-of-concept to assess the effectiveness of these methods to produce effective and meaningful performance measures and aid in optimizing the operational efficiencies of signal systems.

2. Traffic Signal Technician Training

The objective of this project is to develop training and a certification process for traffic signal technicians. A practical and cost-effective training and certification program will be provided for the Transportation Cabinet's traffic signal technicians.

3. Adaptive Signal Systems

The objective of this study is to perform a comprehensive evaluation of an Adaptive Traffic Control System deployed along US 60 (Winchester Road). In addition, KTC will utilize hardware-in-the-loop micro-simulation to test and evaluate the ATCS under a wide range of conditions and develop preliminary

guidance for ATCS deployments. The pilot project will also be used to increase interest and knowledge of ATCSs and encourage their use and implementation throughout the state.

4. Travel Time Analysis

Travel time analyses compare the performance on popular commutes using annually updated information. Via these analyses, the DOT can address bottleneck and safety concerns and ultimately reduce congestion. All of which leads to lower fuel costs, fewer greenhouse gas emissions, and reduced travel time.

5. LED Traffic Signals (CMAQ project)

This initiative is aimed at replacing traditional fluorescent bulbs in traffic signals with more efficient and durable LED bulbs. Such bulbs provide a 90% increase in energy savings, less maintenance, and a more reliable and extended lifespan.

Federal Sustainable Highways Initiative

I. Introduction

The Federal Sustainable Highways Initiative defines a sustainable highway as one that satisfies the life cycle functional requirements of societal development and economic growth while striving to enhance the natural environment and reduce consumption of natural resources. Recognizing the need for a universal tool that measures sustainability within the transportation industry, the Sustainable Highways Initiative has implemented the INVEST self-evaluation tool.

II. Purpose

The goals of the tool are to assist in the tracking and assessing of sustainability progress, encourage broad participation in sustainability initiatives, evaluate sustainability trade-offs, meet and anticipate new requirements, find and address barriers, and communicate benefits and goals.

III. Methodology

The program name for the self-evaluation tool is INVEST, and it comprises both a set of best practices for highway projects and tools for assessing a project against these criteria. However, although it offers guidelines and evaluations, it is not a mandate. It operates by first identifying a set of criteria for best practices

and then directing research into and application of these practices. Further, it provides a standard quantitative evaluation method that can be broadly applied.

Each criterion can be traced back to at least one of the three sustainability principles of environment, society, and economy. As the nature of these sustainability principles requires industries to make trade-offs between or among different aspects of sustainability, INVEST has the potential to greatly benefit the process. The criteria are presented in tables 1 and 2.

Once a project is evaluated via the below criteria, it is scored based upon the percentage of the criterion it successfully adheres to. Those programs that adhere to 30% or more of the criteria receive a Bronze rating, those adhering to 40% of the criteria receive a silver rating, those adhering to 50% receive a gold rating, and those adhering to 60% receive a platinum rating.

Table 1: FHWA Sustainable Highways Criteria and Triple Bottom Line Principles for System Planning

System Planning and Processes Criteria by Principles			
Criteria Number and Title	Triple Bottom Line Principles		
	Environmental	Social	Economic
SP-1: Integrated Planning: Land Use and Economic Development			✓
SP-2: Integrated Planning: Natural Environment	✓		
SP-3: Integrated Planning: Community		✓	
SP-4: Accessibility		✓	
SP-5: Safety Planning		✓	✓
SP-6: Multimodal Transportation		✓	✓
SP-7: Freight Planning			✓
SP-8: Travel Demand Management	✓	✓	✓
SP-9: Air Quality	✓	✓	
SP-10: Energy and Fuels	✓	✓	✓
SP-11: Financial Sustainability			✓
SP-12: Analysis Methods	✓	✓	✓
SP-13: Congestion Management	✓	✓	✓
SP-14: Linking Asset Management and Planning	✓		✓
SP-15: Linking Planning and NEPA	✓	✓	✓
SP-16: Infrastructure Resiliency	✓	✓	

Source: Federal Highway Administration, U.S. Department of Transportation

Table 2: FHWA Sustainable Highways Criteria and Triple Bottom Line Principles for Project Delivery

Appendix F – Year 1 Interim Report (State Level Analysis of Transportation Sustainability)

Project Delivery Criteria by Principles			
Criteria Number and Title	Triple Bottom Line Principles		
	Environmental	Social	Economic
PD-1: Cost Benefit Analysis	✓	✓	✓
PD-2: Highway and Traffic Safety		✓	✓
PD-3: Context Sensitive Project Development	✓	✓	✓
PD-4: Lifecycle Cost Analyses	✓		✓
PD-5: Freight Mobility	✓		✓
PD-6: Educational Outreach	✓	✓	✓
PD-7: Tracking Environmental Commitments	✓	✓	
PD-8: Habitat Restoration	✓		
PD-9: Stormwater	✓		
PD-10: Ecological Connectivity	✓	✓	✓
PD-11: Recycle & Reuse Materials	✓		✓
PD-12: Create Renewable Energy	✓		✓
PD-13: Site Vegetation	✓		✓
PD-14: Pedestrian Access	✓	✓	✓
PD-15: Bicycle Access	✓	✓	✓
PD-16: Transit & HOV Access	✓	✓	✓
PD-17: Historical, Archaeological, and Cultural Preservation		✓	
PD-18: Scenic, Natural, or Recreational Qualities		✓	
PD-19: Low-Emitting Materials	✓	✓	
PD-20: Energy Efficient Lighting	✓		✓
PD-21: ITS for Systems Operations	✓	✓	✓
PD-22: Long-Life Pavement Design	✓		✓
PD-23: Reduced Energy and Emissions in Pavement Materials	✓	✓	✓
PD-24: Contractor Warranty	✓		✓
PD-25: Earthwork Balance	✓		✓
PD-26: Construction Environmental Training	✓		
PD-27: Construction Equipment Emission Reduction	✓	✓	
PD-28: Construction Noise Mitigation	✓	✓	
PD-29: Construction Quality Control Plan	✓		✓
PD-30: Construction Waste Management	✓		✓

Source: Federal Highway Administration, U.S. Department of Transportation

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Green Infrastructure

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The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the University of Kentucky, Kentucky Transportation Cabinet, or Federal Highway Administration. This report does not constitute a standard, specification, or regulation. The inclusion of manufacturer names and trade names is for identification purposes and is not to be considered an endorsement.

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Year 2 Interim Report

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Appendix G – Year 2 Interim Report (Review of Transportation Sustainability Metrics)

The following individuals contributed greatly to the successful completion of this project through their participation on the Study Advisory Committee:

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Over the past 25 years a growing chorus of governments around the world has called for more sustainable forms of economic development. These calls stem from the recognition that contemporary development practices often result in environmental degradation, which in turn will prevent future generations from pursuing their economic aspirations in a manner comparable to today's. No definition of sustainable development has gained universal currency; however, most definitions generally include provisions for economic development that minimizes the degradation of finite natural resources while fostering social justice.

Over the past 10 years interest in sustainability has expanded into the transportation field; there has been growing momentum to build and maintain highways in a more sustainable manner. Practitioners have not yet completely agreed upon what features are characteristic of a sustainable transportation system, but they have identified some common elements. Sustainable transportation systems typically improve economic efficiency, support a competitive economy, preserve the welfare of humans and ecosystems, use design principles that limit waste and emissions while fostering infrastructure resiliency, and promote socially equitable access to a variety of transportation options.

The State of Kentucky has expressed interest in assessing to what extent its highway design, construction, and operations incorporate sustainability principles. Kentucky's interest is in keeping with the nationwide push to develop transportation solutions that aid short-term economic growth while also protecting the environment and ensuring that future generations have the resources needed to stimulate economic development. This research reviews the application of sustainable thinking to road construction and design, looks at methods for evaluating highway sustainability, and identifies potential highways in the State of Kentucky that, during the next year, will be the subjects of the Kentucky Transportation Center's evaluation.

This report focuses on the application of sustainability principles to highway design and construction. Chapter 1 provides a general overview of what sustainability is, and how the concept has developed over the past 25 years. After sketching a brief history of sustainability, the basics of sustainable highways are discussed to demonstrate how contemporary thinking on sustainable infrastructure borrows heavily from ideas first applied to economic development. This chapter concludes with a brief discussion of why sustainable roadways are valuable assets – not only do they promote economic growth, environmental protection, and social equity, but using sustainable design and construction methods reduce lifecycle costs while enhancing infrastructure resiliency.

Over the past five years a number of systems have been designed at the national and state level to measure roadway sustainability. Chapter 2 discusses what benefits can be realized by formally evaluating the sustainability of highway projects. It then appraises the two sustainability rating systems most commonly used in the United States – Greenroads and the FHWA's INVEST 1.0 tool. This chapter has three purposes: 1) familiarize readers with how these ratings systems score sustainability; 2) discriminate between Greenroads and INVEST, with the aim of identifying their respective strengths and weaknesses; and 3) determine which system is appropriate to use to assess the sustainability of selected highway construction and maintenance projects in Kentucky. Although both rating systems share many similar features, and implement closely aligned definitions of sustainability, INVEST provides a better option to score projects because of its flexibility. Unlike Greenroads, which has a primary focus on the design of Greenfield Construction, INVEST allows users to choose from a variety of scorecards depending on the scope of the project considered. It has customized scorecards, giving users the ability to score not only new construction or major rehabilitation projects, but also minor projects like resurfacing.

Chapter 3 outlines the methodology that will be used to score case studies in the State of Kentucky during the upcoming phase of research. Documentation is required to provide objective ratings. This chapter provides extensive details on the nature of that documentation and the steps involved in scoring projects. The purpose of scoring projects is twofold. First, researchers will determine whether a project would qualify for a sustainability certification under the INVEST system. Second, scoring projects provides an opportunity to determine what kind of sustainable design and construction methods could be added to a project without excessive cost. Chapter 4 discusses the criteria used to select highways and compiles the highways selected for evaluation. Currently, there are 14 road projects on the list; the goal is to generate ratings for five to seven of these. KTC researchers consulted with branch managers and the study advisory committee (SAC) to determine appropriate projects. After KTC developed an initial pool of candidates, the SAC ranked the projects based on priority; during the next phase of research, KTC researchers will begin at the top of this list and work their way down until they have scored the targeted number of projects. Chapter 5 offers a brief conclusion and a discussion of future work objectives.

1.1 Introduction

The purpose of this first chapter is to introduce the concept of sustainability and the ways it has been applied within the context of transportation. First, it summarizes current thinking regarding sustainability. Because of the subject's complex nature, there has been vigorous debate over what kinds of practices are sustainable, and what activities are unsustainable. These introductory comments familiarize the reader with the essential tenets of sustainability; their goal is not to exhaustively review debates about sustainability, or to resolve them. Rather, the emphasis is placed on illuminating ideas that have gained purchase among transportation planners and professionals. This establishes a bridge to later sections of the chapter, which explicitly discuss the ways in which the concept of sustainability has been deployed within the field of transportation planning to enhance roadway sustainability through innovative engineering, design, and construction methodologies. The chapter finishes with a discussion about the benefits state transportation agencies and stakeholders may realize by proactively incorporating a sustainability agenda into highway design and construction. Chapter 2 will expand upon these considerations through an analysis of various sustainability rating systems that have been designed to 1) measure the sustainability of roads and 2) specify a set of best practices that can be used to improve the sustainability of road projects. A key takeaway from this chapter is that sustainability is not purely concerned with improving the environment; sustainable transportation policies also aim to encourage economic development and expand access to the transportation system.

1.2 Defining Sustainability

Traditionally, the concept of sustainability has prioritized the human relationship with the environment, but has not engaged to the same degree with issues of economic development and social equity. Although the concept of sustainability did not receive a formal definition until the 1970s and 1980s, there has long been the recognition that natural capital is finite, and that human well-being depends on using those resources in a wise, economic, and conservative manner (Mebratu 1998). It is understandable sustainability is most closely linked to questions about the health of ecological systems and the damage humans impart to them through their day-to-day activities. During the 1960s and 1970s, in the United States, people became more aware of the environmental degradation afflicting the landscape. This led to increased calls for policies meant to curb the human excesses that not only damaged the environment, but also posed a threat to human health. The passage of the National Environmental Policy Act in 1970 was a milestone in that it demanded environmental considerations be taken into account when making policy decisions at a federal level. Although this was a landmark piece of legislation, and represented a response to what were perceived as burgeoning crises facing the environment, it did not explicitly call for more sustainable forms of development.

The idea of sustainable development gained widespread visibility after the release of *Our Common Future* in 1987, published by the UN's World Commission on Environment and Development (Daly 1996). Arguably, this was a decisive turning point as the report introduced a definition of sustainable development that is oft-cited even 25 years later: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, pp. 105). While this definition retains currency, there are numerous disagreements whether this statement offers any kind of practical guidance about how to achieve sustainability. The WCED report was also important because it shifted thinking about sustainability from an environmental-centric perspective, to one more concerned with maintaining economic development into the future. Priority is given to sustainable growth. While the environment is not pushed into the background entirely, *Our Common Future* catalyzed a more expansive approach to sustainability that was not singularly focused on environmental

matters – though they do remain central because of the integral role that natural resources have in opening up the possibility of economic development. Daly (1991) outlines what steps must be taken to label a set of practices and policies sustainable: rates of renewable resource use cannot exceed the rates of regeneration; the pace at which non-renewable resources are used cannot be faster than the rate at which new renewable resources are developed; and pollution emissions must not be overwhelming such that they cause lasting and permanent harm to ecosystems or human health. The basic idea behind institutional concepts of sustainability is that economic development must be pursued in a way that minimizes damage to natural resources. “Institutional” in this context refers to definitions favored by governments, supra-national organizations, and other entities that operate outside of an academic context and are directly involved with policymaking (see Table 1.1. for a listing of institutional definitions of sustainability).

During the 1990s a revised understanding of sustainability emerged that sought to balance environmental concerns, issues of social equity, and economic growth. John Elkington (1998, 2002) coined the term “triple bottom line” to describe the appropriate purview of sustainability. The triple bottom line was originally intended to give corporations guidance they could use to enhance sustainability. The triple bottom line thus focuses on the economic, environmental, and social value that is either added or destroyed by pursuing a set of practices. Elkington targeted the private sector with his ideas, but they quickly took hold in governmental and institutional settings. For example, at the 2002 World Summit on Sustainable Development participants endorsed a vision of sustainability that stood on the three pillars of environment, economy, and society. The Johannesburg Declaration, which emerged from this conference urged “a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development—economic development, social development and environmental protection—at local, national, regional, and global levels” (quoted in Kates et al. 2005). The triple bottom line has served to counteract the reorientation that occurred following *Our Common Future*; it has sought to highlight that economic growth and development are needed, but they cannot be neglected at the expense of other considerations.

The triple bottom line has become the dominant paradigm in institutional thinking about sustainability. Avoiding questions of social justice and environmental protection will lead to unsustainable policies. What remains to be seen is how well this approach can in fact encourage the implementation of sustainable policies across local, regional, and national scales. As Pawlowski (2008) writes, sustainable development has been driven mostly by stakeholders working at the local level to achieve the necessary buy-in. Sustainability is within reach at the local level, but it remains unclear whether policies oriented towards sustainability can be scaled up to have more far-reaching influence. This question may be unresolved, however, the fact that sustainable policies have been most successful at local and state levels suggests transportation and infrastructure is a logical sector in which to develop policy strategies to improve sustainability. Even so, the daunting challenge for transportation planners is to define sustainability with enough flexibility and specificity that it translates into practical, actionable policies. Many have used the institutional definitions as a starting point to identify the attributes of sustainable roadways. Listed in Table 1.1 below is a sampling of definitions of sustainability that have been advanced by different agencies, governments, and organizations.

Table 1.1 – Institutional and Governmental Definitions of Sustainability

Source	Definition
World Commission on Environment and Development (United Nations)	Sustainable development “meets the needs of the present without compromising the ability of future

Environment Canada	generations to meet their own needs” “Sustainable development can be defined as the process of developing land, cities, business and communities so that our current needs are met without compromising the ability of future generations to meet their own needs. It recognizes that social, economic and environmental issues are interconnected and that decisions must incorporate each of these aspects in order to be successful over the longer term.”
Themes Sustainable Development	“Sustainable development is the achievement of continued economic development without detriment to the environmental and natural resources”
Center for Sustainability	Sustainability is “the capacity for continuance into the long term future.” Anything that can go on being done on an indefinite basis is sustainable. Anything that cannot go on being done indefinitely is unsustainable.
US Environmental Protection Agency	“Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations”
Partnership for Sustainable Communities (Interagency Partnership between the US DOT, EPA, and HUD)	“Sustainable communities are places that have a variety of housing and transportation choices, with destinations close to home. As a result, they tend to have lower transportation costs, reduce air pollution, and stormwater runoff, decrease infrastructure costs, preserve historic properties and sensitive lands, save people time in traffic, be more economically resilient and meet market demand for different types of housing at different price points”

Partially after Litman and Burwell (2006)

Most of the ideas about sustainability listed in the table use the 1987 *Our Common Future* definition as their springboard. The framings differ slightly, however, based on the aim of the organization or government that does the defining. Broadly, these conceptualizations of sustainability share a concern with environmental security, intergenerational equity, and the imperative to fulfill basic needs for all humans. The environment serves as lynchpin. Environmental degradation undermines all efforts to achieve sustainability. As such, there is a danger in privileging one facet of the triple bottom line above all others. As Bell and Morse (2008) write, “the precise meaning of sustainable, and what it embraces, varies depending on who is using it, and in what context (page 8). At the very least, the triple bottom line concept has illuminated the importance of balance – detaching the concept of sustainability from environmental protection is untenable (Redclift 2005). None of this is to deny that sustainability is a valid concept. Rather, it is to note it is elastic, and that implementing definitions via policy can take on an astounding number of forms. It also speaks to the context-sensitive nature of sustainability. What is

considered sustainable in one context may produce unacceptable levels of environmental damage, or undermine social justice, in another.

Definitions act as programmatic statements that orient the way in which a particular entity pursues sustainability, however, economists and environmental scientists add another layer of complexity. They distinguish between different forms of sustainability: negative, superficial, weak, and strong. A negative definition of sustainability rejects the concept outright; it refutes the benefits, or even the possibility, of adopting any kind of policy that purports to improve sustainability. Usually these objections are made on economic grounds – adopting a sustainable agenda will cost too much over the short-term and will bring negligible benefits over the long-term. A superficial notion of sustainability is pervasive in contemporary political discourse. If planners, politicians, environmental managers, or businesses reference or appeal to the concept of sustainability without enacting policies that materially improve sustainability, it is a sure sign that a superficial definition has been used. Certainly, among citizens and consumers who are concerned about non-sustainable practices, talking about the importance of sustainability will allay their fears that nothing is being done. But the entire purpose of discussing sustainability in a superficial way can be to avoid making any kind of changes in behavior. The language of sustainability is thus used to disguise the fact that the policies that are identified as sustainable by businesses or governments will do little to improve sustainability.

More often cited are the definitions of weak sustainability and strong sustainability. Weak sustainability accentuates the importance of economic growth. By increasing the efficiency of resource use, proponents of weak sustainability claim it is possible to maintain steady economic growth. According to this definition, humanly made capital and natural capital are seen as interchangeable – depleting natural capital is a concern but technological innovations will ensure that human capital can substitute for the loss of natural resources. As such, advocates of weak sustainability place faith in the ability of technological innovation to correct for our environmental problems. It also proposes that investing in non-natural forms of capital can either offset the loss of natural resources or compensate for ecological damage (Gutés 1996). Conversely, strong sustainability dismisses the view that natural capital is interchangeable with human-produced capital. Supporters of strong sustainability are urgently concerned with environmental conservation, and willing to accept that sustained economic growth may be incompatible with preserving ecological integrity. The underlying premise of strong sustainability is the requirement “of balancing the depletion of non-renewable resources with enhancing the stock of renewable resources” (Hediger, 1999).

This brief sketch of sustainability concepts is not an exhaustive review. It has focused on ideas salient to the world of transportation and infrastructure. In its most basic sense, the triple bottom line of concept argues that sustainability is the product of integrating economic growth with a commitment to ecological protection and the improvement of social equity, both in the near term, and across multiple generations.

1.3 Defining Sustainable Transportation and Sustainable Highways

Although the broad concept of sustainability has elicited much debate, the question the rest of this chapter seeks to answer is what relevance does sustainability have for transportation? Sustainability became a topic of conversation during the 1980s; however, transportation researchers did not broach the question of sustainable transportation until the 1990s. This coincided with the recognition that poorly planned, and ill-conceived infrastructure projects are unsustainable. Litman and Burwell (2006),

using the triple bottom line approach, describe what effects unsustainable infrastructure planning and construction has on economies, the environment, and communities. Table 1.2 lists these impacts.

Table 1.2 – Transportation Impacts on Sustainability

<i>Economic Impacts</i>	<i>Social Impacts</i>	<i>Environmental Impacts</i>
Traffic congestion	Inequity of impacts	Air and water pollution
Mobility barriers	Mobility disadvantaged	Habitat loss
Accident damages	Human health impacts	Hydrologic impacts
Facility costs	Community interaction	DNRR
Consumer costs	Community livability	
DNRR	Aesthetics	

After Litman and Burwell (2006, page 335). DNRR = Depletion of Non-Renewable Resources

Black (1996) offers a definition of sustainable transportation that mirrors the definition of sustainability that is found in *Our Common Future*. He argues that sustainable transportation satisfies “current transport and mobility needs without compromising the ability of future generations to meet these needs” (page 151). This formulation appears often in writing about sustainable transportation, although it is worth noting how vague this definition is. Kevern (2011) specifies that sustainable roadway construction makes use of green, or recycled materials, and relies on techniques that improve the durability of infrastructure to maximize their useful service life. Durability and reliability are common themes in the sustainable transportation literature. Any transportation project entails using natural, often nonrenewable resources. This is unavoidable. But if there is a greater commitment to sustainable practices, by ensuring the service life of a road is longer than what it otherwise would be, then state and local transportation agencies can reduce nonrenewable resource use. Likewise, if roads are more durable and do not require frequent repair, it lessens the amount of stress placed on the environment. Adopting a sustainable approach to transportation serves as a small component of a larger sustainability agenda. Indeed, interest in sustainable infrastructure has exploded over the past ten years, and a number of programs have arisen that evaluate the sustainability of individual road projects, and offer guidance on best construction and planning practices.

The next two subsections briefly describe sustainable transportation systems and sustainable roadways. The two concepts are not synonymous. Roadway sustainability is usually evaluated on a project-by-project basis. The rating systems discussed in Chapter 2 focus on individual projects; they are not intended to evaluate if a state or local agency has comprehensively integrated sustainability principles into broad scale transportation planning. Likewise, they cannot assess the sustainability of regional- or national-scale transportation systems. As such, sustainable transportation systems encompass a broader ambit; systemic analyses would focus on policymaking at large spatial scales. But it is worth noting that a sustainable transportation system will be made up of individual roadways designed with sustainability in mind. Therefore, overlap exists between the two concepts. The main concern of this report is with sustainable roadways, or the individual project level.

1.3.1 Sustainable Transportation Systems

Answering the question of what qualities characterize sustainable transportation systems means first addressing what attributes an *unsustainable* system possesses. Black (1996) identifies a number of characteristics that make a system unsustainable. These include:

- Transportation systems that are petroleum-based
- Poor air quality at local and regional levels due to heavy vehicle use
- Intense traffic congestion
- Excessive noise (the mitigation of which has been tackled in many European countries, but this remains a lower priority in the United States)
- High level of fatalities caused by accidents
- Social groups of different standing lacking equal opportunity to take advantage of transport options
- Habitat and biota negatively impacted

All transportation projects involve a series of tradeoffs. While Black's list is on the mark, it is also idealistic in the sense that it is unrealistic to think the U.S. can attain perfectly sustainable transportation systems. Moving away from a petroleum-based model is unlikely currently. Aside from incentivizing public transport, there will be difficulties in eliminating traffic congestion entirely, or drastically cutting back air pollution. While the elements Black cites are useful points to keep in mind, it also speaks to the problem of state transportation agencies and local government having the ability to correct some features of an unsustainable setup. However, some of the other problems Black specifies can be tackled during the planning process. Habitat degradation is one example. Constructing roadways fragments previously unbroken habitat, which can inhibit movements of various species. The result for these animals is restricted geographic ranges. Although species viability may not diminish immediately, habitat destruction and fragmentation pose a threat to their long-term welfare – this creates an extinction debt, which is effectively a delayed response to habitat loss (Rogers et al. 2009). Finding ecologically sensitive methods of design and construction will improve sustainability. Black's listing also calls attention to the unequal roles different issues have in undermining transportation sustainability. For instance, the triple bottom line concept accords great importance to environmental protection and social equity. Arguably, minimizing habitat fragmentation will have a larger impact on enhancing sustainability than reducing excessive noise. This suggests that while a number of negative qualities diminish sustainability, it is important for planners and contractors to privilege the most urgent concerns when thinking about how to improve sustainability. As Chapter 2 demonstrates, a key drawback of rating systems is their propensity to award points for making changes that will have a minor influence on the greatest concerns.

Thinking about the question of what is unsustainable prompts the question of what is sustainable. Because state transportation agencies look to the triple bottom line for guidance, its tenets often feature in definitions of sustainable transportation systems. The New York DOT (2010), which pioneered GreenLITES, argue that sustainable transportation systems must aim to improve "the economic and social quality of life while limiting impacts on the environment to the carrying capacity of nature". Schiller et al. (2008) contend that transportation practices that promote "healthier ways of meeting individual and community needs while reducing the social and environmental impacts of current mobility practices" are sustainable (pp. xxi). The creation of a sustainable transportation system demands planners and contractors remain mindful of the multiple variables that are manipulated during the course of a project to bring it to fruition. This means that planning and designing a roadway should consider current and future land-use practices. Schiller et al. (2008) note that sustainable transportation systems embody a holistic approach to design and construction. Sustainable transportation "is essentially a societal, rather than strictly technical, process that depends upon planning, policy, economics, and citizen involvement" (Schiller et al. 2008, xxi).

Litman and Burwell (2006, page 345) identify two competing philosophies for incorporating sustainability principles into transportation system planning. Reductionist approaches treat sustainability as reducible to a set of individual problems that are solvable using strategies already incorporated into existing transportation planning frameworks. Comprehensive philosophies, conversely, apply a holistic view of sustainability. That is, transportations can achieve sustainability if planning and construction are coordinated in an integrated manner. It will help to illustrate each approach. Suppose a system is plagued by traffic congestion. Opting for a reductionist solution would treat the traffic congestion in isolation (for example, by building more lanes). But a singular approach is problematic because it is debatable whether adding lanes will reduce congestion. More importantly, treating this issue in isolation *may* temporarily alleviate congestion, but it could have an overall negative impact on sustainability. Lane construction can disturb already-compromised habitat, lead to higher levels of erosion, and reduce the capacity of the system to be multimodal, all of which are key features of a sustainable system. Litman and Burwell (2006) are careful to argue one perspective is not inherently better than another; however, addressing problems on a piecemeal basis is unlikely the best path to achieve sustainability because it may ignore the multiplier/spillover effect whereby solving one problem creates others.

Based on a literature review, the following list contains the features or characteristics often associated with sustainable transportation systems. These systems:

- Maximize economic efficiency
- Minimize short- and long-term economic costs
- Do not endanger the welfare of humans or ecosystems
- Support a competitive economy
- Limit emissions and waste
- Use renewable resources at rates below what they regenerate at
- Adopt novel paving techniques, such as the use of warm-mix asphalt, which is more environmentally friendly and has greater durability
- Avoid limiting the economic, environmental, or social welfare of later generations

So far, little has been said about the social component of the triple bottom line. Sustainable transportation systems avoid disproportionately burdening low-income and minority commuters, either by denying them access to a variety of transportation choices, or by displacing them in order to clear room for new roads. Further, sustainable transportation planning makes use of context sensitive solutions (NCHRP 2002, 2009). As noted previously, the importance of context complicates our ideas about sustainability. While the triple bottom line serves as an underlying foundation that guides the planning of sustainable transportation systems, determining the precise design, contracting practices, and maintenance operations demands that responsible parties work to ensure that the final roadways work within the landscape context, while also serving the needs of individual communities. Indeed, while the triple bottom line is a valuable heuristic, to place sustainability concepts into practice requires planning that diverges from purely textbook definitions of sustainability that are idealized and divorced from the settings in which transportation planning occurs (see NCHRP 2009). For example, the blueprint for a sustainable urban road will differ significantly from the kind of design and construction needed to create a sustainable rural road. Table 1.2 summarizes different institutional definitions of sustainable transportation systems. Including these definitions underlines the themes that run through institutional

and governmental thinking about sustainable transportation, and gives the reader a better sense of the modest nuances that differentiate competing perspectives.

Table 1.3 Definitions of Sustainable Transportation Systems

Source	Definition
European Conference of Ministers of Transport	“A sustainable transport system is one that is accessible, safe, environmentally-friendly, and affordable.”
Transport Canada	“The goal of sustainable transportation is to ensure that environmental, social and economic considerations are factored into decisions affecting transportation activity.”
European Commission’s Energy, Environment and Sustainable Development Programme	“A sustainable urban transport and land use system (a) provides access to goods and services in an efficient way for all inhabitants of the urban area; (b) protects the environment, cultural heritage and ecosystems for the present generation; and (c) does not endanger the opportunities of future generations to reach at least the same welfare level as those living now, including the welfare they derive from their natural environment and cultural heritage.”
Transportation Research Board	“Sustainability is not about threat analysis; sustainability is about systems analysis. Specifically, it is about how environmental, economic, and social systems interact to their mutual advantage or disadvantage at various space-based scales of operation.”
Organization for Economic Co-operation and Development (OECD)	Sustainable transportation “does not endanger public health or ecosystems [and] meets the needs for access consistent with (a) use of renewable resources that are below their rates of regeneration, and (b) use of non-renewable resources below the rates of development of renewable substitutes.”

All of these definitions hit on the main themes of environmental protection, economic development, and social equity. However, there are discrepancies with respect to the level of specificity. Clearly, the current thinking about sustainable transportation systems is heavily indebted to the course charted in *Our Common Future*. One additional point worth highlighting is the assertion by the Transportation Research Board that spatial scale is an important consideration for understanding and implementing sustainable solutions. This aspect is overlooked in most discussions of sustainability. Scalability of solutions is, to some degree, a question about designing context-sensitive solutions. However, it also highlights the importance of integrating planning so that differently scaled projects (e.g. state highways, urban thoroughfares, suburban streets) work with one another to create a system of roads that are sustainable. Individual road types should be designed with some broader picture in mind of how the system fits together, so that each kind of road reinforces the sustainability of the other road types.

1.3.2 Sustainable Highways

Sustainable highways are closely related to sustainable transportation systems. The concept of sustainable highways is focused on the planning, design, and construction of individual road projects. Many of the characteristics of sustainable transportation systems extend to single projects. Sustainable highways are not only context sensitive, but various state transportation agencies, and the federal government, have sought to articulate what features make a road sustainable. The Federal Highway Administration (FHWA), to take one example, emphasizes a sustainability approach that considers planning, project development, and operations and maintenance. From this agency's perspective, a sustainable design alone will not suffice, there must be safeguards built into planning to ensure sustainable design elements are preserved throughout the life cycle of the roadway. While more expansive definitions of sustainability place importance on intergenerational equity, the FHWA adopts a narrower approach. Although it contains provisions related to social equity, the agency's overarching concern is with environmental protection, economic efficiency, and multimodal design. Current and future users of a road, according to the FHWA, should share the same benefits of a road project. Likewise, if a project is not cost effective over its entire service life, it fails a key litmus test of sustainability. Where equity does appear in the FHWA's understanding of sustainable highways, it appears mostly in the guidance for improving bicycle and pedestrian access, preserving culturally significant landscape features, and doing educational outreach. Thus, the FHWA is principally concerned with foregrounding the sustainability of the infrastructure itself; whether this contributes to sustainability on a wider social scale is unclear.

Table 1.4 acts as an extension of Table 1.3. However, here the focus is on sustainable highways (as opposed to transportation systems).

Table 1.4 Definitions of Sustainable Highways

Source	Definition
Green Highways Partnership	"Green highways are those that integrate transportation functionality and ecological sustainability to serve as environmentally responsible and sustainable highways in all aspects, including design, construction, and maintenance"
Federal Highway Administration (FHWA)	"A sustainable highway should satisfy life cycle functional requirements of societal development and economic growth while reducing negative impacts to the environment and consumption of natural resources. The sustainability characteristics of a highway should be assessed and considered from conception through construction and in maintenance operations throughout its lifecycle."
New York GreenLITES Initiative	Sustainable highways "protect and enhance the environment; conserve energy and natural resources; preserve or enhance the historic, scenic, and aesthetic project setting characteristics; encourage public involvement in

USDA Forest Service	the transportation planning process; integrate smart growth and other sound land-use practices; and encourage new and innovative approaches to sustainable design”
Greenroads	“An environmentally friendly road should minimize ground disturbance; be well-drained and appropriately surfaced to control erosion and loss of material; employ effective erosion control measures; and be regularly maintained while continuing to meet user needs”
Sustainable Transportation Council	<p>“A Greenroad provides environmental, economic and social benefits. It efficiently uses resources and renewable materials, helps reduce emissions, manages waste, enables multimodal transport, and is designed to be accessible by all”</p> <p>Sustainable transportation:</p> <ul style="list-style-type: none"> • Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations. • Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy. • Limits emissions and waste within the planet’s ability to absorb them, minimizes consumption of non-renewable resource, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

Based on the definitions above, it is possible to generalize some of the principal features of sustainable roads. A sustainable road:

- Integrates transportation functionality with ecological sustainability
- Incorporates appealing aesthetics and preserves historical or cultural landmarks
- Includes bio-filtration mechanisms, makes use of recycled pavement materials, porous shoulder pavement, and builds in wildlife crossings
- Prioritizes high-quality construction techniques, which prolongs lifecycle and reduces maintenance costs
- Is planned with input from citizens and other relevant stakeholders who may be affected by its construction
- Has the capacity to support natural laws (work within the physical constraints imposed by nature) and human values by minimizing the use of non-renewable and renewable resources

As the effects of climate change become more pressing, and as human demands place an increasing amount of pressure on the environment, the need to adopt a sustainable approach to roadway construction becomes more urgent. The purpose is not to sacrifice mobility to completely protect the environment – an impossible task in any case – but to develop innovative methods of designing and constructing roads to improve the quality of the environment, establish the necessary conditions to promote economic development, and are also more open and accessible (AASHTO 2008, page x). This task is a challenging one, but clearly there is an abundance of knowledge available that will assist federal, state, and local governments as they shift toward a more sustainable pathway.

1.4 Contrasting Sustainability and Livability

Recently, a distinction has been made between the concepts of sustainability and livability. Many definitions of sustainability invoke the notion of livability. The main difference between the two concepts is the temporal scale over which they are applied. Sustainability, while requiring short-term action, is largely oriented toward achieving economic development, environmental protection, and social equity over the long-term. Livability, on the other hand, applies to the near-term. Livability, for transportation, “is about using transportation facilities and services to help achieve broader community goals, such as increasing travel choices, improving economic competitiveness, and enhancing unique community characteristics” (FHWA 2012, page 1). Livable transportation systems are multimodal; while sustainability attempts to promote intergenerational equity and improve economic growth and environmental quality on a large spatial scale, livability pertains to the planning, funding, and implementation strategies at the community level. Arguably, livability does not have the same level of environmental focus as sustainability (which is not to say it neglects it entirely) given that it is about improving the transportation experiences of communities. Livable transportation also emphasizes making transportation decisions to improve the fortunes of communities. That is, if a community opts for a livability approach, the outcome will be improved economies that rely upon a foundation of transportation options that are efficient and dependable. While dissimilar from one another, sustainability and livability are interrelated given that oftentimes transportation planning is not accomplished on a broad scale, but is the result of numerous (sometimes disconnected) projects that unfold at the local, regional, and state level. The most appropriate way of characterizing livability is as a necessary, but not a sufficient, condition for achieving sustainability. The concept of livability enfolds the following elements and practices (FHWA 2012):

- Improving road safety and capacity with better planning, design, and construction
- Integrating health and community design considerations into transportation planning that creates more livable places where residents can easily access a variety of transportation options
- The use of travel demand management approaches and management and operation strategies to increase the efficiency of transportation investments
- Expanding the role of new technologies in road projects, including intelligent transportation systems, green infrastructure, and quiet pavement
- Producing a robust and dependable public transportation system to encourage economic development and open up access to a variety of housing and employment choices
- Creating tight interconnections between different transportation modes to produce a fully connected and usable transportation system

1.5 Why Sustainable Roadways?

In recent years transportation planners have increasingly woven sustainability principles into the planning and execution of infrastructure projects. But this leaves an important question unanswered, namely, what tangible benefits do sustainable roadways bring to communities? Certainly, infrastructure is an integral component of any community's or region's pursuit of economic growth. The efficient movement of vehicles, goods, and people facilitates economic productivity and minimizes losses due to traffic congestion and poorly designed roadways, which cause people to spend countless hours stuck on the road instead of productively laboring. Well-designed, sustainable roads also provide the advantage of being durable. Incorporating a variety of design techniques that lay the foundation for a thoroughly multimodal transportation system (that ensures bicyclists, pedestrians, users of public transit, and automobile users) gives individuals a variety of transportation options, and improves the accessibility of a city, which opens up new employment and housing options that had previously been off limits because the absence of a viable, interconnected transport system placed them out of reach. Decreasing life cycle costs and improving the durability of roads through sustainable design and construction methods undoubtedly places state transportation agencies and local governments in a better financial position. With lower expenditures during the operations and maintenance phase of a roadway's service life, it gives stakeholders the ability to invest in new infrastructure projects, or in other non-transportation related areas. Improving the triple bottom line bolsters the economic bottom line of those agencies and governments tasked with executing road projects.

If infrastructure is vital to an area's long-term growth prospects, then communities need to decide whether to work towards that growth in a sustainable way, or in a way that neglects sustainability. The second option may very well maximize short-term returns on investment. Using the cheapest paving materials, using non-renewable resources in a wasteful manner, designing roads that cater purely to vehicle traffic, and avoiding the issue of environmental destruction may produce infrastructure inexpensively, however, over time, these decisions will exact economic costs that many state and local governments will find burdensome, and in some cases unable to pay. More frequent repairs to roads, demands from citizens for alternative transport options, and negative ecological impacts are all likely consequences that may arise because an unsustainable vision of roadway design is adopted. Obviously, the short-term economic gains generated by pursuing the cheapest mode of building would be reduced, or negated entirely if communities, states, and other entities were required to go back in and do costly repairs or redesigns of a project. Acting unsustainably will produce the unforeseen costs that unavoidably arise from making rash design and construction decisions. Incorporating sustainability principles into transportation planning fosters a development plan that is not nearsighted. This will distribute the benefits of economic growth over a longer period, reducing potential costs associated with environmental degradation and repairing highways constructed using a business-as-usual model that sidesteps questions of sustainability. In many cases, incorporating sustainable planning and construction practices will not greatly affect the overall cost of the project. In cases where expense is greater, the difference in cost is offset many times over the long-term by lessening the economic obligations on states and municipalities that accompany redesigning and repairing roadways that were unsustainable from the start. Using sustainability principles now ensures that the money saved can be reinvested in the future to improve growth and further expand transportation options. Chapter 2 will further explore the multifaceted benefits – environmental, social, and economic – that sustainable highways bring to the communities they are placed in.

1.6 Summary

Sustainability is difficult to define, but most institutions agree that it involves crafting development strategies that pay close attention to the triple bottom line – sustaining economic growth, improving and protecting the environment, and promoting social equity across generations. When applied to the world of transportation, sustainability concepts encompass many of the same goals; however, they are geared towards improving sustainability through infrastructure projects. Encouraging road projects that are sustainable, durable, and expand a variety of transportation options to all members of a community is a sure way to achieve greater sustainability while contributing to a more livable environment. Because there is not a universal formula to achieve sustainability in roadway projects, context sensitive solutions are necessary that take account of the contingencies embedded in the settings where road construction takes place. While this chapter has defined the basic components of sustainable highways, what has not been discussed are the methods that state and local agencies can use to assess the sustainability of their infrastructure projects. Chapter 2 accomplishes this by discussing two methods of performing this kind of assessment – Greenroads and the FHWA’s Sustainable Highways Self-Evaluation Tool. A comparison of these systems is made to determine which one is most appropriate for judging the sustainability of different road projects in the State of Kentucky.

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Appendix G – Year 2 Interim Report (Review of Transportation Sustainability Metrics)

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2.1 Introduction

Having discussed the concepts of sustainability and sustainable roadways in the previous chapter, this one looks at new rating systems that have been developed to evaluate the sustainability of roadways. Currently no state (or the federal government) requires that road projects receive a sustainability assessment. In this sense, using the rating systems is purely voluntary. With a system like Greenroads, it is possible to have a road project certified as sustainable after an outside review team independently rates the project. However, most of the rating systems created thus far do not have a certification mechanism. Instead, project managers and state transportation agencies can use these systems to determine the level of sustainability they are achieving. This chapter discusses the methods that rating systems use to measure sustainability. It then talks about two of the most prominent rating systems – Greenroads and the Federal Highway Administration’s INVEST. Although other states have developed evaluation tools and sustainability metrics (e.g. Illinois, New York, and Wisconsin), FHWA’s INVEST and Greenroads are by far the most visible nationally. Based on earlier research, this chapter discusses a Kentucky road project (KY 1830) that was examined using these rating systems. Although not comprehensive, the purpose of this informal analysis is to provide a sense of what kind of research has previously been done, and to give readers an idea about the additional expenditures that would be necessary to bring this specific project up to a minimum sustainability threshold, as articulated by Greenroads and FHWA’s INVEST. Because it is a national tool and does not require third-party certification, it is the recommendation of this report that the State of Kentucky adopt the FHWA’s INVEST criteria to assess roadway sustainability. Another reason for adopting INVEST is the less restrictive requirements it imposes on projects, whereas Greenroads is much stricter about projects meeting a standardized set of criteria (unreasonably inflexible, which statement is justified later in this chapter). While each system is oriented, loosely, around the triple bottom line concept, the FHWA approach is more flexible in its scoring methodologies, and as such puts forward a more practical view of sustainability.

2.2 Measuring Roadway Sustainability: Methods and Benefits

If there is no universal agreement about what sustainability is, this raises the question of how to measure the sustainability of a roadway. As the previous chapter clarified, while sustainability remains a contentious topic there is a fair amount of agreement regarding the ingredients necessary to create a sustainable road. In the transportation sector a number of programs have emerged over the past five years designed to evaluate the sustainability of road projects. Most of these rating systems rely on a mixture of semi-quantitative metrics and more qualitative information (planning and design documents; financial analysis; lifecycle assessment) to gauge roadway sustainability. So far, a number of states have implemented formal programs that can certify whether a road is in fact sustainable – in New York GreenLITES has been developed to accomplish this, while Greenroads originated in Washington State (although Greenroads is attempting to gain a regional, and possibly national foothold). At the national level, the FHWA has developed INVEST, a freely available tool that state transportation agencies, and other interested parties, can use to measure the sustainability of roadways. The FHWA recently relaunched this tool at INVEST 1.0, which updates previous versions, and incorporates a method for scoring projects of varying magnitudes. In this sense, INVEST is scalable, and rating scorecards have been designed to accommodate different projects (e.g. greenfield construction, paving and rehabilitation projects, among others). Because these systems build off of the triple bottom line, what these systems measure is the success with which a project 1) enhances or maintains economic development; 2) protects and improves environmental integrity; and 3) helps create a more equitable transportation system.

The benefit of rating systems is that they offer a standardized platform for calculating sustainability. As such, these repeatable accounting systems can be applied to highway projects in any context. While systems can be adjusted to accommodate different magnitude projects, the core metrics on which sustainability is scored does not change. Using rating systems is relatively easy, although a complete assessment is possible only after a project has reached completion. However, the intention of scoring systems is not just to offer planners, state transportation agencies, and contractors with a *post hoc* method of measuring sustainability. By laying out what is sustainable and what is not sustainable, rating systems implicitly encourage a proactive approach to design, engineering, and contracting. With knowledge of what design elements and construction practices earn points, stakeholders can make informed decisions about how they will pursue sustainability. Following project completion, revamping or redesigning aspects of a road to enhance its sustainability would be costly, and oftentimes unfeasible. Thus it is in the interests of stakeholders to know in advance about the metrics that are used to analyze projects. Whether or not rating systems spur new activity in sustainable design and construction is a question that remains unanswered.

Rating systems operate on a straightforward principle. Rating systems use discrete sustainability criteria that are evaluated independently of one another. For example, a project can receive points for including provisions to restore habitat or increase pedestrian access. Systems like Greenroads and INVEST have over 40 categories that are scored. To illustrate this more concretely, take an example from Greenroads. One of Greenroads' metrics is 'Runoff Quality.' The idea behind this criterion is that using design features that minimize runoff from a road will improve stormwater management, and lower the negative impact on surrounding ecosystems. If there is excessive runoff, it can accelerate erosion along roadside habitats. If large amounts of unconsolidated soil occupy roadside, the fast-moving water sheeting off of pavement can pick up that soil and convey it to streams, ponds, and ditches, which can negatively affect riparian habitats, especially aquatic life. Runoff can also contain pollutants originating from pavement (e.g. oil). Greenroads awards 1-3 points for effective runoff mitigation. The Greenroads manual supplies formulas to calculate the usefulness of the measures instituted. A project earns a higher score by implementing a plan that keeps, for example, the concentration of suspended sediment and oil to a minimum. A road project qualifies as sustainable by accumulating credits, and passing a threshold (which differ according to the rating system – see the next section for details). Although different rating systems have proprietary criteria and methods of scoring, there is a great deal of overlap with respect to what qualities improve roadway sustainability. Projects are assessed based on the planning and design phase (i.e. whether sustainable principles guide design), the construction phase, and lastly the maintenance and operation phase. The metrics look at numerous facets of roads – access, construction methods, materials used during construction (e.g. use of recycled materials), equity, and the overall environmental friendliness of the project. The diversity of these criteria consequently precludes a quick summary that accurately captures everything these rating systems seek to measure. A detailed summary of each rating system and their rating criteria is beyond the scope of this project; readers should consult the individual manuals for exhaustive narratives of how projects are scored.

If the State of Kentucky wants to adopt a method of systematically auditing roadway sustainability, interested stakeholders, including the Kentucky Transportation Cabinet, will need to decide which rating system 1) best fits the needs of the state; and 2) provides the most accurate gauge of how sustainable a project actually is. Eventually, this may involve adopting an existing rating system, but revising it to meet Kentucky's needs. Or, possibly developing a certification system that enables the State to objectively evaluate road projects, and if warranted, designate them as achieving a certain level of sustainability. Moving forward, a few precautionary notes are necessary. As Haichert et al. (2009) observe, the main

shortcoming of rating systems is that they tend to award points or credits for activities or design elements that do little to improve the sustainability of transportation. When deciding on a rating system, the State of Kentucky should consider what elements of sustainability will have the greatest long-term impact (e.g. planning that emphasizes economic development, habitat protection). Because sustainability is a multi-faceted concept, the State of Kentucky may benefit by beginning with existing systems and fine-tuning them in accordance with the State's long-term environmental and economic goals.

Although flawed, rating systems serve an important function. They can provide the State of Kentucky with a baseline estimate of where the current design, construction, and maintenance practices rate in terms of their sustainability. By evaluating recently finished road projects, the State can self-assess current practices, and determine what areas could use improvement, and what aspects of sustainability it wants to target going forward. Because this report will assign rating to projects, the remainder of this chapter briefly discusses two evaluation systems – Greenroads and the FHWA's INVEST 1.0 tool. Each system is treated separately; they are then compared to evaluate their strengths and weaknesses. The purpose of this sequence is twofold. First, it familiarizes the reader with some of the details of these systems. Second, it enables us to justify our decision to use one of the systems to evaluate roadway sustainability. While these programs are *entirely voluntary*, as neither state nor federal law mandates that transportation projects achieve a minimum level of sustainability, it is important to note that by measuring sustainability it is possible to identify new, more efficient methods of designing, building, and maintaining roads. Sustainability, while often associated with the environment, is very much an economical consideration as well. Road projects that are unsustainable, and which produce infrastructure that deteriorates rapidly, can result in states and municipalities incurring expenses that were entirely preventable had a more sustainable path been chosen. Improving roadway sustainability is also a strategy for creating more resilient and durable roads. Thus, placing transportation on a more sustainable path can yield substantial economic benefits, and potentially foster long-term economic development. Even in the absence of a legal mandate, that State of Kentucky has material and financial interests in pursuing a more sustainable form of infrastructure development. Doing so will prove beneficial for the environment, amplify social equity, and set the stages for shoring up the State's economic bottom line.

2.3 Greenroads

Originally developed by a research team at the University of Washington, Greenroads is perhaps the most visible sustainability rating system. It also has in place a formal certification mechanism, which can designate a road as sustainable. A certification attests to a roadway's sustainability, but arguably the certification per se does not carry with it any tangible benefits. For a project to receive certification, it must meet eleven core project requirements and accumulate a number of additional voluntary credits. Under Greenroads, a project must meet these requirements (Table 2.1). The thinking behind the project requirements is they represent a set of practices and procedures that are absolutely essential to creating a sustainable roadway. Because of this, Greenroads is more restrictive than INVEST 1.0. That is, if a project misses even a *single* requirement it cannot qualify as sustainable. In addition to the eleven core requirements there are 37 separate categories in which a project can accrue credits. These 37 categories are voluntary criteria. None of them are required, but certification is impossible without amassing a minimum of 32 points. Each voluntary category has a point value assigned to it. That is, in each category a project can earn one to five points depending on what measures are taken. Not all categories have a maximum of five points associated with them; some are worth a maximum of two or three points. Recalling the example cited in the previous example, the 'Runoff Quality' criteria is worth

up to three points. More points are awarded for more stringent and sustainable measures. Very basically, a plan that is designed to modestly improve runoff quality may receive one point, however, a project that imposes sufficiently robust measures to enhance runoff quality can earn three points. It is imperative to emphasize a main drawback of Greenroads – if *any* of the eleven core project requirements are not met a project could receive every available voluntary credit but it would not be eligible for certification. This is arguably an inflexible way to approach the question of sustainability, and could potentially discourage some stakeholders from pursuing a sustainability agenda, particularly if they are unclear about the long-term benefits of doing so. Another blind spot of Greenroads is that it has been designed to evaluate 1) new road construction projects; and 2) smaller rehabilitation projects geared towards making roadways more sustainable. These are two extremely broad categories, and Greenroads does not offer customizable scorecards to evaluate projects of varying sizes. This gives a misleading picture of sustainability, because what is feasible from a logistic and constructability point of view will not be the same for a resurfacing project and new road construction in an urban area. Table 2.1 lists the eleven core project requirements included in Greenroads, and a brief description of each. This is intended to give readers an idea of the absolute minimum standards a project must aspire to in order to achieve a sustainable designation

Table 2.1 Core Project Requirements for Greenroads Certification

Requirement	Description
Environmental Review Process	Use an informed decision-making process to perform a comprehensive environmental review of a project
Lifecycle Cost Analysis	Conduct a lifecycle cost analysis that includes, at minimum, agency costs and work zone user costs
Lifecycle Inventory	Assess the lifecycle inventory of the final pavement design that takes into consideration energy use and emissions
Quality Control Plan	Establish procedures to monitor and improve the construction quality
Noise Mitigation Plan	Develop a plan to minimize the noise experienced in surrounding neighborhoods during construction
Waste Management Plan	A formal waste management plan accounts and tracks construction waste, the cost of disposal, and any safety measures taken by workers to reduce exposure to hazardous materials
Pollution Prevention Plan	Develop strategies to reduce stormwater pollution and erosion associated with construction
Low Impact Development	Implement low-impact development stormwater management solutions; these attempt to keep pre- and post-development hydrologic conditions as near to one another as possible
Pavement Management System	Devise a management plan to extend the life of roadways through regular inspection and preservation actions
Site Maintenance Plan	An ongoing procedure designed to preserve the environmental quality and aesthetics of roadways during use; includes roadway maintenance,

Educational Outreach	cleaning, vegetation upkeep, and keeping other elements (e.g. traffic signals) in good working order Develop a plan to bring awareness of sustainability activities to the public and stakeholders through various education initiatives
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These eleven requirements all relate to the triple bottom line of sustainability. Several criteria are directly concerned with maintaining and improving environmental quality by minimizing the project's ecological footprint, and through the use of construction strategies that stress the use of recycled materials and new paving technologies. Likewise, lifecycle cost analysis informs project planners about the most efficient use of resources, which can save money and improve economic sustainability. However, while all of these touch on the triple bottom line of sustainability, it is worth noting that the social pillar of sustainability does not have a strong presence (though arguably improving the environment and the economy has economic implications). But there are no requirements with respect to ensuring the project strives to be multimodal, or developing plans to encourage equal access to transportation options. Most of these requirements pertain to planning. While good planning is invaluable, it does not necessarily improve the material outcome of a project, or bolster its sustainability. What social elements are included – noise mitigation plan and educational outreach – have, at best, a very minor influence over roadway sustainability, particularly if the project is viewed from a lifecycle perspective. A sustainable road, after completion, cannot be left unattended and preserve its status as sustainable. While one of the project requirements is a site maintenance plan, the focus here is narrowed to preserving environmental quality. But again, this neglects the economic and social pillars of sustainability, largely. This is problematic because it demonstrates Greenroads privileges one dimension of sustainability over others – the environment. While environmental protection is integral to any sustainable road, it is not in the interests of state transportation agencies to valorize it at the expense of economic or social concerns. The triple bottom line concept is foundational for Greenroads, however, the system accords importance to four other dimensions of sustainability, which are listed in Table 2.2.

Table 2.2 Additional Sustainability Components

<i>Sustainability Component</i>	<i>Definition</i>
Extent	Any project has a well-defined spatial and temporal extent. This represents the idea that a project's sustainability can be measured within these defined constraints.
Expectation	These are the key human value constraints that have been identified for a project. They can relate to design, system-wide outcomes, or the overall quality of construction. Expectations are defined in specific contexts, and so vary geographically.
Experience	Assists in translating the idea of sustainability into practice. Experience includes technical expertise, innovation, historical knowledge, all of which inform decision-making.
Exposure	This also relates to putting sustainability into practice. Specifically, it refers to the concept that

making projects sustainable requires ongoing educational and outreach efforts among the public, transportation professionals, stakeholders, and agencies.

These additional elements do give sustainability a wider ambit. Although underdeveloped, the system draws awareness to the spatial and temporal aspects of road projects, however, this awareness does not translate into modified scoring procedures that take into account the ways in which spatial and temporal scales modify our understanding of sustainability, and more importantly, the level of sustainability it is possible to achieve with a given project. Along with the main tenets of ecology, equity, and economy, the additional components help orient stakeholders as during all phases of road construction.

Although all projects must meet the basic requirements, certification is not possible without accumulating a large number of voluntary credits (a minimum of 37 –see Table 2.3 for different certification levels). All of the voluntary credits – which are awarded based on accomplishments in the voluntary categories – related to at least one of the seven pillars of sustainability as outlined by Greenroads. Most of the time, a category relates to more than one pillar. The best way to think about voluntary credits is that they represent sustainability enhancements. If a developer includes features with the intent of gaining more points through voluntary credits, they are effectively making a road more sustainable. Voluntary credits are earned by making project improvements in five different areas:

- Environment and water management
- Opening up access and increasing the equity of the roadway
- Following more stringent construction practices
- Through the use of materials and resources that do not place a drain on the environment
- Via the implementation of advanced paving technologies

Currently, Greenroads has four levels of certification. These are listed below:

Table 2.3 Greenroads Certification Levels

Level	Voluntary Credit Points Required
Certified	32-42
Silver	43-53
Gold	54-63
Evergreen	Above 64

Note: The Voluntary Credit points are in addition to the Project Requirements

Greenroads offers one method to quantify and certify the sustainability of a road project. While it adopts the triple bottom line concept of sustainability, it builds a more expansive vision of sustainability through the four additional sustainability dimensions that are included (e.g. experience, exposure). Greenroads does have some inbuilt flexibility given that project managers and stakeholders can decide what voluntary credits best fit the needs of a project. Deciding which credits to aim for will often depend on the project context, and the project scope. Where Greenroads is unbending, however, is on the issue of meeting the eleven basic project requirements – all projects must include these or sacrifice certification. While Greenroads is a valuable tool that can move us towards a more sustainable approach to transportation, one of the criticisms leveled at it is that it prioritizes design at the expense of other

factors relevant to sustainability. This, and the restrictive requirements Greenroads has in place make it questionable that it would be appropriate for use during this project. A fuller discussion on this topic is included later in this chapter.

2.4 FHWA Sustainable Highways Self-Evaluation Tool

The Federal Highway Administration has recently launched INVEST 1.0, which much like Greenroads, is a sustainability rating system; however, it is arguably more comprehensive than Greenroads because it has customized scorecards that cater to road projects of different sizes and magnitudes. INVEST also includes scorecards to rate three different project phases – System Planning, Project Development, and Operations & Maintenance. This differentiates INVEST from Greenroads because it deploys a vision of sustainability that applies to the entire lifecycle of a road project. While it is true Greenroads does require lifecycle assessments and inventories, it devotes less attention to non-design-related criteria, particularly as it relates to operations and maintenance. Consistent with other rating systems, INVEST adopts the triple bottom line concept of sustainability, noting that “The goal of sustainability is the satisfaction of basic social and economic needs, both present and future, and the responsible use of natural resources, all while maintaining or improving the well-being of the environment on which life depends” (FHWA 2012). Sustainable highways, according to the FHWA, should also improve levels of access, provide an efficient and dependable way to move people and goods, and give individuals a wide variety of transportation options. A sustainable transportation system is also multimodal. INVEST is a collection of sustainability best practices; projects are awarded points for achieving specified sustainability benchmarks. Overall, INVEST includes 60 different criteria, divided into the three aforementioned phases, or modules. Different modules have different target audiences and purposes. The Systems Planning criteria deal with the initial stages of planning, and many of the criteria focus on how to work sustainable principles into a project at this point. The FHWA suggests that state transportation agencies and metropolitan planning organizations will enjoy the greatest benefits from this module.

This report is focused on project development, which INVEST scores using 29 different categories. A complete listing is beyond the scope of this report, but some of the criteria used to rate project development include: lifecycle cost analysis; context sensitive project delivery; protecting vulnerable habitats; recycling materials; and using context sensitive solutions.

Project scope and magnitude is an important consideration with INVEST 1.0. Previous versions of INVEST utilized basic or extended scorecards; stakeholders were free to choose the appropriate scorecard for their project (extended scorecards were used to evaluate new construction projects, while basic scorecards were used to assess minor repair and rehabilitation projects). However, with INVEST 1.0, stakeholders now have the option of choosing from among six different scorecards based on the nature of their project. Five of these have been designed by the FHWA, while a sixth custom scorecard gives stakeholders the leverage to score their projects if they do not fit into predefined categories. Table 2.4 lists the different projects INVEST is used to rate, and contains brief descriptions of each.

Table 2.4 INVEST 1.0 Scorecards

Scorecard Option	Description
Paving	Used on projects that are devoted exclusively to pavement preservation; restoration projects that extend the service life of existing facilities and enhance safety; or pavement restoration projects that restore pavement structure, ride quality, and spot safety. It can be used for projects in urban or rural locations.
Basic Rural	Used for small, rural reconstruction or rural bridge replacement projects that <i>do not</i> expand the capacity of the roadway.
Basic Urban	Used for small urban reconstruction or urban bridge replacement projects that do not expand capacity of the roadway.
Extended Rural	Used for rural projects for a new roadway facility; structure projects where nothing of its type currently exists; and major reconstruction projects that add travel lanes to an existing roadway or bridge.
Extended Urban	Used for urban projects for a new roadway facility; structure projects where nothing of its type currently exists; and major reconstruction projects that add travel lanes to an existing roadway or bridge.
Custom	Used for projects that do not fit any of the predefined scorecard options. This scorecard gives the user the ability to develop a unique set of criteria that is most appropriate for the project being evaluated. The Custom Scorecard starts with a core set of 19 criteria that must be included as part of the score. However, there are no achievement or “certification” levels associated with the custom scorecard.

Source: FHWA (2012, pp. vii)

The scope of a project dictates the scoring criteria used. For example, fewer criteria are used to score a paving project than Greenfield Construction. Figure 2.1 lists the different criteria according to which the six different project types are scored by. Returning to the previous example, with paving or minor maintenance activities the road is already emplaced, which eliminates the need to address questions about historical preservation, vegetation composition and ecological connectivity, or habitat restoration. Project managers lack resources to tackle such issues when the primary objective of a project is to improve its structural integrity and function without building an entirely new road. However, there are still methods project managers can use to improve road sustainability in these cases, like using products such as warm-mix asphalt, which reduces emissions, or relying on pavement that is formulated to last for an extended period of time, which can improve sustainability. The principal way paving projects

contribute to enhancing sustainability is by decreasing the frequency at which resurfacing has to take place. Because resurfacing leads to air pollution and requires large expenditures of energy, doing it at frequent intervals subtracts from a roadway's sustainability.

Figure 2.1 Summary of Criteria Used to Score Different Road Projects

Project Development by Criteria Scorecard						
	Paving	Urban Basic	Urban Extended	Rural Basic	Rural Extended	Custom Core Criteria ¹
PD-1 Economic Analyses			✓		✓	
PD-2 Life-Cycle Cost Analyses	✓	✓	✓	✓	✓	✓
PD-3 Context Sensitive Project Development		✓	✓	✓	✓	✓
PD-4 Highway and Traffic Safety	✓	✓	✓	✓	✓	✓
PD-5 Educational Outreach	✓	✓	✓	✓	✓	✓
PD-6 Tracking Environmental Commitments	✓	✓	✓	✓	✓	✓
PD-7 Habitat Restoration		✓	✓	✓	✓	✓
PD-8 Stormwater		✓	✓	✓	✓	✓
PD-9 Ecological Connectivity			✓	✓	✓	
PD-10 Pedestrian Access		✓	✓			
PD-11 Bicycle Access		✓	✓			
PD-12 Transit & HOV Access		✓	✓			
PD-13 Freight Mobility			✓		✓	
PD-14 ITS for System Operations		✓	✓		✓	
PD-15 Historical, Archaeological, and Cultural Preservation		✓	✓	✓	✓	✓
PD-16 Scenic, Natural, or Recreational Qualities			✓	✓	✓	
PD-17 Energy Efficiency		✓	✓	✓	✓	✓
PD-18 Site Vegetation		✓	✓	✓	✓	✓
PD-19 Reduce and Reuse Materials	✓	✓	✓	✓	✓	✓
PD-20 Recycle Materials	✓	✓	✓	✓	✓	✓
PD-21 Earthwork Balance			✓		✓	
PD-22 Long Life Pavement Design	✓	✓	✓	✓	✓	✓
PD-23 Reduced Energy and Emissions in Pavement Materials	✓	✓	✓	✓	✓	✓
PD-24 Contractor Warranty	✓	✓	✓	✓	✓	✓
PD-25 Construction Environmental Training		✓	✓	✓	✓	✓
PD-26 Construction Equipment Emission Reduction	✓	✓	✓	✓	✓	✓
PD-27 Construction Noise Mitigation		✓	✓			
PD-28 Construction Quality Control Plan	✓	✓	✓	✓	✓	✓
PD-29 Construction Waste Management	✓	✓	✓	✓	✓	✓
Total Number of Criteria in Scorecard	12	24	29	21	25	19

¹ – Indicates the core criteria that must be included in the custom scorecard. The user may choose as many additional criteria as desired.

Like Greenroads, INVEST rates the sustainability of projects based on the total number of points accrued. But unlike Greenroads, there is no method of having a road professionally certified as sustainable. INVEST is thus more concerned with guiding stakeholders as they decide what practices might benefit them. Because it is entirely voluntary – with no possibility of outside award or certification – stakeholders can determine which practices fit their context. INVEST is a collection of sustainability best practices; while stakeholders have the ability to informally score their projects, INVEST functions as

a one-stop compendium of all construction and design practices that have identifiable sustainability benefits. It may potentially give Kentucky or other states the foundation to develop proprietary rating systems. These systems could then be used to score projects and encourage the use of sustainable practices; further, states could incentivize stakeholders if a particular level of achievement is reached. Table 2.5 summarizes the different achievement levels specified by INVEST.

Table 2.5 Achievement Levels for FHWA INVEST 1.0

<i>Achievement Level</i>	<i>Points Required</i>
Bronze	Earn at least 30% of total available points
Silver	Earn at least 40% of total available points
Gold	Earn at least 50% of total available points
Platinum	Earn at least 60% of total available points

A “sustainable project” must earn at least 30 percent of total available points. Anything below this constitutes an unsustainable highway project. Because evaluation is entirely voluntary there is no formal means for project planners to receive an official third-party certification attesting to the sustainability of their project. All evaluation is informal and conducted by individuals directly involved with the project. While there is no formal certification, INVEST is designed to prompt critical reflection on the part of project managers regarding the sustainability of programs already completed, or currently under design. It also provides a means of assessing various tradeoffs involved in the construction process. Achieving a perfect sustainability score is highly improbable because of the immense difficulty ensuring that all criteria scores are optimized. For example, project planners may want to include pedestrian access and bicycle access in a new roadway project. However, they could discover there is simply not enough room available to accommodate both, forcing the planners to consider the costs and benefits of including one mode of transport in lieu of another. Deciding which option best meets the needs of the community, and the broader environmental and economic context, call for decision-makers to sacrifice one element of sustainability in order to preserve another.

2.5 Comparison of Greenroads and INVEST 1.0

Greenroads and the FHWA’s INVEST share similar goals, namely promoting more sustainable practices in the infrastructure sector. By outlining best practices, each system advocates for a vision of road construction that sees infrastructure as a key (and essential) piece of building a more sustainable society. What seems lacking in each system, however, is a rigorous, statistical analysis of the benefits that adopting sustainable practices will actually bring to communities. Obviously this is a long-term project, but it is worth bearing in mind that while many of the practices each system associates with sustainability appear, intuitively, to support it, there is still a lack of quantitative data that demonstrates the environmental, economic, and social benefits of doing things in a more sustainable manner. This should not cause readers to treat Greenroads and INVEST with skepticism – they should be aware that the benefits of sustainable practices are not fully resolved, and probably will not be in the foreseeable future. Yes, they help, but the question is how much? Neither system has a good answer to this question, but that does not mean we should delay action. Both systems would stand to benefit from developing a system of metrics stakeholders could use to monitor the ongoing progress, and gains made by using sustainable practices. A fuller comparison of the rating systems will clarify which one is more useful for the State of Kentucky as it contemplates how extensively it wants to pursue a sustainability agenda.

Each rating system relies upon broadly similar definitions of sustainability rooted in the triple bottom line concept. Greenroads does take a slightly expanded view, including considerations about spatial and temporal extent over which sustainability is measured, the expectations associated with a project, and the adaptive learning process that project managers and other stakeholders are exposed to, which enables them to expand their understanding of sustainability as projects unfold (called “Experience” in the Greenroads lexicon). Greenroads also encourages “Exposure,” which is basically educational outreach to inform the public about sustainability. While INVEST does not formally enlarge its concept of sustainability, some of these ideas are embedded in the system via the criteria that are evaluated. For instance, with respect to spatial and temporal issues, INVEST makes available a variety of scorecards that allow stakeholders to determine which one is best adapted to the size and magnitude of their project. Greenroads lacks this capability. Further, some of the attributes Greenroads associates with “Experience” are included in INVEST. Two examples are developing noise mitigation plans and pavement management systems. Similarly, INVEST awards points for informing the public about sustainability efforts. Thus, while it does not recognize educational outreach as something that is intrinsic to the definition of sustainability, by crediting projects that do perform this function it is clear the system places a value on it. Accordingly, while Greenroads attempts to slightly reformulate the definition of sustainability, it is worth underlining that INVEST accommodates the changes Greenroads makes within its own assessment criteria. That is, there is nothing strikingly original about Greenroads’ idea of sustainability. The system introduces a “new” concept of sustainability, but one that is not entirely original, and which other sustainability rating systems, aside from Greenroads, already have implicitly built into their structure through the criteria they use to evaluate projects. Greenroads and INVEST are open-ended, and their rating criteria are subject to revision; both make clear that future developments will likely tweak their contents. Thus, while a set of core metrics have been identified, each system allows for revisions, and the introduction of new criteria, which can be tested and refined. As such, while Greenroads attempts to create daylight between itself and its competitors, this effect is illusory as current thinking about sustainable roadways is largely invariant between various rating systems.

Two points sharply distinguish Greenroads from INVEST. Greenroads targets project design and planning while INVEST adopts a more holistic and temporally extensive approach to sustainability by scoring different phases of project development and implementation using its three modules. Second, Greenroads offers a formal certification project to stakeholders; this, however, is not available from the FHWA. The FHWA makes clear that INVEST is a collection of sustainability best practices that can instruct stakeholders; the metrics it uses lets stakeholders decide how aggressively they wish to pursue sustainability. This is not to say that Greenroads mandates specific practices, however, if stakeholders wish for a project to receive certification they have to achieve a minimum number of points – which potentially reduces flexibility, and possibly too narrowly constrains our definition of what constitutes sustainability. INVEST does not seek to foster any kind of competition between states or parties involved in road construction, but it does provide them with the information to make decisions about what best practices work for them.

As noted in Section 2.2, because Greenroads has a pathway to sustainable certification, it makes demands of stakeholders that, in some circumstances, are unreasonable. For example, the eleven Project Requirements is one example of this. If a project lacks one of these requirements it is automatically disqualified from being designated as sustainable. Further, if stakeholders want to pursue certification there are additional expenses involved. Greenroads will contract with stakeholders to conduct a formal assessment, but each project costs \$4,995 to assess. Further, Greenroads notes that complex, multi-phase projects do not count as a single project for evaluation purposes – they count as

multiple projects. As such, each phase or section of the project would have to be evaluated independently, which can quickly raise the cost involved in (potentially) achieving certification. Because Greenroads focuses on project design there are no provisions for awarding points based on the long-term maintenance of completed road projects. This is a rather shortsighted view of sustainability. Achieving sustainability is not something accomplished through design, and permanently attained once a road has been built. Sustainability must be conceptualized as an ongoing process; to maintain a road in a sustainable state requires an adaptive approach to management that preserves sustainability via a range of maintenance strategies. Although planners are required to perform a lifecycle cost analysis and a lifecycle inventory analysis to obtain Greenroads certification, there is no requirement in place to determine whether roads remain in a well-kept (and sustainable) condition over the long-term, which is concerning as the concept of sustainability demands stakeholders make long-term commitments which not only preserve, but also add to the sustainability of roads. On the project development side, FHWA's INVEST uses separate scorecards based on the magnitude of the project. This speaks to the greater flexibility of the INVEST system. Unlike Greenroads, it is not one-size-fits-all in terms of scoring. Consequently, INVEST is better designed to handle evaluation in a broad range of contexts. The custom scorecard option only adds to this flexibility.

While Greenroads holds promise, it is the recommendation of this report that the State of Kentucky chooses the FHWA INVEST tool when assessing roadway sustainability. Its primary strength lies in its greater flexibility and its attentiveness to a wider range of issues that contribute to making a road sustainable well into the future. By using a versatile tool that places the onus of evaluation on the State of Kentucky, the State can not only develop a baseline understanding of where its sustainability practices currently rate, it can look at whether the definition of sustainability advanced by INVEST is consistent with the Kentucky Transportation Cabinet's long-term plans for developing a more sustainable agenda. If the Cabinet disagrees with aspects of INVEST, there is room to create a proprietary rating system, and set of best practices, that work within the unique contextual constraints (economic, social, environmental) Kentucky faces. Such a project would have a large scope. However, given that one face of sustainability is using context sensitive solutions, developing a concept of sustainability that is context dependent – and not borrowed from a generalized template – would give the State of Kentucky the ability to follow a path it believes will be the most productive and appropriate for its infrastructure, its businesses, and most importantly, its citizens.

2.6 Benefits of Sustainability and Using Sustainability Metrics for Kentucky

Chapter 1 introduced some of the arguments in favor of sustainability metrics, which this section expands on. Although there is still uncertainty over rating systems' accuracy, and how different practices convert into real-world benefits, these systems represent an important first step for sustainability advocates. Proponents of sustainability cannot rely on vague appeals about environmental improvement or intergenerational equity to ground their arguments. To substantiate the importance of them, we need a series of quantifiable metrics that translate into numerical results that are easily interpreted. Rating systems are semi-quantitative in the sense that they do rely on empirical measurements to award points, but further research is needed on the topic of how the various levels of achievement identified by the systems translate into tangible benefits. For instance, what benefits might a community realize from pouring additional funds into a project, bringing it up to a Gold certification, from a Silver rating, under the Greenroads system? While state transportation agencies can calculate the additional expense it would require to accomplish this, the short- and long-term benefits of doing so are more difficult to calculate, or model. The next step is to develop more rigorous ways of validating

the guidance offered by these systems. Even with that caveat, rating systems, although still in the early stages of development, move the process in the right direction, and give stakeholders the tools needed to construct arguments in favor of sustainability, which are supported by quantitative data.

Using sustainability metrics can still give stakeholders the leeway to concentrate on the facet of sustainability that is most important for their projects, and for the communities in which they work. As Chapter 1 demonstrated, conceptualizing sustainability as something that relates *only* to environmental protection is an overly narrow reading. The triple bottom line concept enables stakeholders to forcefully argue for new forms of economic growth that are sustainable; indeed, the triple bottom line is not rigid in prescribing whether the economic, social, or environmental pillars should take priority. Many states will favor economic sustainability because it places the stress on growth and development, and this is entirely appropriate. Using metrics provides these stakeholders with a roadmap, letting them understand the consequences of different transportation decisions from all three angles. Sustainability also redirects our notions of what economic development should entail. By approaching transportation sustainably, stakeholders and policymakers shift their focus from short-term economic gains to a more far-reaching view that positions the transportation system as an integral part of any plan to prolong economic growth. Short-term fixes can potentially catalyze long-term stagnation; by using a suite of sustainability metrics, stakeholders can identify the best method of avoiding this trap, and figure out what role the infrastructure plays in achieving this goal. The main idea to keep in mind is this: while it is possible to rapidly accelerate economic growth over the short-term by implementing unsustainable practices, it is unreasonable to believe this form of economic expansion can proceed indefinitely. Thinking sustainably ensures that states and municipalities do not suffer a crash by privileging short-term growth over long-term, steady and prudent growth.

If infrastructure development is not pursued in a way that affords environmental protection and opens up greater access to all demographic groups, it is unsustainable. Indeed, although privileging one sustainability pillar over others is reasonable, it is worth repeating that neglecting the other two completely will usher in an economically precarious situation. As in all states, Kentucky's infrastructure is a lynchpin of its economy. As such, Kentucky's long-term economic health is connected to the sustainability of transportation systems that provides the means to connect cities and towns, and move people and goods. Highways that are built and maintained in a sustainable manner will ensure that Kentucky operates its infrastructure in the most efficient and economical way possible. In doing so, the state can reduce the economic burdens it might otherwise face if forced to spend large sums caring for, and repairing, ill-designed roads. This is particularly important when budgetary resources are stretched because of already-fragile economic conditions.

Achieving sustainability does require tradeoffs. That is, sometimes policymakers and planners will have to choose between a number of options that do not simultaneously maximize social, economic, and ecological goals. However, it is worth noting that in many cases at least two of these interests converge, especially in the realm of transportation planning. For example, recycling and reusing roadway construction materials lowers the cost of a project while also reducing its environmental footprint given that natural resources that otherwise would have been extracted remain in place. Likewise, developing plans to minimize stormwater runoff provides environmental benefits in the form of limiting erosion, but it can also improve human health: an effective plan lessens the amount of potentially contaminated water entering the sewers and groundwater. Another example – preserving natural habitats improves a community's economic situation by encouraging local tourism, which can bring an influx of revenue into an area. By using evaluative criteria such as Greenroads, or as this report recommends, the INVEST tool, stakeholders can devise new ways of balancing the social, environmental, and ecological costs and

benefits of completing a specific road project. Table 2.6 lists the benefits, from an anthropocentric- and ecosystem-based perspective, of choosing a sustainable pathway for highway planning.

Table 2.6 Benefits of Adopting Sustainable Transportation Planning

<i>Eco-Centric Benefits</i>	<i>Anthropocentric Benefits</i>
Reduction in Raw Material Use	Improve Access
Reduction in Fossil Fuel Use	Improve Mobility
Creates Energy	Increases Service Life
Reduction in Water Use	Improves Human Health and Safety
Reduction in Air Emissions	Improves Local Economies
Reduction in Greenhouse Gases	Reduction in Initial Costs
Reduction in Water Pollution	Reduction in Lifecycle Costs
Reduction in Solid Waste	Improves Accountability
Habitat Restoration	Increases Awareness
Creates Habitat	Aesthetic Enhancements
Reduces the Human Footprint	

After Greenroads (2011)

There are overlaps; arbitrarily separating the benefits that accrue to humans and ecosystems is a bit misleading because they are in fact closely interrelated. Nonetheless, this ledger gives planners an idea of what changes when sustainable planning is used, which they can extrapolate out to determine the nature of the long-term economic savings.

Kentucky can take its cue from other states by proactively weaving a sustainability agenda into its transportation planning. In doing so, Kentucky would provide a much-needed voice that contributes to debates about sustainable highways, which are currently monopolized by a few states. Currently, a limited number of states actively pursue a sustainable agenda. By getting in on the ground floor, the State of Kentucky can help refine current rating systems, and enhance the dialogue taking place regarding sustainable roads. Being viewed as a leader on these matters has the potential to increase Kentucky's stature on sustainability-related issues, which could itself prove economically beneficial. A final reason for pursuing this pathway is that a mandatory evaluation of each road project's sustainable attributes is not currently mandated by law, in the future there is the potential that the State of Kentucky (along with other states) will have the obligation to perform such surveys. In getting ahead of the curve on these issues, Kentucky, and other states that adopt the standards outlined in Greenroads or INVEST, build on them, and will find themselves in an advantageous position, and can potentially have a more effective voice in articulating what criteria are most useful to assess the sustainability of a roadway project.

2.7 Summary

This chapter has compared Greenroads and FHWA's INVEST 1.0. While both rating systems adopt a view of sustainability founded on the triple bottom line concept, this report recommends that Kentucky use INVEST to evaluate the sustainability of current transportation planning and construction practices. INVEST has a supple framework that allows stakeholders to choose a scorecard that matches the type of project they are working on, whereas Greenroads offers less flexibility. Further, INVEST moves beyond project design, and establishes methods to rate the sustainability of system planning, and operations and maintenance. INVEST offers a broader template from which to begin and greater flexibility to

evaluate a wide range of projects with varying scopes. Starting with a more expansive system would benefit the State of Kentucky because the Transportation Cabinet could decide what elements of sustainability are important for preserving the integrity of its transportation system over the long-term so that it contributes to the economic development of the State. After strategically identifying what aspects of sustainability will prove the most beneficial, the State of Kentucky has the opportunity to develop a proprietary approach to evaluating sustainable best practices. As the final section of this report makes clear, sustainability is not just about protecting the environment, it is also about shoring up the long-term economic security of the State, and ensuring that Kentucky's infrastructure remains sound and able to support activities that improve economic growth well into the future. Therefore, the State of Kentucky would benefit by identifying sustainability metrics to determine the best means of optimizing infrastructure's contribution to a flourishing economy. While there is no legal mandate to pursue this course of action, the economic benefits could potentially be significant.

References

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3.1 Introduction

Chapter 2 discussed the details of INVEST 1.0 and provided justification for its use in this project. Unlike other scoring methods, INVEST provides users with the greatest flexibility to evaluate the sustainability of a wide range of highway construction projects – from minor resurfacing to constructing new roads from scratch. The focal point of the proposed research is the project development phase of the project lifecycle. INVEST does offer two additional scorecards, one for system planning and one for operations and maintenance. However, because the research is most concerned with the design considerations and construction techniques that inform project execution, only the project development phase will be scored. Future research may examine the other dimensions of sustainability that INVEST measures, however, keeping a narrow focus on project development will provide KYTC with a baseline sustainability assessment of current design, construction, and implementation practices. The remainder of this chapter briefly describes the methods KTC researchers will use to assess the selected projects. Because the INVEST manual exhaustively documents scoring procedures, this chapter will offer only a brief summary of the scoring criteria themselves and the documentation required by KTC researchers to perform their evaluations (see FHWA 2012).

3.2 Scoring Methodology

KTC researchers will rate projects by using the methods contained in the INVEST 1.0 manual. A website has been designed in conjunction with INVEST that streamlines the scoring process by allowing researchers to generate a sustainability rating based on answers to a series of questions about design, construction, policy, and other relevant documents. Where possible, KTC researchers will make use of this online tool – it will expedite the final phase of the project and provide more time to analyze individual case studies to determine their various strengths and weaknesses. As noted, all scoring must be justified by document sources, which ensures the accuracy and integrity of the final determination of a project's sustainability. For each case study, KTC researchers will hold a meeting with project engineers who were responsible for overseeing the development, implementation, and completion of a project. The purpose of this meeting will be to collect the appropriate documents to score the projects. Table 3.1 provides a listing of the 29 project development components, a description of each, and required documentation, as specified by the INVEST 1.0 manual. While the list is extensive, it is important to note that for most project components a *single* source is sufficient to provide adequate documentation (although there are exceptions: e.g. PD-6). Before meeting with project engineers and other relevant officials, KTC researchers will send a copy of these requirements so they have a full understanding of documentation requirements. To clarify the purpose of INVEST beforehand, and what each project component measures, project engineers will also receive a list of brief component descriptions to familiarize themselves with the facets of sustainability INVEST deems constitutive of a sustainable highway (see Table 3.2). Advance reception of these materials will facilitate a smooth meeting between KTC researchers and project engineers, ensuring that minimal time is wasted. After meetings and document acquisition have been completed, KTC researchers will systematically score each project. To maintain objectivity, neither KYTC officials nor anyone with a vested interest in the outcome of the rating process will be consulted during this phase of the research. This will ensure all assessments are conducted in an objective and impartial manner, and that results accurately reflect the respective projects' level of sustainability. After scoring has been completed, KTC researchers will analyze each project to highlight those areas in which each excels and those which could be improved. Although retroactively refitting projects with new features is not possible at this juncture, these analyses will be helpful during future road construction and maintenance operations. With the knowledge gained from this research, project engineers can identify elements of sustainability they can work into projects

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in a cost-effective way. Following analysis of each project, KTC researchers will develop a synthesis that summarizes the main findings of the project and offers guidance on strategies the State of Kentucky can take advantage of during project design and implementation to bolster infrastructure sustainability.

Table 3.1 Assessed Project Components and Required Documentation

Component	Component Description	Documentation Sources
PD-1	Economic Analyses	Results of a benefit-cost analysis or economic impact analysis, including: 3. Documentation of techniques used 4. Underlying assumptions of economic models Any One of these three sources: 4. Calculations used for the LCCA – must include summary of inputs/outputs 5. Copy of the owner-agency policy on LCCA 6. Calculations for LCCA performed as part of a pavement management system to set best practices for pavement design
PD-2	Life-Cycle Cost Analyses	
PD-3	Context Sensitive Project Design	Any documentation of CSS principles (or equivalent processes) used on the project One or More of the following sources: 7. Documentation of human factors considered during project development 8. Documentation of an RSA 9. Documentation of the project scoping process – must include data analysis describing how the existing facility’s safety performance was used to make project improvements 10. Documentation (project reports, technical memos) that show the application of HSM-quality evaluations of the project and alternatives considered 11. Design exception review and evaluation reports approved by the relevant agency – must include <i>quantitative</i> estimates of the expected safety performance of the design exception, specific mitigation measures, and <i>quantitative</i> estimates of safety performance resulting from proposed mitigation measures 12. Documentation that evaluates the project post-completion, which includes crash data from before and after implementation – must use advanced statistical methods that account for RTM
PD-4	Highway and Traffic Safety	One or more of the following criteria: 6. Public outreach materials that describe sustainability features incorporated into the project.
PD-5	Educational Outreach	

		<ul style="list-style-type: none"> 7. Brochures or other printed information that has been made publicly available 8. Website addresses and/or screen captures of the sites describing project sustainability 9. An agency guide, specification, or policy 10. Copies of school or professional presentations and the date of the presentations
		Both of these sources:
		<ul style="list-style-type: none"> 3. Documentation of environmental tracking system – must include instructions on what is included, and chains of documentation flows through different project phases 4. Contract documents requiring contractors to assign an <i>independent</i> environmental compliance manager
PD-6	Tracking Environmental Performance	One of the following sources:
		<ul style="list-style-type: none"> 4. Contract documents that: a) measure baseline site conditions, and b) ecological improvements made during construction 5. Technical reports or permitting documents that outline which species will benefit from site improvements 6. Technical reports describing how impacts to habitat were minimized during the project development
PD-7	Habitat Restoration	One or more of the following sources:
		<ul style="list-style-type: none"> 3. Project drainage report or other relevant calculations/studies 4. Project contract documents
PD-8	Stormwater	One or more of the following sources:
		<ul style="list-style-type: none"> 5. Ecological study framed using NEPA documentation 6. State permitting documents that includes consideration of ecological connectivity 7. Contract documents illustrating improvements in wildlife crossings 8. Documents attesting that efforts to minimize ecological impacts have been taken throughout the project development process
PD-9	Ecological Connectivity	One or more of the following sources:
		<ul style="list-style-type: none"> 4. Planning documents that address pedestrian access, and how it fits with existing land uses and/or existing General and
PD-10	Pedestrian Access	

		Transportation Plans
		5. Results of public input on proposed pedestrian facilities
		6. Contract documents illustrating enhancement of pedestrian access
		One or more of the following sources:
		5. Documents addressing bicycle access within the project, how it fits with existing land uses and/or General and Transportation Plans, project analysis, or a Bicycle Master planning process
		6. Results of public input on proposed bicycle facilities
		7. Contract of contract specifications and plans for proposed bicycle facilities
PD-11	Bicycle Access	8. Total costs for new/improved bicycle facilities
		One or more of the following sources:
		4. Description of purpose and need for HOV access on the project
		5. Total costs to install new HOV facilities or upgrade current ones
PD-12	Transit and HOV Access	6. Contract specifications and budget items that address transit and HOV
		One or more of the following sources:
		4. Description of the purpose and need for freight access on the road project
		5. Results of public input on proposed freight upgrades or installations
PD-13	Freight Mobility	6. Contract documents showing freight facilities
		One or more of the following sources:
		4. Listing of ITS applications and their corresponding categories
		5. Contract documents listing ITS applications that will be installed on the project
PD-14	ITS for Systems Operations	6. Photos or other documentation providing evidence of installed applications
		One or more of the following sources:
		5. Documents showing the resource or location is eligible for the US NRHP
PD-15	Historical, Archaeological, and Cultural Preservation	6. Documents of relevant organizations indicating what tribal or other interests will be represented

PD-16	Scenic, Natural, or Recreational Qualities	<ul style="list-style-type: none"> 7. Description of project features and policies that minimize adverse effects, in accordance with Sec. 106 of NHPA 8. Description of activities used to avoid impacts, improve, or enhance features
		<p>One or more of the following sources:</p> <ul style="list-style-type: none"> 6. Documentation of national, State, or Indian tribe designation if byway designation is used to satisfy this requirement 7. Other documents showing the scenic, natural, or recreational values of the project 8. Contract documents illustrating where roadside access points are located, or other protection, preservation, or enhancement actions taken 9. Description of how impacts were minimized on the project site 10. Description of activities used to avoid impacts, improve, or enhance features
PD-17	Energy Efficiency	<p>One or more of the following sources:</p> <ul style="list-style-type: none"> 6. Documented energy usage evaluation and reduction plan 7. Calculations documenting the amount of energy that would be used if the project was to be constructed with high-pressure sodium fixture, the expected energy usage after incorporating design improvements, and resulting energy savings 8. Contract documents and/or cut sheets of luminaires installed on the project 9. Sample cut sheets <i>and</i> specifications for each technology installed on the project showing expected wattage generated by each component 10. Documents for plans to audit energy use following construction
		<p>One or more of the following sources:</p> <ul style="list-style-type: none"> 5. Vegetation or landscape plan that shows type, size, and location of all plant species 6. Specification sections relating to site vegetation 7. Copy of the policies or procedures used to select plant species 8. Design study report conducted by an appropriate agency that analyzes existing site vegetation, impacts, reuse of vegetation,
PD-18	Site Vegetation	

		references to assess invasive species, and planned vegetation species
PD-19	Reduce and Reuse Materials	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> 4. Calculations that show the remaining service life of pavements or bridges before and after the expected projects; there should be a clear demonstration that treatments applied will extend its service life 5. Calculation of the percentage of pavement area treated, which includes new and existing pavement 6. Approved mix design for pavement materials
PD-20	Recycle Materials	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> 4. Calculations showing the computed percentage of pavement and/or structural material recycled 5. Calculation of the percentage of pavement area recycled in-place 6. Calculation that shows the percentage of luminaires, signal poles, and sign structures reused
PD-21	Earthwork Balance	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> 3. A grading plan that reports <i>total</i> cut and fill quantities and <i>total</i> miscellaneous cut and fill quantities 4. Inspector or contractor's actual construction earthwork volumes or the project; this includes actual cut and fill, volume of unused embankment materials, and the volume of material imported and exported to a site
PD-22	Long-Life Pavement Design	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> 4. Calculations that demonstrate the total percentage of <i>trafficked</i> lane pavement surface areas with long-life designs 5. The recognized, adopted and documented pavement design procedure 6. Documents illustrating pavement was designed using a minimum 20- or 40-year service life
PD-23	Reduced Energy and Emissions in Pavement Materials	<p>One or more of the following sources:</p> <ol style="list-style-type: none"> 4. Calculations showing at least 50 percent of total project pavement material meets threshold criteria

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PD-24	Contractor Warranty	5. Asphalt or concrete mix designs showing design criteria were met
		6. Documents from the cement production facility, asphalt plant, or concrete mixing plant that provide evidence requirements were met
PD-25	Construction Environmental Training	The following documentation sources:
		2. Contract documents that include details of warranty
PD-26	Construction Equipment Emissions Reduction	One or more of the following sources:
		3. Contractor documents demonstrating an Environmental Awareness Training Plan is required of project personnel
PD-27	Construction Noise Mitigation	4. Contents of the Environmental Awareness Training Plan
		One or more of the following sources:
PD-28	Construction Quality Control Plan	4. Signed letter from the prime contractor indicating that the total non-road construction fleet operating hours and the percentage of the operating hours meet one of the three specified criteria
		5. Provide a list of all non-road construction equipment used on the project; the list should contain: a) the make and model of each piece of equipment; and b) operating hours associated with the project
PD-29	Construction Waste Management Plan	6. Documents stating the contractor implemented a no-idling policy
		One or more of the following sources:
		4. Contract documents specifying contractors develop a noise mitigation and/or monitor noise during construction
		5. A copy of the noise mitigation plan
		6. Relevant noise permits, or agency or local authority noise policies
		One or more of the following sources:
		3. Contract document specifications requiring contractors to develop and implement a project-specific Quality Control Plan
		4. Contract document specifications requiring quality price adjustment clauses
		One or more of the following sources:
		3. Contract documents requiring contractors to develop and

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| | <p>implement a project-specific construction waste management plan (or its functional equivalent)</p> <p>4. Documents showing when (including quantities) construction materials were diverted from landfills. This includes trucking tickets with weights, destinations, materials, and calculations of percentages diverted from landfills</p> |
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Table 3.2 – Brief Descriptions of Project Development Components

<p>1) <u>Economic Analysis</u> (2- 5p) – <i>Cost benefit analysis</i> (including non-monetary transactions) and/or <i>economic impact analysis</i> (including indirect economic effects).</p> <p>2) <u>Life-Cycle Cost Analyses</u> (1- 3p) – Perform LCCA on pavement structures, stormwater infrastructure, and/ or major features (i.e. bridges, tunnels, etc.).</p> <p>3) <u>Context Sensitive Project Development</u> (1- 5p) – Use CSS guidelines for planning and training, including a multidisciplinary approach and cooperation with stakeholders.</p> <p>4) <u>Highway and Traffic Safety</u> (1- 10p) – Use <i>Road Safety Audits</i> (RSA) and quantitative models to evaluate projects for safety; additional points for public awareness campaigns and post-implementation monitoring.</p> <p>5) <u>Educational Outreach</u> (2p) – Promote public awareness of and involvement in sustainability features of project through point-of-interest displays, websites, stakeholder guides, and school and professional presentations.</p> <p>6) <u>Tracking Environmental Commitments</u> (2- 5p) – Document environmental commitments during project and keep track of them throughout and after completion; have independent environmental compliance monitor reporting directly to regulatory agencies.</p> <p>7) <u>Habitat Restoration</u> (1- 3p) – Demonstrate that project alignment and/or cross section was modified to minimize or avoid habitat impacts; implement habitat restoration projects, even if impacted species <i>not</i> on endangered species list.</p> <p>8) <u>Stormwater</u> (1- 9p) - Manage water runoff on project site by using BMPs (Best Management Practices) to treat 80 percent plus for pollution; and controlling 80 percent plus of flow.</p> <p>9) <u>Ecological Connectivity</u> (1- 3p) –Provide wildlife access across roadways, provide wildlife crossing structures on new alignments; assess and if necessary upgrade existing alignments</p> <p>10) <u>Pedestrian Access</u> (1- 2p) – Create or upgrade pedestrian facilities for safety, comfort, connectivity, and (optionally) aesthetic/social amenities.</p> <p>11) <u>Bicycle Access</u> (1- 2p) – Create or upgrade bicycle facilities for safety, connectivity, aesthetics, convenience, and comfort.</p> <p>12) <u>Transit and HOV Access</u> (1- 5p) - Promote public transit and HOV (high occupancy vehicle) by upgrading transit stations, signage, and park & ride lots; implement use privileges on roadways (i.e., car pool lanes)</p> <p>13) <u>Freight Mobility</u> (1- 7p) - Improve safety, efficiency, and impacts of freight through regulations such as non-idling policies; expansion of rest area (especially electrified), delivery parking, and truck-only lanes; improvement of road design; and automated and virtual weigh-in-motion stations.</p> <p>14) <u>ITS for System Operations</u> (1- 5p) – Implement one or more ITS (Intelligent Transportation System) applications from a list of 15 categories (electronics payments/pricing, emergency management, enforcement, information dissemination, information management, ITS infrastructure backbone, lane management, ramp control, response and treatment, road weather management, surveillance, traffic control, traffic incident management, traveler information, warning systems).</p> <p>15) <u>Historical, Archaeological and Cultural Preservation</u> (1- 3p) - document and protect historical or cultural assets, and promote public access</p> <p>16) <u>Scenic, Natural or Recreational Qualities</u> (1- 3p) – Provide access and stoppage for scenic or recreational spots along project route</p> <p>17) <u>Energy Efficiency</u> (1- 8p) – Reduce energy consumed by reducing lighting, installing energy-efficient fixtures, and/or using renewable power sources.</p> <p>18) <u>Site Vegetation</u> (1- 3p) – Plant low-maintenance (i.e. not requiring mowing or mechanical irrigation), preferably native species for on-site vegetation.</p>
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- 19) Reduce and Reuse Materials (1- 8p) – Extend pavement service life; reduce amount of new pavement materials needed by incorporating portions of old pavement structures; preserve or retrofit existing bridges; repurpose rather than dismantle old pavement structures; and/or reuse industrial byproducts in new roadway elements.
- 20) Recycle Materials (1- 8p) – Use recycled asphalt or concrete in new pavement, granular base course, and/or embankments; recycle in-place pavement; and/or reincorporate old minor structure elements (i.e. lights, signs, and poles).
- 21) Earthwork Balance (1- 3p) - use as much cut (excavated) earthen material from project as possible for fill (embankment) material on same project.
- 22) Long-Life Pavement Design (5p) - 75 percent plus of new or reconstructed pavement meets approved design requirements to last 40 or more years.
- 23) Reduced Energy and Emissions in Pavement Materials (3p) – 50 percent or more of pavement material must be manufactured using low-energy processes (warm mix asphalt, Energy Star certified cement production, and various other certified standards).
- 24) Contractor Warranty (1- 3p) – Require 3- 5 year warranties from construction contractor.
- 25) Construction and Environmental Training (1p) – Require contractor to provide environmental awareness training for project personnel.
- 26) Construction Equipment Emission Reduction (1- 2p) – Use non-road construction equipment that meets EPA engine emission standards and/or have diesel retrofit devices for after-treatment of pollution; implement no-idling policy; and/or use larger non-road earthwork-hauling vehicles.
- 27) Construction Noise Mitigation (1- 2p) – Require contractor to have and to monitor NMP (noise mitigation plan).
- 28) Construction Quality Control Plan (2- 5p) – Require contractor to have formal plan; use Quality Price Adjustment Clauses to link contractor payment to future performance of project.
- 29) Construction Waste Management (1- 3p) – Require contractor to have formal Construction Waste Management Plan (CWMP); divert 50- 75 percent of construction waste from landfills.

3.3 Summary

This chapter has described the methodology based upon the INVEST system used to score projects, provided a list of documentation required to rate projects, and offered brief précis of the project components the INVEST tool focuses on. This chapter did not provide a detailed breakdown of how the different project components are scored; including this would add unnecessary material that is explained thoroughly in the INVEST 1.0 manual (see FHWA 2012). The plan below summarizes the steps KTC researchers will go through during the final phase of research; any changes would be made only following consultation with the study advisory committee:

1. Set up a meeting with project engineers to discuss the selected case studies.
2. Supply project engineers with the information contained in Tables 3.1 and 3.2.
3. Meet with project engineers to discuss case studies and collect documents.
4. Use the INVEST 1.0 rating system to score each project.
5. Analyze the results of each case study, pinpointing areas in which it scores highly and in which it does not.
6. Based on the analysis, provide a detailed interpretation of each case study, identifying project components that could have been made more sustainable without significantly increasing costs.
7. Using the selected case studies, produce a report titled “State of Sustainable Highways in Kentucky” that summarizes findings and makes practical recommendations to enhance the sustainability of the state’s current infrastructure and to sensibly guide future project development.

Chapter 4: Criteria for Case Study Participation and Selected Projects

The case studies for the project have been selected using input from branch managers and the study advisory committee (SAC). KTC researchers initially identified approximately 30 projects of interests they believed merited a sustainability evaluation. After drafting an initial list, KTC researchers solicited feedback from branch managers in the central and eastern part of the state (to keep the project focus on areas near Lexington). During these initial consultations, KTC researchers explained the purpose of the research to branch managers, furnished them with the draft list of projects, and asked if there were additional projects they would recommend evaluating. To clarify the nature of the project, branch managers were provided with a summary of the INVEST system and a brief primer on the awarding of credits (e.g. Table 3.2). Branch managers were asked to take the INVEST criteria into consideration when making their suggestions. Once project recommendations were received, the SAC members were asked to rank the projects based on: 1) incorporation of sustainable design features or construction practices; and 2) ease of obtaining the necessary documentation to generate an accurate sustainability score. The second requirement was particularly important; lacking proper documentation, it would not be possible to objectively score a project. Regarding the first benchmark, the research will score the sustainability of construction and maintenance projects that have sought to incorporate some elements of sustainable design or construction; the purpose of this research *is not* to evaluate a completely random sample of construction and maintenance projects in the State of Kentucky. It is crucial to note that projects were not disqualified from consideration based on speculation they would not rate well.

Table 4.1 lists projects that will be evaluated by KTC researchers. They are ranked in order of priority – i.e. projects at the top of the list have been accorded higher priority by SAC members. Because the final goal is to evaluate and score 5-7 projects, KTC researchers will begin at the top of the list and work downwards until this objective has been met. Lack of either proper documentation or cooperation by district offices is the only issue that would deter researchers at this point. Under no circumstances would the research team begin a project evaluation and then abandon it because it appeared unlikely to score well. Indeed, the goal of KTC is to provide objective, impartial analyses of the selected projects; following this guideline will ensure the research team remains committed to an unbiased review process.

Chapter 4: Criteria for Case Study Participation and Selected Projects

Table 4.1 KYTC Projects for Sustainability Evaluation and Project Team Ranking

<i>KYTC Item Number</i>	<i>Project Type</i>	<i>Project Name</i>	<i>Construction Estimate</i>	<i>Project Description</i>	<i>Potential Credit Alignment</i>	<i>Avg</i>
7-144.01	MAJOR WIDENING	Double Crossover Diamond	\$6,237,711	WIDEN HARRODSBURG ROAD AT NEW CIRCLE ROAD FROM CORPORATE DRIVE TO ALEXANDRIA DRIVE BY INCREASING CAPACITY UNDER THE NCR BRIDGES AND INTERSECTION IMPROVEMENTS.	PD4, PD10, PD11, and others	1.67
7-593.XX	NEW ROUTE	Newtown Pike Extension	VARIOUS	NEWTOWN PIKE EXTENSION FROM WEST MAIN ST. TO SOUTH LIMESTONE ST. IN LEXINGTON.	Various	4.33
4-8103.10	NEW ROUTE	E2RC Section #1	\$32,796,400	NEW CONNECTOR ROAD SECTION 1: FROM E'TOWN BYPASS TO CECILIANNA DRIVE INCLUDING INTERCHANGE WITH E'TOWN BYPASS.	PD2, PD5, PD6, PD8, PD10, PD11, PD15	5
5-397	SAFETY	Eastern Parkway	\$3,617,001	TRAFFIC AND SAFETY IMPROVEMENTS FOR THE EASTERN PARKWAY CORRIDOR NEAR THIRD STREET.	PD3, PD4, PD10, PD11, PD12, PD14	5
6-273	MINOR WIDENING	12th Street Widening in Covington	\$15,500,000	RECONSTRUCT 12TH ST. FR I-75 TO SCOTT STREET (ARRA).	PD10, PD11, and others	5
12-296	MAJOR WIDENING	US 114 Middle Creek Battlefield	\$17,484,583	SALYERSVILLE-PRESTONSBURG; MTN. PARKWAY EXTENSION FROM 0.7MI W OF KY-404 TO US-23	PD3, PD15, PD16	7.33
3-110.00	RECONSTRUCT	Warren County KY 185 Reconstruction	\$48,670,000	RECONSTRUCT KY-185 FROM NORTH OF THE JUNCTION WITH KY-263 NEAR RICHARDSVILLE (MP 6.29) TO THE BUTLER COUNTY LINE (MP 11.913).	PD7, PD15, PD21	7.67
7-####	"Road Diet"	US 25 Georgetown			PD10, PD11	7.67
4-154.00	CONGESTION MITIGATION	US 31W/KY 313 Access Management	\$6,240,000	OPERATIONAL IMPROVEMENTS ON US-31W TO IMPROVE TRAFFIC FLOW.	PD2, PD4, PD5, PD8, PD19	8
5-####	"Road Diet"	US 42 Brownsboro			PD3, PD10, PD21	9
12-####	"Road Diet"	Prestonsburg				9.67
5-####	"Road Diet"	US 60/2nd Street Frankfort				10
4-8103.50	NEW ROUTE	KY 313 to Bullion Connector	\$11,450,000	NEW CONNECTOR FROM VETERAN'S PKWY (KY 1646) TO KY-313.	PD2, PD6, PD8, PD19	10.7