Sustainability Directors Meeting: Briefing Materials
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NCHRP REPORT 750

Strategic Issues Facing Transportation

Volume 4

Sustainability as an Organizing Principle for Transportation Agencies

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

APPENDIX F

TBL Maturity Assessment Tool

This assessment tool was developed as part of NCHRP Project 20-83(7), "Sustainable Transportation Systems and Sustainability as an Organizing Principle for Transportation Agencies." The tool is in the form of a self-administered survey to help transportation agencies assess their maturity and progress toward supporting a triple-bottom-line (TBL) sustainability policy system. It is based on a generalized sustainability maturity model developed as part of this project. This model is shown in Figure F-1.

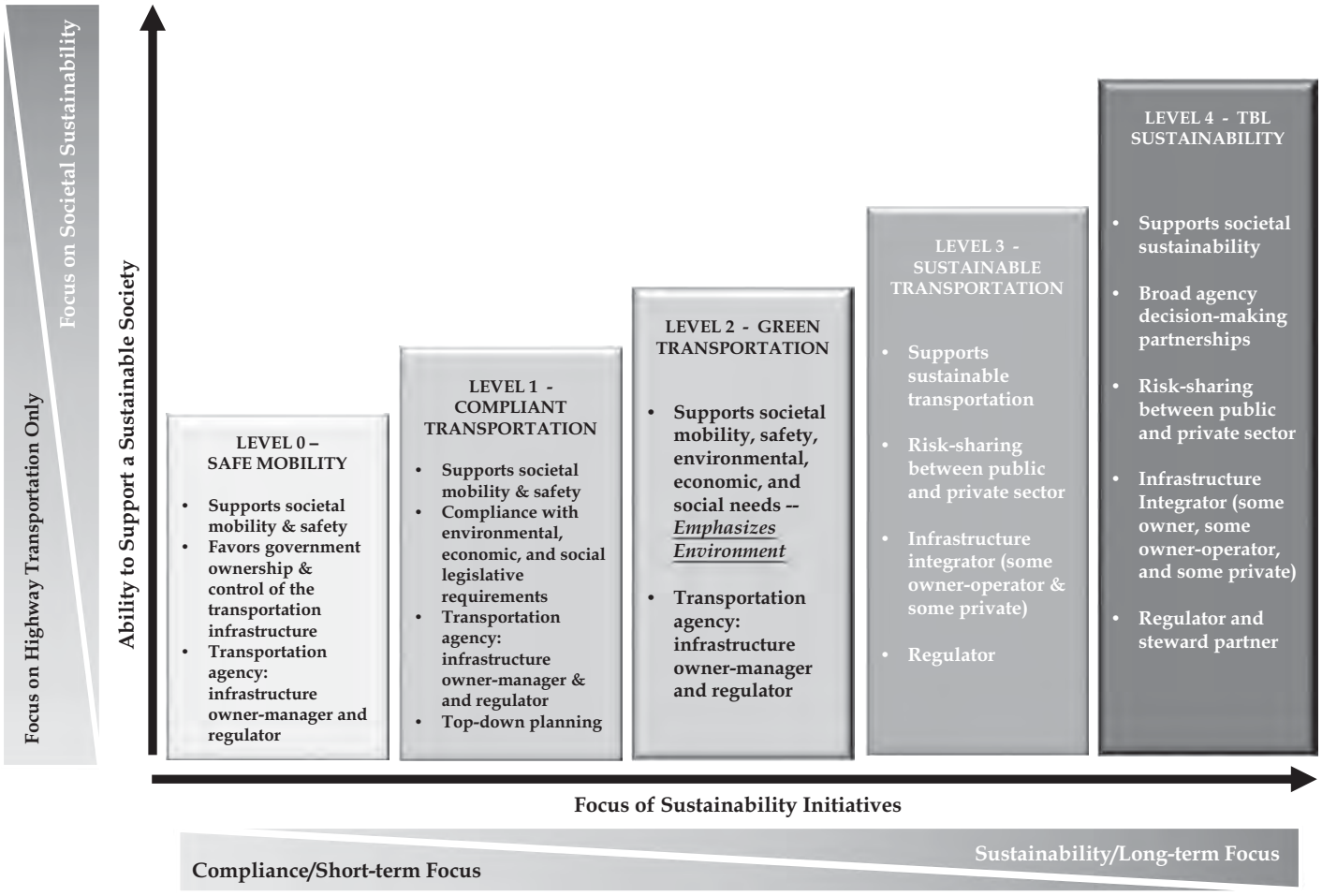


Figure F-1. Sustainability—maturity concept agency view.

This tool is an advisory, heuristic device only.

- *It is intended to encourage discussion and help agencies understand their current position and potential actions that they could take to achieve a high level of maturity vis-à-vis sustainability.*
- *It does not assess the degree to which policies support sustainability. Rather it assesses the maturity of agency structure and business culture related to their ability to support evolving sustainability policy systems.*

The assessment follows a number of basic functional dimensions to characterize an agency along a sustainability maturity scale—based on a vision of how an agency is likely to function under a TBL sustainability policy system. The basic functional dimensions are:

A. Developing Consensus on Needs

B. Planning and Programming

C. Budgeting and Resource Allocation

D. Rulemaking and Regulation

E. Service and Project Delivery

F. Compliance and Dispute Resolution

G. Education and Cultural Development

H. Outreach and Communications (to Public and Stakeholders)

F.1 Instructions

Users should review each of the following tables and select a single set of characteristics that best describe the agency. Users can:

- Combine scores to find an overall maturity rating,
- Compare scores for each dimension to focus on "trailing" functions,
- Judge what is most likely to change under a TBL policy system, and
- Evaluate potential initiatives the agency might take to advance in any functional area.

A. **CONSENSUS ON NEEDS AND GOALS:** Processes by which transportation policy systems identify needs, gaps, and requirements; build consensus around a prioritized ranking of potential needs; and develop acceptable goals and priorities for transportation.		
QUESTION: Are the needs and goals assessment functions in this agency best characterized by:		
SCORE	**STATEMENT**	**YES/NO**
1	• Needs driven by political decisionmakers and major stakeholders • Strategic goals determined by high-level decisionmakers and constrained by funding and regulations (including environmental) • Public participation limited to formal regulated processes	
2	• Needs driven by political decisionmakers and major stakeholders • Strategic goals determined by high-level decisionmakers and constrained by funding and greater focus on regulatory compliance (including environmental) • Some outreach and public consensus building	
3	• Needs driven by political decisionmakers, major stakeholders, and assessment of public sentiment • Greater focus on environmental improvement, stewardship, and social context • Significant formal outreach and consensus-building efforts	
4	• Needs more driven by public sentiment, performance, and sustainability considerations • Goals focus on sustainable transportation services and programs • More transparency and active outreach and two-way public dialogue	
5	• Cross-agency decisionmakers, stakeholders, and the public participate actively in needs determination and goal-setting • Goals and policies focused on TBL sustainability • Active two-way public engagement and consensus in strategic decisions	

B. PLANNING AND PROGRAMMING: Planning and programming refers to the processes by which transportation plans are created to carry out the goals developed in the consensus-building, needs assessment, and goals-setting processes.

QUESTION: Are the planning and programming functions in this agency best characterized by:

SCORE	STATEMENT	YES/NO
1	• Emphasizes mobility, safety, and quantity (more, faster) within mode • Expands in response to travel demand ("accept and accommodate") • Transportation planning is siloed • Transportation planning is not connected to land use decisionmaking • Limited by political jurisdiction • Limited data and related performance measures	
2	• Emphasizes mobility, safety, and quantity (more, faster), alternate modes • Plans, builds based on forecasts of likely demand ("predict and provide") • Transportation planning is siloed • Transportation planning more influenced by land use decisionmaking • Limited by political jurisdiction • Compliance-based reporting	
3	• Emphasizes mobility etc. but considers flexibility, accessibility, connectivity, system efficiency, and environmental context • Emphasizes improved intermodal operations and environment • Manages transportation demand and capacity • Formal and informal links exist between other planning entities • Plans, builds based on forecasts of likely demand and land use plans • Limited by political jurisdiction • Performance-based reporting, including environment	
4	• Emphasizes flexibility, accessibility, connectivity, system efficiency, safety, security, and context • Emphasizes multimodalism and connections between modes • Proactive demand and capacity management • Stronger planning links with other planning entities • Works from preferred vision to planning and provision ("deliberate and decide")—build scenarios, backcast, deliberate, and decide • Planning and investment decisions are driven by reliable and up-to-date data that reflect the full range of effects of transportation investment	
5	• Emphasizes flexibility, accessibility, connectivity, system efficiency, safety, security, and full TBL context • Emphasizes multimodalism and connections between modes • Proactive demand and capacity management • Emphasizes integrated planning engaging multiple agencies • Works from preferred vision to planning and provision ("deliberate and decide")—build TBL scenarios, analyze, deliberate, coordinate • Flexible regional focus that engages multiple jurisdictions	

C. **BUDGETING AND RESOURCE ALLOCATION:** Budgeting and resource allocation includes the processes by which transportation policy systems determine how to collect and distribute resources among different projects and programs (includes budgeting and allocation).

QUESTION: Are the budgeting and resource allocation functions in this agency best characterized by:

SCORE	STATEMENT	YES/NO
1	• Budget process is competitive (e.g., agencies compete for funds), siloed, and driven by previous allocation decisions (e.g., starts with last year's budget) • Ignores larger social, regional, and economic costs and benefits of transportation—focuses on transportation-centric cost–benefit analysis • Inflexible—funds are bucketed and segregated by rules and policy • Politicized—transportation funding is driven by taxes and formulae	
2	• Budget process is competitive (e.g., agencies compete for funds), siloed, and driven by previous allocation decisions (e.g., starts with last year's budget) • Focuses primarily on immediate direct costs, but does include consideration of social, regional, and economic benefits of transportation • Inflexible—funds are bucketed and segregated by rules and policy • Politicized—transportation funding is driven by taxes and formulae	
3	• Budget process is competitive (e.g., agencies compete for funds), siloed, and driven by previous allocation decisions (e.g., starts with last year's budget) • Incorporate full social, environmental, fiscal, economic, and other costs into planning and provision—uses FCA	
4	• Budget process is more integrated and cooperative • Incorporates social, environmental, fiscal, economic, and other costs into planning and provision—uses FCA • More independent funding—funds for transportation are derived more sustainably from users and other benefiting entities	
5	• Budget process is integrated and cooperative across agency boundaries • Incorporates full social, environmental, fiscal, economic, and other costs into planning and provision—uses FCA • Flexible—funds flow to program areas, regions, and modes where they meet greatest TBL societal sustainability needs • Independent funding—funds for transportation are derived sustainably from users and other benefiting entities	

D. RULEMAKING AND REGULATION: Rulemaking and regulations refers to the processes by which rules, regulations, standards, and guidelines are established for compliance with legislated mandates and laws.

QUESTION: Are the rulemaking and regulation functions in this agency best characterized by:

SCORE	STATEMENT	YES/NO
1	• Expert led • Heavily influenced by organized interests and economic stakeholders • Minimal public involvement	
2	• Expert led • Heavily influenced by organized interests and economic stakeholders • Increased public involvement • Highly politicized and conflict based	
3	• Expert led • Open to a plurality of interests, stakeholders, and activists • Substantial public involvement during post-decisionmaking phase (i.e., "do you approve?") • Highly politicized and conflict based	
4	• Public–expert partnership in developing regulation and rules—experts invite and encourage public participation • Open to a plurality of interests, stakeholders, and activists • Substantial public involvement during the entire rulemaking process • Less politicized and more cooperative	
5	• Public–expert partnership in developing regulation and rules—experts invite and encourage public participation • Bias for flexible, voluntary self-regulation • Open to a broad TBL-related plurality of interests, stakeholders, and activists • Substantial public involvement during the entire rulemaking process • Cooperative and consultative	

E. SERVICE AND PRODUCT DELIVERY: Service and product delivery includes processes by which transportation policy systems deliver transportation goods and services to the public and ensure that the level and quality of services meet goals and established standards.

QUESTION: Are the service and project delivery functions in this agency best characterized by:

SCORE	STATEMENT	YES/NO
1	• Efficient and best-value business processes • Transportation and mobility performance measured and reported	
2	• Ad hoc sustainability initiatives • Efficient and best-value business processes—some environmental and social issues considered • Transportation and mobility performance measured and reported • Some environmental performance management reports	
3	• General sustainability objectives established • Sustainability performance (centered on environment) reporting and management common among delivery functions	
4	• Sustainability embedded in all business processes (e.g., project delivery, procurement, O&M) • Sustainability performance (centered on environment) measured and reported across most functions	
5	• Sustainability embedded in all business processes (e.g., project delivery, procurement, O&M) • Sustainability performance measured and reported with TBL-related improvement targets • Commitment to societal sustainability in all service and project delivery functions • Periodic reevaluation of performance measures and regular evaluation of sustainability achievements	

F. **COMPLIANCE AND DISPUTE RESOLUTION:** Compliance and dispute resolution include processes by which the transportation community sees that the intent of legislation, standards, and regulations are complied with and the processes by which disagreements over interpretations or tradeoffs can be resolved.

QUESTION: Are the compliance and dispute resolution functions in this agency best characterized by:

SCORE	STATEMENT	YES/NO
1	• Highly politicized • Informal brokering between powerful stakeholders	
2	• Highly politicized • Informal brokering between powerful stakeholders • Dependence on law and judicial system • Adversarial relationship between key stakeholder groups	
3	• Highly politicized • Less influenced by powerful stakeholders in the decisionmaking process • Dependence on law and judicial system • Less adversarial relationship between key stakeholder groups and more constructive dialogue	
4	• Emphasizes “deliberate and decide” and constructive engagement • Avoids dependence on law and judicial system	
5	• Politics minimized—public involvement and transparency in compliance issues • Emphasizes “deliberate and decide” and emphasis on constructive engagement to solve problems • Avoids dependence on law and judicial system	

G. EDUCATION AND TRAINING: Education and training includes processes by which the transportation community is educated to understand and embrace evolving organizing principles and to adopt (and invest in) behavioral norms associated with those principles.

QUESTION: Are the education and training functions in this agency best characterized by:

SCORE	STATEMENT	YES/NO
1	• Focus on technical specialties and standards • Performance standards and incentives associated with traditional performance measures	
2	• Focus on technical specialties and standards • Performance standards and incentives associated with traditional performance measures • Informal sustainability training and recruitment and integration of environmental specialists into transportation agencies	
3	• Focus on multidisciplinary workforce—development of more flexible performance standards • Developing sustainability education, training, and internal incentives to support sustainable programs • Culture of environmental stewardship	
4	• Focus on multidisciplinary workforce—organization commitment to flexible performance standards • Commitment to sustainability education, training, and internal incentives to support sustainable programs • Culture of transportation sustainability and stewardship	
5	• Focus on multidisciplinary workforce—established and flexible standards associated with sustainability • Commitment to sustainability education, training, and internal incentives to support TBL sustainability • Culture of TBL sustainability and stewardship of societal well-being	

H. OUTREACH AND COMMUNICATIONS: Outreach and communications include processes by which information on needs, strategies, expectations, and results are shared broadly by stakeholders in the public and private-sector transportation community—critical processes to support consensus-building, policymaking, planning, and decisionmaking.

QUESTION: Are the outreach and communication functions in this agency best characterized by:

SCORE	STATEMENT	YES/NO
1	• One-way communication to explain transportation priorities and plans	
2	• One-way communication to explain transportation priorities and plans with formal requirements to present plans but limited feedback	
3	• One-way communication to explain transportation priorities and plans with highly structured presentation and feedback	
4	• Two-way active engagement and communication between transportation agencies, public, stakeholders, and decisionmakers	
5	• Regular two-way active engagement and communication between transportation agencies, public, stakeholders, and decisionmakers • Involvement of stakeholders at all stages of the decisionmaking and planning process • Active outreach to identify and include previously underrepresented groups	

F.2 Overall Rating—Sustainability Maturity Level

For an overall TBL sustainability maturity rating, review the answers for each of the functional dimensions. For the row that best describes your agency, circle the score in the first column of that row (i.e., 1 through 5). When tables for functional dimensions A through H are completed, enter the scores in the table below and sum for the overall rating.

Functional Dimension	Score
A. Consensus on Needs and Goals	
B. Planning and Programming	
C. Budgeting and Resource Allocation	
D. Regulation and Rulemaking	
E. Service and Product Delivery	
F. Compliance and Dispute Resolution	
G. Education, Training, and Culture Change	
H. Outreach and Communications	
Total (sum A through H)	

Compare the score to the following scale for overall maturity level:

Maturity level	Characteristics	Score
Safe Mobility	• Support societal mobility • Favors government ownership & control of the transportation infrastructure • Transportation agency as infrastructure owner–manager & regulator	8 to 11
Compliant Transportation	• Support societal mobility • Compliance with environmental, economic, and social legislative requirements • Transportation agency as infrastructure owner–manager & regulator • Top-down, planning	12 to 19
Green Transportation	• Support societal mobility & environmental, economic, and social needs—*emphasizes environment* • Transportation agency as infrastructure owner–manager & regulator	20 to 27
Sustainable Transportation	• Support sustainable transportation • Favors partnerships between public and private sector • Transportation agency as infrastructure coordinator & regulator	28 to 36
Support TBL Sustainability	• Support societal sustainability • Agnostic on issues of ownership or control of transportation infrastructure—whatever is most sustainable • Transportation agency as transportation system steward	37 to 40

Measuring transportation equity
SSTI Working Paper

INTRODUCTION

Cities, regional planning agencies, and state departments of transportation are growing more interested in evaluating the equity impacts of transportation planning, design and regulation. Early work looking at transportation equity focused mainly on the economic impacts of transportation spending. This focus eventually broadened to include the negative externalities of transportation and, more recently, the accessibility impacts of transportation related decision-making.

This paper presents a framework for evaluating the equity-related impacts of transportation, which accounts for all of the considerations described above, and outlines many of the tools and data sources available for conducting equity analyses using this framework.

EQUITY FRAMEWORK

Equity analyses focus on evaluating how proportionately, or disproportionately, costs and benefits are distributed across different segments of the population. For example, we may be interested in whether one group of people has poor access to jobs and amenities compared to another group, or whether transportation is less safe or more costly for one group of people compared to another.

First, we must identify population groups—environmental justice (EJ) groups—that might be considered disadvantaged or disproportionately affected, depending on particular circumstances. Conventional EJ groups include women, racial or ethnic minorities, low-income households and immigrants. Other transportation-specific groups that may be disproportionately affected include the physically disabled, children and seniors, non-drivers or non-car owners, and those living in rural areas.

Once EJ groups of interest are identified, it is important to consider each of four equity dimensions: accessibility, affordability, health and safety, and procedural equity (Table 1). Whenever possible, it is important to evaluate each of these dimensions by comparing how EJ groups compare to non-EJ groups. This can highlight important inequities in the way that particular groups are served or affected by transportation systems, and point the responsible agencies toward appropriate actions to address those inequities.

Each of these equity dimensions is described below—including commonly available data, tools, and calculation methods for each—followed by examples of how this framework can be implemented to address equity-related issues.

Table 1. Equity framework and dimensions

Equity dimension	Sample metric	Desired outcome	Description
Accessibility	Travel time	Down	Average travel time to selected destinations
	Cumulative opportunities	Up	Number of amenities and services within a given travel time
	Composite access score	Up	Accounts for transportation network, cumulative opportunities and travel time decay functions

Affordability	H+T® Affordability Index	< 45%	Housing and transportation costs as a percent of income
Health and safety	Speed suitability	~ 1.0	Actual speeds / speed limit
	Serious and fatal crashes	Down	Crashes per person (by neighborhood or by mode)
	Exposure to traffic	Down	Average daily traffic near home location
Procedural equity	*Undefined*	–	–

EQUITY DIMENSIONS, DATA AND METHODS

Accessibility

Transportation planners and designers are accustomed to measuring vehicle throughout in order to evaluate system performance. Unfortunately, common mobility metrics such as delay or level of service typically do not properly reflect equity issues and other community interests. For example, measures of traffic flow through a particular community do not necessarily reflect how easily community members can get to work, or what the impacts of traffic flow are on their health and well-being.

Accessibility measures, in contrast, measure the ease of reaching meaningful destinations (e.g., work, school, shopping, health care and services) from a particular location within a particular time or cost threshold. Accessibility, which is the primary function of a transportation system, improves as the number of nearby destinations increases or as the time and distance to reach to individual destinations decreases.

Data and methods

Past practice focused primarily on accessibility to jobs, which provides a limited but important understanding of travel patterns and obstacles. At a minimum, this information can be accessed from the U.S. Census' American Community Survey, which provides data on worker travel times, means of transportation and worker flows, or from travel surveys. Emerging sources of travel data, such as GPS data from mobile phones, navigational devices and wearable fitness devices, promise to offer even more information about travel to work and to other destinations by multiple modes.

Without actual travel data, however, a growing number of tools provide measures of accessibility based on the number of destinations (or "opportunities") that can be reached from a particular location by various modes within a given travel time, giving greater weight to nearer opportunities. Walk Score™, which measures the number of opportunities within walking distance from a given location, is the most widely known example, but is not particularly helpful as a transportation planning and decision-making tool. Three other promising tools include:

- *Accessibility Observatory* – The Accessibility Observatory, based at the University of Minnesota, offers a broad view into regional transportation accessibility using metrics based on the number jobs accessible within a given time threshold by automobile and by transit.
- *Renaissance Planning Group* – The Renaissance Planning Group has developed and calibrated a tool for the Washington, DC area, which measures accessibility to jobs and

other non-work destinations by automobile, transit and walking at various geographic scales.

- *Sugar Access*™ – Sugar Access is a GIS-based application available for purchase from Citlilabs, Inc. The tool comes preloaded with basic data about transportation networks, travel times, transit schedules and points of interest. It produces a variety of accessibility metrics at essentially any geographic scale.

Each tool has its own range of uses. The Accessibility Observatory, for example, promises an easily understood tool that can be used to compare accessibility within and among metropolitan regions throughout the U.S., but may not yet be the most comprehensive tool for transportation planning purposes or detailed project analyses. The Renaissance Planning Group has demonstrated how its accessibility tool can be used in project planning, testing it along a proposed bus rapid transit corridor in Montgomery County, Maryland. The tool, however, still is not widely available for use outside of the Washington, DC area. Sugar Access, in contrast, is ready for use in many areas throughout the U.S. but relies on a number of general assumptions and basic data unless calibrated to local conditions using available local data sources.

In an equity analysis, no matter what tool or data source is used, it may be necessary or useful to parse out accessibility metrics in terms of particular destination types of travel modes. For example, equity analyses commonly measure access to jobs by transit. However, equity concerns may focus on access to groceries, education, services or other opportunities, and may be interested in a wider range of travel modes, including walking or driving.

Affordability

Affordability measures reflect actual out-of-pocket travel costs in monetary terms rather than as time spent or distance traveled. While it is tempting to think of accessibility entirely in monetary terms, that can be problematic in this context for two reasons: 1) doing so makes it difficult to parse out specific accessibility issues, and 2) there is great risk of concealing travel time disparities by assigning different values of time to different income groups.

Data and methods

Currently, one of the most useful tools for measuring transportation affordability is the Housing and Transportation Index (H+T Index), developed by the Center for Neighborhood Technology (CNT). The tool provides estimates of combined household housing and transportation spending as a percent of household income down to the census block level. The H+T accomplishes this using readily available federal data, state, and local data on transportation and housing.

The H+T Index can determine total household transportation costs for both auto and transit modes. The ability of the H+T to drill down to the census block level allows for a comparative analysis of affordability across census blocks in a metro area or a region, if desirable. A comparison of transportation costs among census blocks that are lower income or part of another EJ group and census blocks that have higher annual incomes may reveal equity concerns that should be addressed – for example, in locations where combined housing and transportation costs are greater than 45 percent of median income.

Health and safety

It is not sufficient to measure accessibility or affordability in an equity framework if a transportation system poses considerable health and safety risks to its users or to non-users. This

is particularly true if one particular group puts another group at greater risk, such as by traveling at high speeds through their neighborhood or exposing them to harmful emissions. Sample metrics include:

- Serious and fatal crash rates (by neighborhood or by travel mode)
- Speed suitability (travel speeds divided by speed limits)
- Traffic exposure or related impacts (e.g., air quality)

Data and methods

The most readily available data on safety impacts comes from the Fatal Accident Reporting System (FARS) provided by the National Highway Reporting Safety Administration. This database indicates the location of all fatal crashes in the U.S., whether a non-motorized road user was involved, and the home location of drivers by ZIP code. Due to the relatively rare occurrence of fatal crashes, the inclusion of crashes involving serious injuries offers more robust information about where the greatest safety risks are, when these types of crashes occur, and who is involved. This information may be available in local crash databases, but the quality and content of these databases will vary.

Data related to other traffic impacts might be available from local sources or might need to be collected. This includes local emissions and air quality data, local decibel readings (to account for noise impacts).

Procedural equity

Although we identify procedural equity as a key component in an equity framework, we do not define a metric for this component. In part this reflects the difficulty in identifying proper metrics and the even greater difficulty in actually collecting data to reflect those metrics—for example, public participation rates by race, gender, or income—it also points to the fact the procedural equity is, above all else, a process.

Existing data may provide helpful insight. The entire transportation project delivery process requires constant and deliberate involvement of community members to ensure equitable outcomes. Project staff or team will likely need to be creative to improve participation among historically marginalized groups. This may entail accommodating non-traditional work schedules, holding meetings in transit-accessible locations or in conjunction with already-planned community meetings, soliciting the help and guidance of community leaders, or providing accommodations such as meals or childcare. Some possible ways to measure this involvement include documenting the percent of community members living in a project area that attend meetings, noting if the ethnic/gender/age make up of participants reflects the impacted community.

IMPLEMENTATION

Example: Infill development to eliminate food deserts

One purpose of an equity analysis might be to determine how access to grocers and other food outlets varies among different populations within a given area. A typical finding could be that access is limited in certain neighborhoods (e.g. “food deserts” low-income neighborhoods). A proper response, rather than mobility improvements, might then be to encourage mixed-use infill development near residential areas to introduce new food options in those areas.

Example: Increased transit frequency and/or service hours

An accessibility analysis might reveal that a particular community has poor access to jobs thereby causing individuals to endure long commutes or travel by automobile or other more expensive means when they otherwise would not choose to. This may be addressed increasing transit frequency, implementing transit priority on high traffic routes, expanding service areas, or extending service hours, particularly when those individuals work non-traditional schedules. In additional to increasing travel options for the general population, these measures can greatly reduce transportation costs for certain individuals.

Example: Safer connections for bicycles and pedestrians

An analysis of crashes might reveal that certain neighborhoods experience a disproportionately high number of crashes involving people walking or biking, particularly in proportion to bike and pedestrian mode shares, indicating that facilities are insufficient or crossings are unsafe. Targeting those areas for infrastructure improvements such as crosswalks, bike lanes and traffic calming measures could improve the safety for those already choosing to walk and bike, encourage more individuals to use those modes, and improve accessibility options for those communities.

Emerging Accessibility Metrics: An Overview
State Smart Transportation Initiative
June 2015

Accessibility metrics provide quantitative information about the ease of reaching various types of destinations, usually in terms of travel time. Walk Score is an example of a common accessibility measure, but it only takes into account destinations that are within walking distance from a particular address. An ideal measurement tool can account for a variety of travel modes—walking, biking, transit and automobile—and it is customizable in order to answer a range of questions. For example:

- How accessible are jobs from a given location, using transit?
- How accessible are typical daily needs (e.g., groceries, schools and banks) by walking and biking?
- What areas are particularly inaccessible?
- How does a proposed project (e.g., a new transit line, road connection or development project) improve accessibility?

Accessibility tools that are currently available or in development include:

- Work by the Accessibility Observatory at the University of Minnesota;
- Work by the Renaissance Planning Group; and
- Sugar Access, provided by Citilabs, Inc.

Sugar Access, which comes with preloaded data and runs in Esri ArcMap, offers many of the essential features required of an ideal accessibility measurement tool:

- A wide variety of destination types: households, jobs and other points of interest (POIs);
- The ability to weight different destination types for a composite Access Score;
- A decay function that assigns higher weight to closer destinations;
- Transportation networks for a variety of modes (auto, transit, bike, and walk); and
- An ability to customize inputs and assumptions.

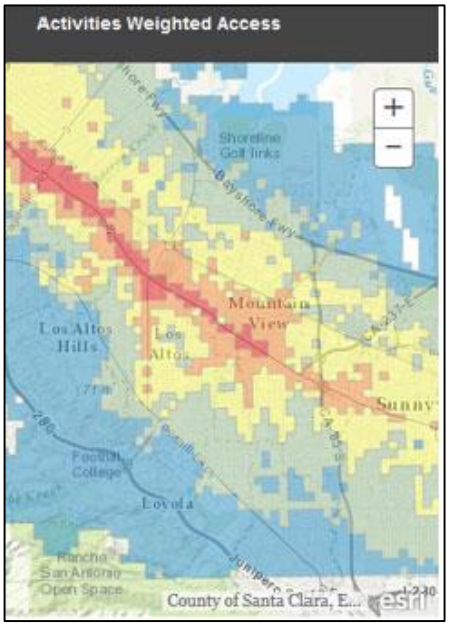
Table

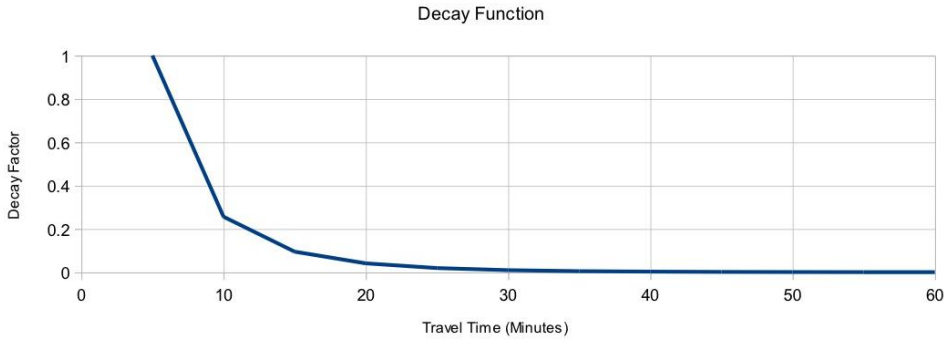
errandValues

OID	POINTCLASS	FAC_TYPE	DESCRIPTIO	POI_TARGET	CAT_WEIGHT
0	400	3578,6000	ATM, Bank	3	18
1	100	5400	Grocery Store	2	24
2	110	9565	Pharmacy	2	18
3	120	9535	Convenience Store	2	16
4	140	9537	Clothing Store	1	7
5	130	9545	Department Store	1	7
6	150	9986	Home Improvement & Hardware Store	1	5
7	180	6512	Shopping/Specialty Store	1	5
8	190	9530	Post Office	1	5
9	160	9988	Office Supply & Services Store	1	3

1 (0 out of 10 Selected)

errandValues





Default destination targets and weights (top left); decay function (bottom left); sample output (right).
All figures from Citilabs, Inc.

Caltrans®

Strategic Management Plan

2015-2020

Goal 3: Sustainability, Livability and Economy

Strategic Objectives	Performance Measures	Targets
PEOPLE: Improve the quality of life for all Californians by providing mobility choice, increasing accessibility to all modes of transportation and creating transportation corridors not only for conveyance of people, goods, and services, but also as livable public spaces.	Percentage increase of non-auto modes for: • Bicycle • Pedestrian • Transit	By 2020, increase non-auto modes: • Triple bicycle; • Double pedestrian; and • Double transit. (2010-12 California Household Travel survey is baseline.)
PLANET: Reduce environmental impacts from the transportation system with emphasis on supporting a statewide reduction of greenhouse gas emissions to achieve 80% below 1990 levels by 2050.	Per capita vehicle miles traveled.	By 2020, achieve 15% reduction (3% per year) of statewide per capita VMT relative to 2010 levels reported by District.
	Percent reduction of transportation system-related air pollution for: • Greenhouse gas (GHG) emissions • Criteria pollutant emissions	• 15% reduction (from 2010 levels) of GHG to achieve 1990 levels by 2020. • 85% reduction (from 2000 levels) in diesel particulate matter emissions statewide by 2020. • 80% reduction (from 2010 levels) in NOx emissions in South Coast Air Basin by 2023.
	Percent reduction of pollutants from Caltrans design, construction, operation, and maintenance of transportation infrastructure and building for: • Greenhouse gas (GHG) emissions • Criteria air emissions • Water pollution	By 2020, reduce Caltrans' internal operational pollutants by District from 2010 levels (from planning, project delivery, construction, operations, maintenance, equipment, and buildings) including: • 15% reduction by 2015 and 20% reduction by 2020 of Caltrans' GHG emissions per EO-B-18-12. • 10% reduction in water pollutants. By 2020, 85% reduction (from 2000 levels) in diesel particulate matter emissions statewide. By 2023, 80% reduction (from 2010 levels) in NOx emissions in South Coast Air Basin.
PROSPERITY: Improve economic prosperity of the State and local communities through a resilient and integrated transportation system.	Freight system competitiveness, transportation system efficiency, return on transportation investment.	By 2020, 10% increase in freight system efficiency.

See Appendix for all strategic objectives, performance measures, and targets.

Goal 3: Sustainability, Livability and Economy

"Make long-lasting, smart mobility decisions that improve the environment, support a vibrant economy, and build communities, not sprawl."

Strategic Objectives	Performance Measures	Targets
PEOPLE: Improve the quality of life for all Californians by providing mobility choice, increasing accessibility to all modes of transportation and creating transportation corridors not only for conveyance of people, goods, and services, but also as livable public spaces.	Percentage increase of non-auto modes for: • Bicycle • Pedestrian • Transit	By 2020, increase non-auto modes*: • Triple bicycle; • Double pedestrian; and • Double transit. (2010-12 California Household Travel survey is baseline.)
	Accessibility Score. (To be determined considering e.g., multi-modal transportation proximity to jobs, disadvantaged communities, housing services, transit-oriented communities, etc.)	By December 2016, develop and adopt Caltrans Accessibility Score.
	Livability Score. (To be determined considering, e.g., quality of life, noise, safety, localized emissions, environmental justice concerns, etc.)	By December 2016, develop and adopt Caltrans Livability Score.
	Percentage of top 25 priority corridor system master plans completed to enhance sustainability of transportation system. (Priority corridors to be determined considering: mobility, freight, highways, transit, rail, bike, pedestrian, aviation, etc.)	By 2017, complete corridor system plans for all State routes. By 2020, complete top 25 corridor system management plans.
PLANET: Reduce environmental impacts from the transportation system with emphasis on supporting a statewide reduction of greenhouse gas emissions to achieve 80% below 1990 levels by 2050.	Per capita vehicle miles traveled. (Reported statewide by District.)	By 2020, achieve 15% reduction (3% per year) of statewide per capita VMT relative to 2010 levels reported by District.
	Percent reduction of transportation system-related air pollution for: • Greenhouse gas (GHG) emissions • Criteria pollutant emissions	15% reduction (from 2010 levels) of GHG to achieve 1990 levels by 2020. 85% reduction (from 2000 levels) in diesel particulate matter emissions statewide by 2020. 80% reduction (from 2010 levels) in NOx emissions in South Coast Air Basin by 2023.

*These targets will be achieved through development and implementation of the Asset Management Plan, as required by SB 486 (Chapter 917, 2014)

Goal 3: Sustainability, Livability and Economy (continued)

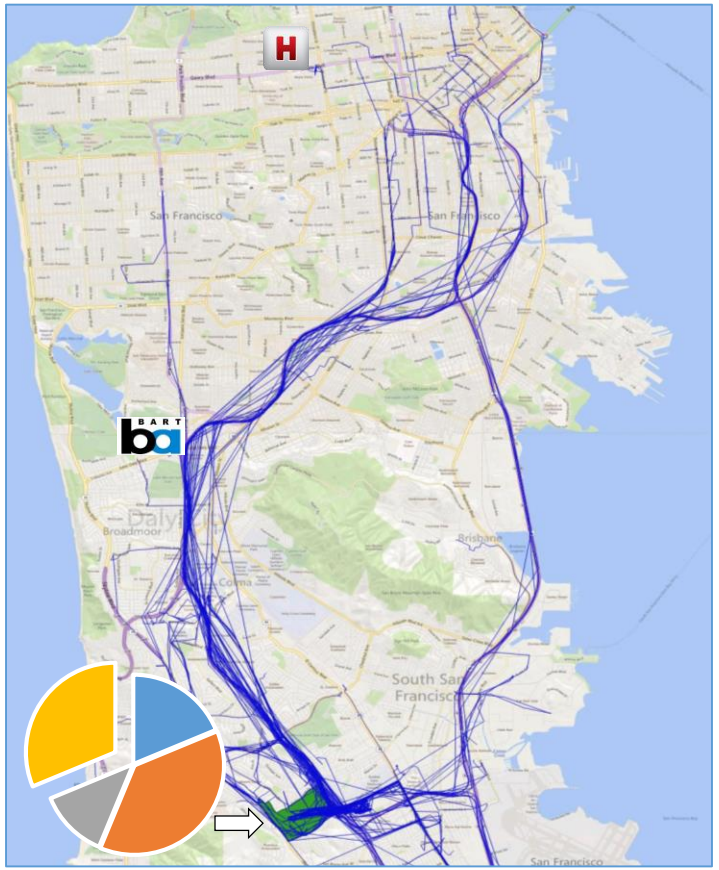
Strategic Objectives	Performance Measures	Targets
PLANET (Continued): Reduce environmental impacts from the transportation system with emphasis on supporting a statewide reduction of greenhouse gas emissions to achieve 80% below 1990 levels by 2050.	Percent reduction of pollutants from Caltrans design, construction, operation, and maintenance of transportation infrastructure and building for: • Greenhouse gas (GHG) emissions • Criteria air emissions • Water pollution	By 2020, reduce Caltrans' internal operational pollutants by District from 2010 levels (from planning, project delivery, construction, operations, maintenance, equipment, and buildings) including: • 15% reduction by 2015 and 20% reduction by 2020 of Caltrans' GHG emissions per EO-B-18-12. • 10% reduction in water pollutants. By 2020, 85% reduction (from 2000 levels) in diesel particulate matter emissions statewide. By 2023, 80% reduction (from 2010 levels) in NOx emissions in South Coast Air Basin.
	Percent increase in transportation projects that include green infrastructure. Weighting mechanism to be developed.	By 2020, increase by 20% (5% per year) incorporating green infrastructure into transportation projects relative to 2010 levels.
PROSPERITY: Improve economic prosperity of the State and local communities through a resilient and integrated transportation system.	Prosperity score. Score to be determined considering, e.g., gross State/ regional product, freight system competitiveness, transportation system efficiency, return on transportation investment, etc.	By 2016, develop and adopt Caltrans prosperity score.
	Freight System Efficiency. Improve freight system efficiency to enhance freight competitiveness and support a sustainable, low emissions freight system.	By 2020, 10% increase in freight system efficiency.

Goal 3: Sustainability, Livability and Economy (continued)

Strategic Objectives	Performance Measures	Targets
PROSPERITY (Continued): Improve economic prosperity of the State and local communities through a resilient and integrated transportation system.	Resiliency Score for: • Climate change resiliency (e.g., vulnerability to flood, sea level rise, etc.) • System resiliency (e.g., adaptability from emergencies, disasters, etc.) • Financial resiliency (e.g., ensure funding considering maintenance, operations, modernization, disasters, financial stability, etc.) Resiliency Score to be determined considering, e.g., asset management, emergency and risk management, climate change, sea level rise, vulnerability, adaptation, etc.)	By December 2017, develop and adopt Caltrans Resiliency Score.
	Reduction of resource consumption by: • Reduction of materials taken to landfills (reduction of virgin materials used, reuse of existing materials for construction, recycling of building, construction, and roadside trash) • Reduction of potable water use	By 2020, reduce resource consumption from 2010 levels by District: • 15% reduction of materials taken to landfills • 15% reduction of potable water use

Understanding trip-making

Analyze…	To understand…
Precise Origins & Demographics	• Trip generation • Equity • Accessibility
Precise Destinations & Day/Time	• Commuting & work locations • Economic development • TDM opportunities
Actual Routes and Trip Duration	• Actual travel times, burden • “Last mile,” parking behavior • Diversion to surface streets • Multimodal opportunities
Vehicle Type and Class	• Criteria emissions • Heavy vehicle traffic • Personal vs. commercial trips
Custom Date Ranges	• “Before and after” studies • Seasonal variance • Trends over time



HB2

Funding the Right
Transportation Projects

The Facts

April 2015

About HB2

House Bill Two (HB2) is about investing limited tax dollars in the right projects that meet the most critical transportation needs in Virginia. At the heart of the new law is scoring projects based on an objective process that involves public engagement and input. Once projects are scored, the Commonwealth Transportation Board (CTB) will have the best information possible to select the right projects for funding.

It's the law

Governor Terry McAuliffe signed HB2 into law in 2014, which directs the CTB to develop and use a scoring process for project selection by July 2016. Candidate projects will be screened to determine if they qualify to be scored. Projects will be scored based on an objective and fair analysis applied statewide. The law will improve transparency and accountability. The public will know how projects scored and the decisions behind the CTB's project selections.

Projects will be scored according to key factors

The factors are congestion mitigation, economic development, accessibility, safety, environmental quality and land use and transportation coordination (in areas over 200,000 in population). Projects that reduce congestion would rise to the top in traffic-clogged regions like Northern Virginia and Hampton Roads. Projects that stimulate economic growth may be more important for rural and other regions in the state.

Localities are involved in creating the scoring process

The commonwealth is engaging localities, regional planning organizations, transit authorities and other stakeholders in the development of the scoring process. For each of the key factors, multiple measures will be applied. Stakeholders will provide input on weighing the factors and selecting the measures within each highway construction district. By law, congestion mitigation will be the highest weighted factor in the Northern Virginia and Hampton Roads districts. This information will be provided to the CTB who will make the final decision on the scoring process.

Certain projects are required to be scored

This includes projects that will address needs as identified in the commonwealth's long-range transportation strategic plan called VTrans 2040. These projects will improve transportation on Corridors of Statewide Significance, regional multi-modal networks and urban development areas. The CTB must consider highway, transit, rail, road operational improvements and transportation demand projects, such as vanpooling and ridesharing.

Allocation of certain funding is subject to scoring under HB2

This applies to discretionary state and federal funds, and to funding allocations under the optional CTB formula for high priority projects, public-private partnerships, and smart roadway projects.

Some projects are exempted from scoring

The law excludes safety projects and asset management projects such as rehabilitating aging pavements and bridges. Certain funding sources are exempted, including the Congestion Mitigation and Air Quality, Highway Safety Improvement, Transportation Alternatives, Regional Surface Transportation and Revenue Sharing programs, and secondary/urban formula funds. Scoring will not apply to projects solely funded through the Northern Virginia or Hampton Roads regional revenues. At the discretion of the CTB, projects that are fully funded and have completed environmental review in the Six-Year Improvement Program may be exempt.

Some projects have been flagged for scoring

In preparation to implement the scoring process, funding has been removed from a group of projects in the FY 2015 -2019 Six-Year Improvement Program. These projects will be scored because they meet the criteria as described by law under HB2. They are not fully funded and have not completed environmental work. Enough funding remains on these projects to take them to the next milestone. The rest of the funding has been removed from these projects and set aside for the HB2 process.

The scoring process will be developed in 2015 and implemented in 2016

Following public engagement, the CTB will release the draft scoring process in March 2015 and adopt the final scoring process in June 2015. There will be a call for candidate projects in the summer of 2015. Projects will be screened and scored through early 2016. Once the projects are scored and public input received, the CTB will select projects for funding to be included in the draft Six-Year Improvement Program, with the final program adopted in June 2016.

Getting involved

Public engagement is critical to the process. The commonwealth is reaching out to localities and regional governments through surveys, meetings and workshops to get their input on the draft scoring process from January to March 2015. Public meetings will be held on the draft scoring process in the spring before the final scoring process is adopted in June 2015. The CTB will consider stakeholder and public input prior to approving and implementing the scoring process to select projects.

Go to VirginiaHB2.org to learn more and tell us what you think

VDOT Virginia Department of Transportation

VIRGINIA SIC SEMPER TYRANNIS

DRPT

Mosaic
Value and Cost Informed Planning

Things to know...

PRECISION. Mosaic is designed to inform transportation decision-making at the system level. Many impacts are estimated with a range of uncertainty best suited to high-level analysis. It is not intended to evaluate direct and indirect impacts of specific projects with the detail necessary for project-level analysis. Mosaic is a gauge, but not a microscope.

STUDY AREA. Mosaic can be used at any large geographic scale—city, county, or region, as well as for special studies such as complex corridors. It is not intended for project-level analysis.

TRAVEL MODEL AVAILABILITY. Mosaic does not require a travel model. However, its accuracy is greatly increased by using travel model data. Since larger cities or metropolitan areas are likely to have travel models available, they are more likely to benefit from Mosaic's full suite of indicators and tools. Without travel model data, Mosaic users have more indicators measured on the MODA weighted values scale and fewer in the benefit-cost portion of Mosaic.

BUNDLES. At the heart of Mosaic analysis are bundles containing all kinds of infrastructure projects and program investments. Mosaic enables you to test different ways of achieving the vision and goals defined by your planning process. For example, you can compare and evaluate particular mode or multimodal investment strategies and/or vary the level of investment across bundles. Mosaic shows their components of value and enables you to compare each bundle's overall results.

PROGRAMS. Mosaic measures the costs and benefits of programs as well as projects. Mosaic includes a list of transportation programmatic actions that have proven effective in reducing or managing vehicular demand. This enables users to select, evaluate, and incorporate the programs best suited to local conditions. The guide includes costs and ranges of estimates for the effectiveness of programs designed to reduce vehicular demand. Professional judgment is always required in identifying appropriate program inputs.

Time and effort.

Mosaic is not a quick exercise. It takes time and data. A considerable amount of the necessary data is likely to be developed routinely as part of your transportation planning process. Mosaic requires some additional data and provides a structure for identifying data needed and tracking and storing much of it. Mosaic results may be surprising — users will need to take time to understand results and interpret findings in light of the quality of data used and stakeholder expectations.

www.oregonmosaic.org

AN INTRODUCTION TO MOSAIC

Mosaic is a new methodology for use in transportation planning developed by the Oregon Department of Transportation in collaboration with local, regional, and statewide stakeholders. The approach offers planners and decision-makers an effective and efficient way to evaluate the social, environmental, and economic costs and benefits of transportation actions and investments. The approach can be adapted to fit the needs of many different communities.

The Mosaic tool offers a common set of measures by which to evaluate options. It assists decision makers in selecting more cost-effective actions and investments. Mosaic's approach offers the unique advantage of providing a clear, traceable, and transparent record of the evaluation process, analysis, and decision-making for transportation actions and investments.

Mosaic is designed for planning level analysis and not for project level analysis or project prioritization or selection. Mosaic compares groups of investments (bundles) to one another, but does not work at a fine enough resolution to evaluate individual projects.

What does Mosaic do for transportation planning?

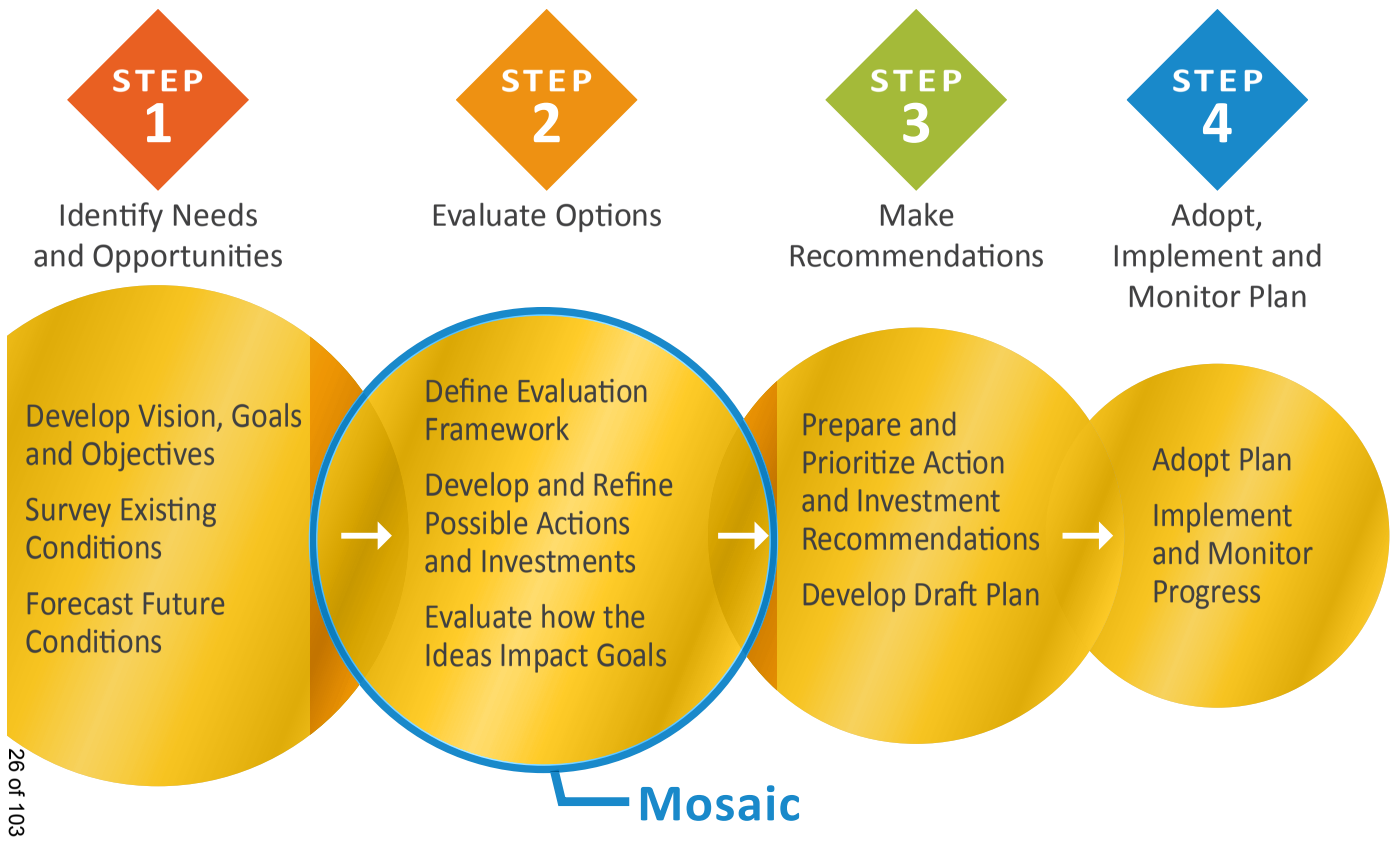
Making transportation decisions that meet the many needs of a community is challenging. The social, environmental and economic costs and benefits of different options have traditionally been hard to evaluate. The Mosaic approach enables the benefits and costs of transportation options and investments to be weighed on a common scale.

Mosaic supports transportation planning activities during the middle stages of a typical planning process—specifically, the evaluation and refinement of bundles of actions and investments.

PLANNING ACTIVITY	MOSAIC ROLE
Define evaluation framework	Offers researched set of categories and indicators Identifies required data
Refine possible bundles of investments and actions	Compares possible investment bundles against indicators and one another Programs Guide helps identify other possible actions
Evaluate actions and investment bundles	Calculates monetized and non-monetized impacts Accounts for environmental, social, and economic effects Measures value Highlights tradeoffs Accounts for risk and uncertainty

MOSAIC'S ROLE IN TRANSPORTATION PLANNING

How Mosaic Nests Within the Typical Oregon Planning Process



Mosaic informs decision-making

Mosaic informs, but does not dictate decisions. Mosaic will not show you the "right" decision; it will show you information about the impacts, benefits, and costs of different possible actions and investments that must be considered to arrive at a decision. Some results may be surprising and may challenge assumptions or preferences. Discussion of the results is at the core of Mosaic — Mosaic provides new and varied information that adds depth to the conversation about transportation investments.

Mosaic, like any model of its kind, relies on the skills and expertise of agency staff for data inputs and other background assumptions. With their participation, all of the inputs, assumptions, and background calculations can be readily reviewed and discussed by stakeholders.

Mosaic measures value

Mosaic measures nine distinct "categories" of value that result from transportation investments and programs. Within each category, Mosaic contains a small number of "indicators". These are specific metrics, for example, estimates of travel time, jobs, or air quality. The categories are selected to reflect goals and policies of the Oregon Transportation Plan. Indicators represent unique aspects of value. Thus, as a group they avoid double-counting.

Mosaic offers two different methods for measuring value. The first method is a measurement in dollars. Mosaic incorporates the latest research on the monetized value of transportation actions and includes more than previous methods. The second is a scoring and weighting framework, or "multi-objective decision analysis (MODA)." This second method of measuring value allows for estimation of indicators where there is not sufficient research to support monetization. Decision makers apply weights to impacts that cannot be measured in dollars to generate an aggregate score or ranking for the alternatives being evaluated. By using weighting, a community can express its values in Mosaic analysis.

What skills are necessary to use Mosaic?

The following skills, already present in the training and experience of Oregon's planning professionals, are necessary for the application of Mosaic:

1. A broad understanding of travel behavior and how it responds to changes in networks, policies and programs
2. For those places where travel models exist, the ability to use existing models to generate travel forecasts
3. Familiarity with Geographic Information System (GIS) software and with the layers of data available in the study area
4. The ability to estimate planning-level costs of transportation improvements
5. Familiarity with socio-economic data (e.g., population, household income, employment) commonly used in transportation planning
6. Familiarity with the terminology of travel behavior, spatial data and economic analysis
7. Experience in using Excel-based analytic tools
8. Above all, a desire to increase the value we receive from transportation investments

With these skills, a planning professional is able to understand the intent and content of Mosaic. However, a planner will likely need training or assistance with the details of using the analysis tool and ensuring an effective process for using Mosaic in planning.

In addition to these areas of experience and information available on Mosaic's websites, first time Mosaic users will need access to other professionals who can offer technical assistance, answer questions, and support the work of populating the workbook with data.

Project Selection Advisory Council Recommendations
Executive Summary

Background

The Project Selection Advisory Council (the Council), as established by the Massachusetts Legislature in Section 11 of Chapter 46 of the Acts of 2013, was charged with developing uniform criteria and a prioritization process to be used by MassDOT in the preparation of MassDOT's 5-year Comprehensive Transportation Plan, what MassDOT refers to as the Capital Improvement Plan (CIP).

The intent of the legislation was to create a uniform, transparent, data-driven approach to determining how limited resources are allocated to preserve, modernize, and expand the Commonwealth's transportation system.

Explicit requirements of the legislation include for the Council to:
• Hold six public hearings to solicit public comment, one in each MassDOT Highway District
• Develop uniform criteria and a transparent prioritization formula
• Deliver formal recommendations to the Legislature

The Council members were appointed as per specifications in the statute and represent various interests and areas of transportation expertise from around the state. The Council has met regularly since early 2014, with the initial December 31, 2014 deadline having been extended to June 30, 2015 to allow the new gubernatorial administration to inform the recommendations.

The scope of the Council's work focused primarily on MassDOT Highway (including bicycle and pedestrian facilities), MBTA, and Regional Transit projects—the recipients of the bulk of the more flexible funding categories. Moreover, these divisions have more comparable purposes and activity types versus Aeronautics and the Registry of Motor Vehicles.

Based on a review of best practices from other states, as well as a review of existing MassDOT and MBTA processes, and Metropolitan Planning Organization (MPO) transportation evaluation criteria, the Council is recommending a project prioritization formula and framework that will leverage successful existing processes in the development of a more uniform, data-driven, and transparent project selection process.

Recommendations for Framework

After considerable deliberation, the Council is recommending to evaluate projects using six different scoring categories, with their own specific set of criteria and weights:

- Highway Modernization
- Highway Capacity
- MBTA Modernization
- MBTA Capacity
- Regional Transit Modernization
- Regional Transit Capacity

The Council believes that having separate categories for these project types will allow for a more focused comparison of projects with mode specific data that adheres to primary funding agency performance targets.

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www.mass.gov/massdot

The Council is defining **Modernization Projects** as projects aimed at leveraging the need to rehabilitate or replace assets in poor condition to then also make broader improvements. These improvements can include incorporating new technology or making other enhancements to support economic development, improve mobility, reduce negative impacts to the environment, or increase safety. The impetus for these projects does not come solely from an asset management system.[1]

- Highway Examples: roadway reconstruction, upgraded tolling infrastructure.
- Transit Examples: positive train control; bus stop, transit station or maintenance facility upgrades; rehabilitating transit vehicles or bus stops.

Capacity Projects are projects that add new connections or expand existing ones that no longer address user demand.

- Highway Examples: new off-road multi-use paths, new bypass roads, connector roads, frontage roads, fly-overs, new or re-engineered interchanges.
- Transit Examples: extending a transit line, additional buses beyond a 1:1 replacement rate, new bus stops or transit stations, new or expanded maintenance facilities.

The "Scoring System Recommendations" document outlines the criteria, weights, objectives, and data requirements pertaining to each of the six scoring systems.

The Council is proposing a full framework for prioritization that recognizes that evaluating specific projects cannot be done in isolation. Even the most strategically designed criteria cannot ensure that an appropriate distribution of projects across asset categories and across regions is achieved. Therefore, the Council is recommending the following process be undertaken as part of project selection:

1. **Project Evaluation**: Evaluate projects at initiation to determine whether they have the potential to ultimately be programmed in the CIP and should therefore proceed into design.

2. **Performance and Funding Targets**: Develop fiscally constrained performance targets and use these to set asset-level funding targets for the given 5-year plan. The weMove Massachusetts Planning for Performance tool can help support the development of funding targets.[2]

3. **Funding Allocation**: On an annual basis, re-score projects taking into consideration project readiness and any changes in cost and scope to assign to a budget year. This funding allocation is preliminary and may be modified based on Step 4.

[1] *Asset management programs will not be subject to the evaluation criteria; however, they will be subject to steps 2-5 and Council recommendations regarding transparency.*

[2] *MassDOT is working to refine and update the WeMove Massachusetts Planning for Performance Tool to accommodate the needs outlined in Steps 2 and 4.*

4. **Comparison to Targets**:

   Asset Balance: Compare the anticipated performance outcomes of the preliminary 5-year funding allocation to the asset-level funding targets established in Step 2 using the weMove Massachusetts Planning for Performance Tool.

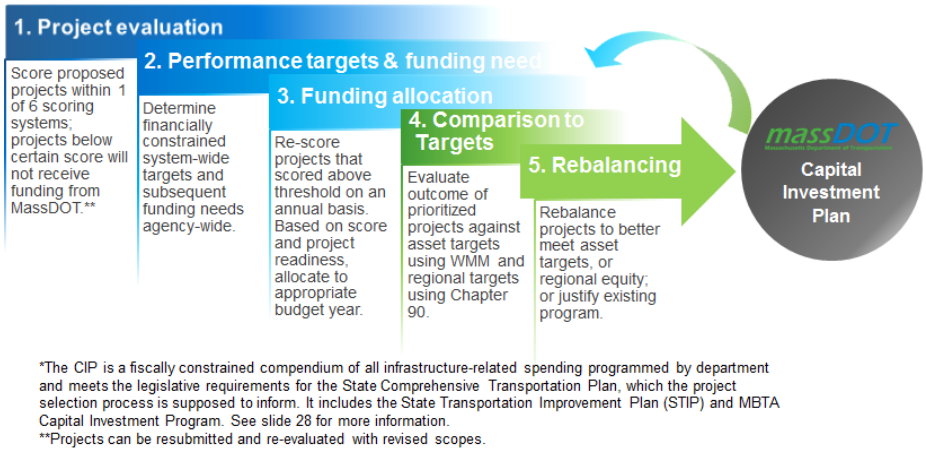
   Regional Balance: At the same time, compare the preliminary 5-year funding allocation for each highway district to the share of Chapter 90 funding allocated to each highway district to ensure that the distribution of funding meets a standard of regional equity.

5. **Rebalancing**:

   If the preliminary funding allocation for each asset results in +/- 10% difference from the established target, then a publicly available justification for proceeding with the preliminary funding allocation will need to be made.

   If the share of the preliminary funding allocation to each district is not within +/- 10% of the Chapter 90 share to each district, then a publicly available justification for proceeding with the preliminary funding allocation will need to be made.

   Alternatively, if there is no justification for the deviation from the established targets, then projects will need to be replaced in order to address those targets.



Recommendations for Implementation

The Council recommends that four scoring committees be established with representatives of subject matter experts and a designee from the Secretary to score the following scoring systems:

1. Highway Modernization
2. MBTA Modernization
3. Regional Transit Modernization
4. Capacity Projects (all modes)

The initiator of the project can designate the appropriate scoring system; however, it will be up to the scoring committee to confirm it has been classified appropriately. The scoring committee should meet at least once a year to review scored projects and select a threshold for which projects should advance based on the project evaluation score and anticipated funding levels.

Projects will be re-scored annually once they are anticipated to be ready for inclusion in the five-year CIP.

All project scoring should be made publicly available.

An internal steering committee will be established to develop standard operating procedures and more specific scoring guidance based on Council recommendations. The steering committee will also oversee any changes to the scoring formula or framework based on new data or systems that become available or to respond to how successfully the framework works when put into practice on a large scale. It is recommended that the justification for any changes be made available on the Project Selection website.

The Steering Committee will also provide guidance on how to begin transitioning from existing processes to incorporation of the project selection criteria and framework. It is the Council's goal for processes to be in place to allow for the Council's recommendations to begin to be implemented for projects going into FY 2017 CIP.

MAKING A COMPELLING CASE

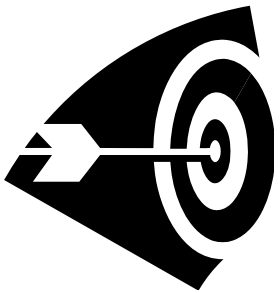
PERFORMANCE-DRIVEN INVESTMENTS IN THE MAP-21 ERA

Dave Vautin

METROPOLITAN TRANSPORTATION COMMISSION

SSTI WEBINAR – MAY 30, 2014

Image Source: https://www.flickr.com/photos/sg09/8401320130



Targets Assessment

Assessed qualitatively using target scores (max score of +10).

1. Climate Protection
2. Adequate Housing
3. Particulate Matter
4. Collisions
5. Active Transportation
6. Open Space
7. Equitable Access
8. Economic Vitality
9. Non-Auto Mode Share/VMT
10. State of Good Repair

Benefit-Cost Assessment

Assessed quantitatively using MTC Travel Model One.

BENEFITS

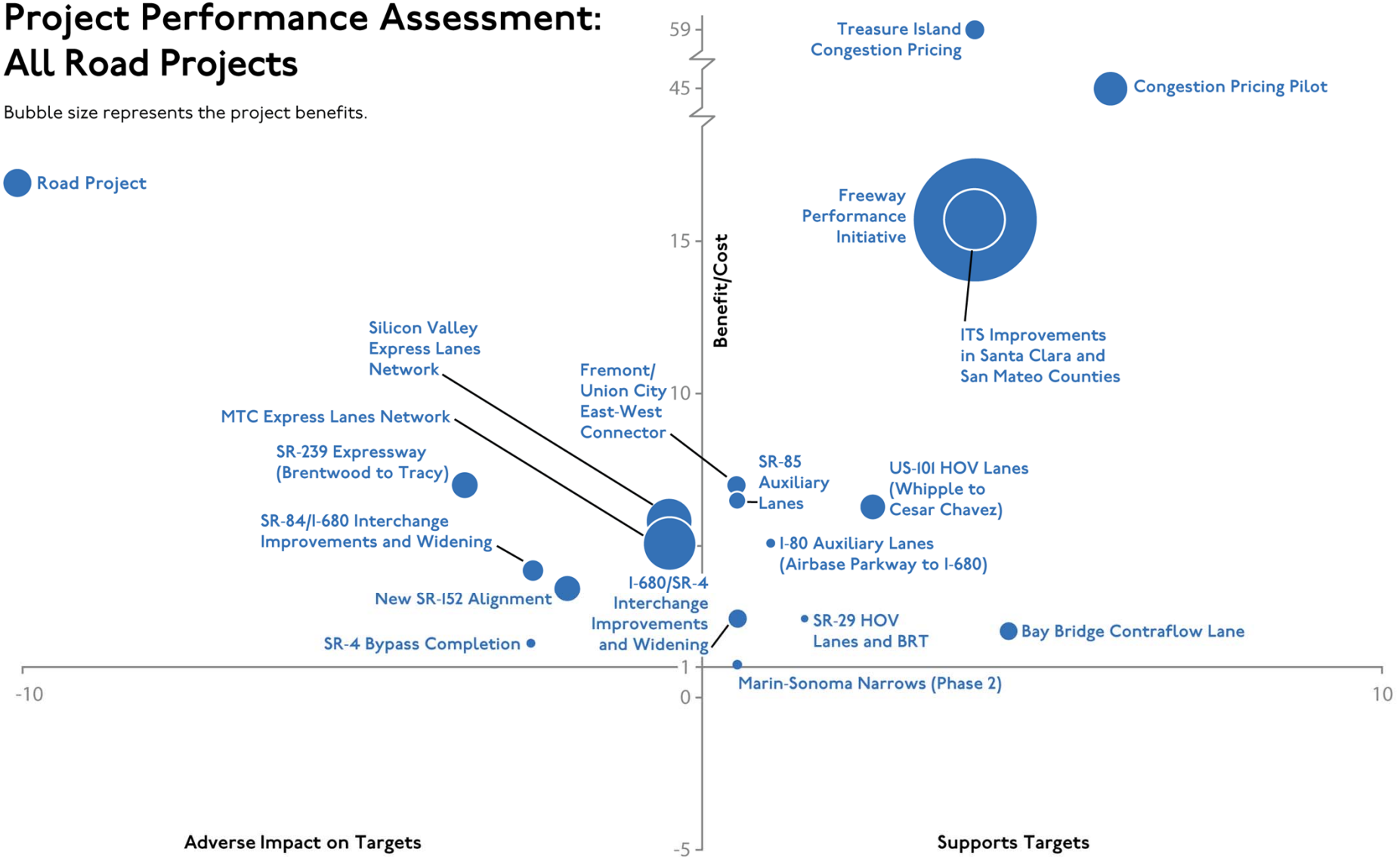
- Travel time (including recurring & non-recurring delay)
- Travel cost (auto operating/ownership, parking)
- Emissions (CO_2, $PM_{2.5}$, ROG, NO_x)
- Collisions (fatalities, injuries, property damage)
- Health impacts due to active transport
- Noise

COSTS

- Capital costs
- Net operating and maintenance (O&M) costs

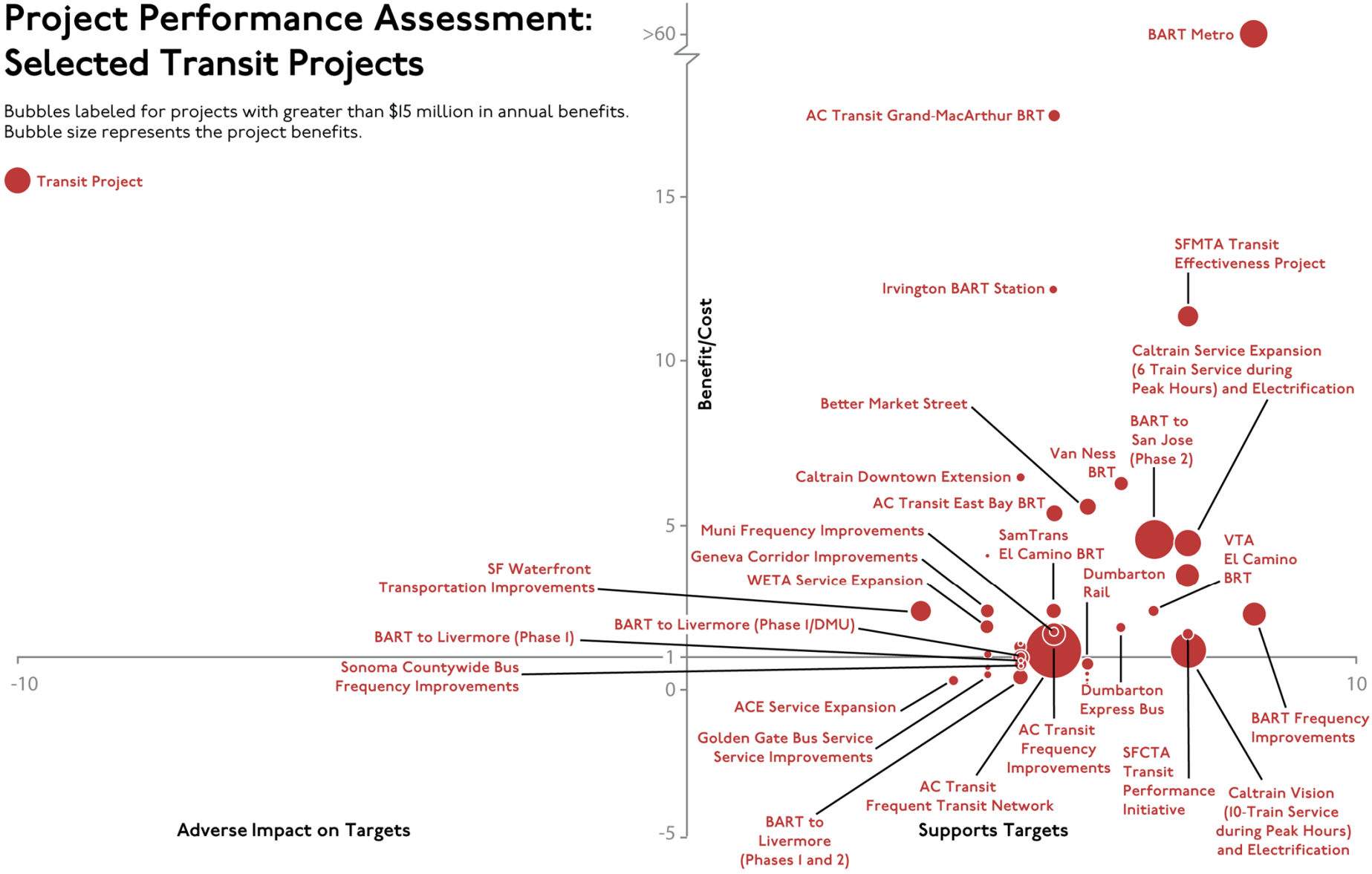
Project Performance Assessment: All Road Projects

Bubble size represents the project benefits.



Project Performance Assessment: Selected Transit Projects

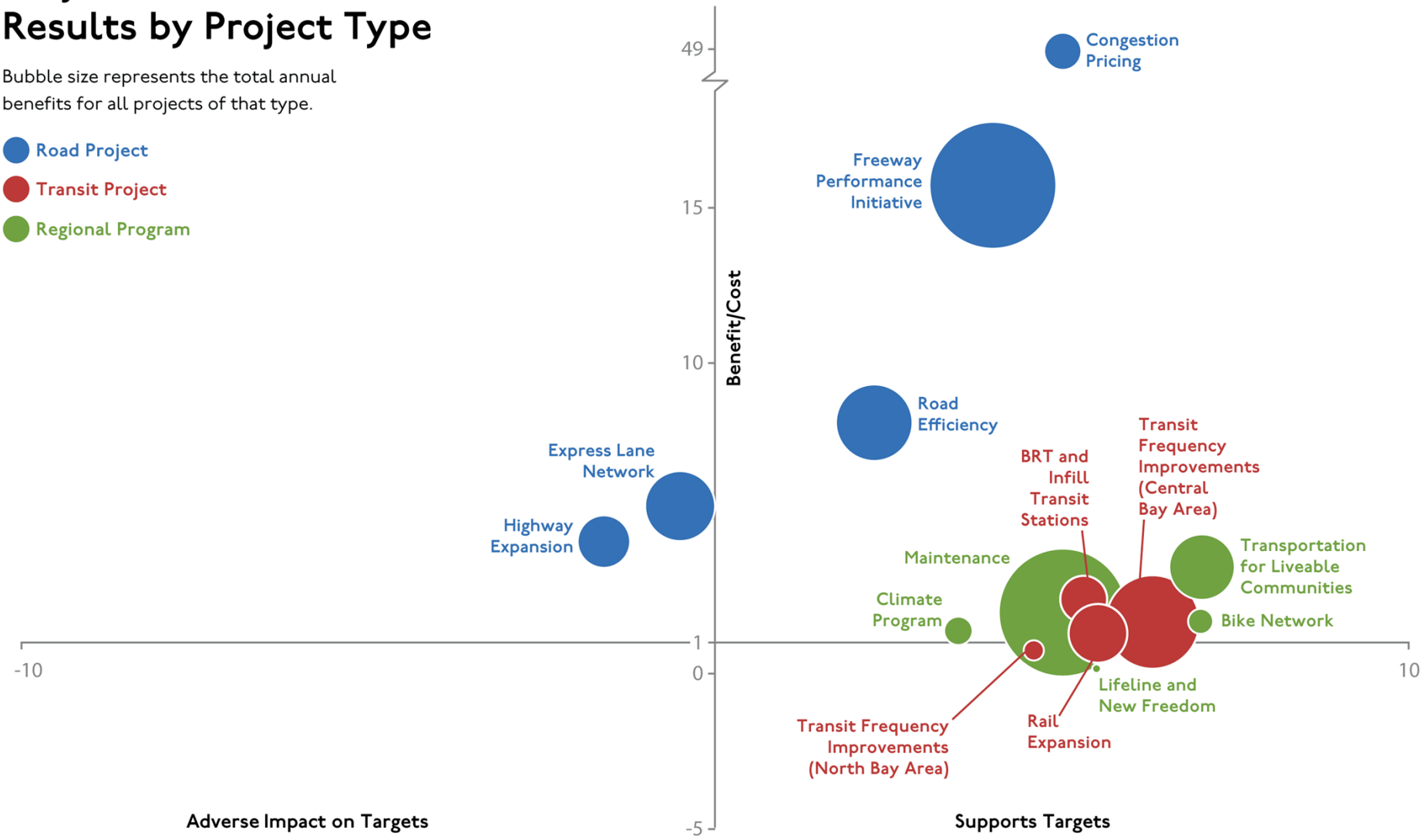
Bubbles labeled for projects with greater than $15 million in annual benefits.
Bubble size represents the project benefits.



Project Performance Assessment: Results by Project Type

Bubble size represents the total annual benefits for all projects of that type.

- Road Project
- Transit Project
- Regional Program



City of Philadelphia Green Streets Design Manual

Philadelphia Water Department | Streets Philadelphia

MAYOR'S OFFICE OF TRANSPORTATION AND UTILITIES

2014

Green Street Stormwater Management Practices

chapter 2

2.1 Introduction to Stormwater Management Practices (SMPs) Appropriate for the Right-of-Way

Within this Manual, a variety of designs are presented: Stormwater Planters, Stormwater Bump-outs, Stormwater Trees, Stormwater Tree Trenches, Permeable Pavement. Each of these SMPs is designed to help infiltrate and detain stormwater runoff within the right-of-way.

Any GSI proposed in the right-of-way must consider the effects the SMPs will have on the existing street and all of its users, including motorists, bicyclists, and pedestrians. Well-designed SMPs with rich plantings and quality building materials can be a centerpiece, gateway feature or community enhancement near residences, parks, plazas, bus stops, and in parking areas. Plant material within green stormwater infrastructure facilities can be selected to tolerate salts, drought and temporary inundation, depending on individual site conditions. Additionally, their visibility at the street level provides opportunities for green stormwater infrastructure-related educational and interpretive signage.

Storage and treatment capacity can be increased by connecting green stormwater infrastructure facilities so that they operate as one system along the street. Multiple facilities can treat more runoff, and the total street system must be designed to respond to the many different site conditions that might promote, or negate, the use of certain facilities.

Stormwater management practices are divided into two categories for the purposes of this manual. For those currently in use by the Water Department, typical design and related standards are provided. For those not yet in practice, which will be evaluated through piloting and application in the coming years, standards will be developed and incorporated in a future version of the manual.

2.2 Stormwater Management Practices – Currently Used

Over the past decade, the Water Department has made a significant commitment to the design and construction of GSI demonstration projects throughout the City. By implementing a number of projects aimed at demonstrating the utility of various green stormwater control technologies in highly urbanized areas, the Water Department has helped to raise awareness of GSI among City residents and the regulatory community.

The following practices have been implemented within the City of Philadelphia:

- Stormwater Trees
- Stormwater Tree Trenches
- Stormwater Planters
- Permeable Pavement
- Stormwater Bump-outs (midblock and corner)

2.3 Stormwater Management Practices – Under Development

There are a number of stormwater management practices deemed appropriate for use within the right-of-way in other cities, however application of such practices has not yet been piloted within the City of Philadelphia. This section of the manual is intended to be amended as additional stormwater management techniques are identified and proposed for application on Philadelphia streets.

Two such SMPs are currently being piloted, and may become typical SMPs in the future.

- Green Gutters
- Stormwater Drainage Wells

Note that these SMPs are not exhaustive of all types of GSI practices. Other SMPs may be designed and implemented depending on the need or context.

SMP Fact Sheets

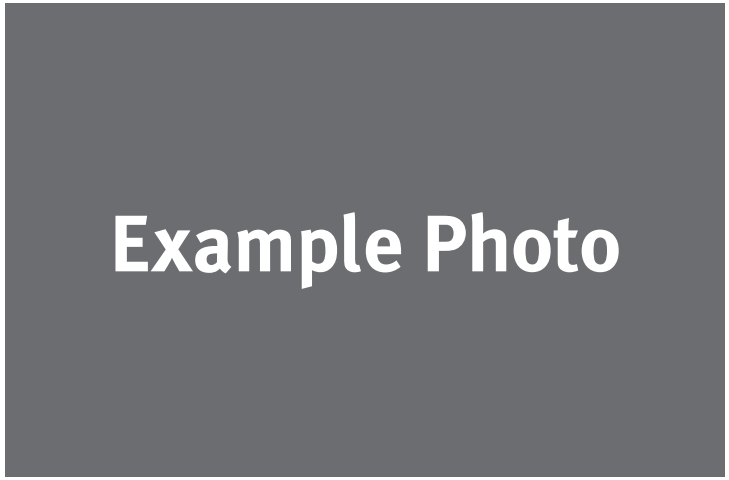


Photo Caption

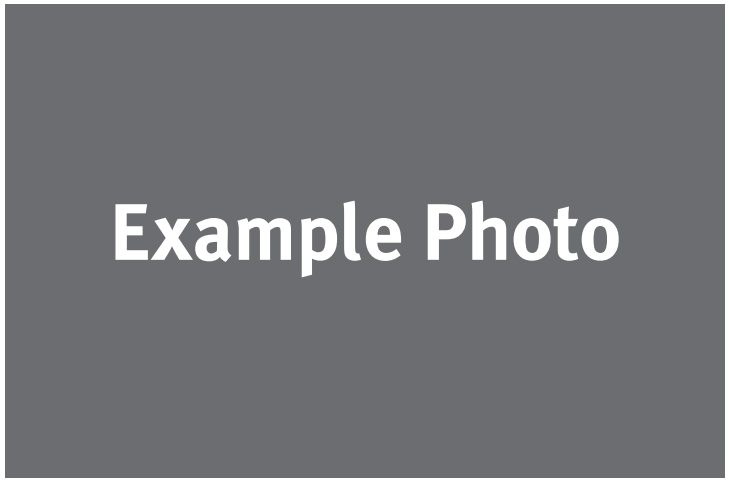


Photo Caption

Overview

A general description of the SMP is provided, including information about its function and aesthetics.

Benefits

- Information regarding benefits associated with the given SMP are listed.

Potential Constraints and Considerations

- Potential constraints and considerations associated with the use of a particular SMP in a given street context are highlighted.

Interaction with Bicyclists and Pedestrians

- Potential for an SMP to have implications on bicyclists and/or pedestrians are highlighted

Urban Design Context

- A description of how this SMP fits in with or complements the urban design context is provided.

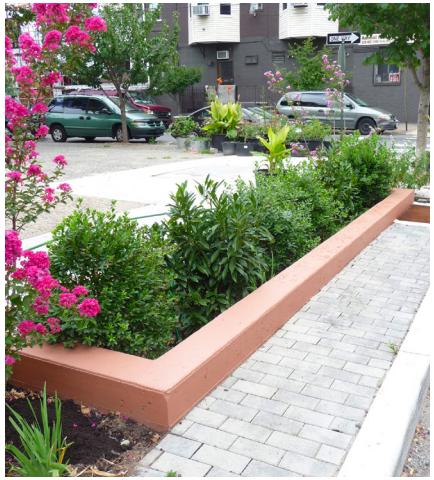
Maintenance

- A general overview of maintenance tasks associated with a given SMP are noted.

Examples

- Examples of projects in Philadelphia where this SMP has been implemented are provided.

Stormwater Planter



Columbus Square

The Philadelphia Navy Yard

Overview

A stormwater planter is a specialized, landscaped planter installed in the sidewalk area and designed to manage stormwater runoff. Runoff is routed to the planter by setting the top of the planting media in the planter lower than the street's gutter elevation and connecting the planter to one or more inlets (types vary), allowing stormwater runoff from the street to flow into the planter. Runoff from the adjacent sidewalk can flow directly into the stormwater planter from the surface. Plantings are incorporated within the facility to provide uptake of water and pollutants. Though stormwater planters can be designed in a variety of shapes and sizes, they are typically rectangular in form with vertical sidewalls on all four sides and an open bottom.

Benefits

- Water filters through the planting soil, improving water quality.
- Provides a physical buffer between pedestrians and the street.
- Creates aesthetic improvements to streetscape.
- Can be sized and placed to fit between existing surface features such as driveways, signs, street furnishings, and street trees.
- Provides an area within the right-of-way for smaller plantings in addition to street trees.

Potential Constraints and Considerations

- Requires adequate sidewalk width to accommodate both the planter and pedestrian circulation; refer to the Complete Streets Design Handbook, Section 4.3.2
- Can sometimes be challenging to limit interior depth of planter depending on surrounding surface grades.
- Must consider step-out areas for on-street parking or vehicle stopping.

Interaction with Bicyclists and Pedestrians

- Provides a separation between pedestrians and moving traffic.
- May intrude into the walking zone a maximum width of two feet, maximum length of 10 feet, and a minimum spacing of 30 feet. Refer to the Complete Streets Design Handbook, Section 4.3.2.

Urban Design Context

- Provides a formal streetscape element.
- Edge treatment may contribute to streetscape design (i.e., a perimeter wall could be designed to function as a seat wall, a perimeter fence could be an aesthetic feature, or the edging may include artistic elements).
- Stormwater Planters are designated as a priority design treatment for all street types by the Complete Streets Design Handbook.

Maintenance

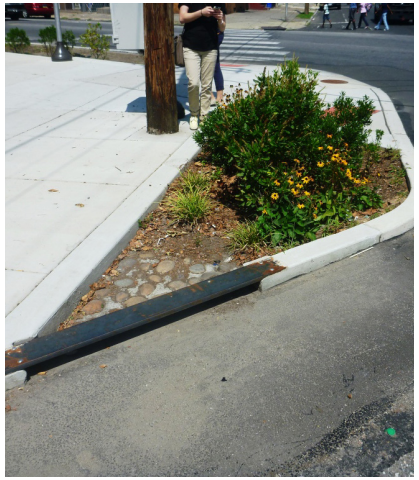
- Routine landscape maintenance needed, such as trimming, watering during droughts, weeding, and litter removal, etc.
- Routine cleaning of inlets and pipes is required.

Examples

- Columbus Square
- The Philadelphia Navy Yard

Figure 2.1: Three-Dimensional View of a Stormwater Planter

Stormwater Bump-out



Shepard Recreation Center Corner Bump-out

Queen Lane Mid-Block Bump-out

Overview

A stormwater bump-out is a landscaped curb extension that extends the existing curb line into the cartway. It is designed to manage stormwater runoff by setting the top of the planting media in the bump-out lower than the street's gutter elevation and connecting the bump-out to one or more inlets (types vary), which allows stormwater runoff from the street to flow into the bump-outs. Runoff from the adjacent sidewalk can flow directly into the stormwater bump-out from the surface. They are designed to capture, slow, and infiltrate stormwater within a planted area or subsurface stone bed. Landscape plantings within the curb extension effectively take up some of the stormwater through their root systems. The remaining stormwater is temporarily stored within the curb extension until it either infiltrates or drains back to the sewer. In mid-block bump-outs, overflow exits through an opening on the downstream side, and flows into a nearby storm drain inlet.

Benefits

- Water filters through the planting soil, improving water quality.
- Provides a physical buffer between pedestrians and the street.
- Does not require encroachment into sidewalk area.
- Encourages slower vehicle speeds by physically and visually narrowing the street.
- Reduces pedestrian crossing distances when used at intersections.
- Provides an area within the right-of-way for smaller plantings in addition to street trees.

Potential Constraints and Considerations

- Must consider existing on-street parking conditions, street width, and vehicle turning radii.
- Alteration of existing curb line will directly impact existing street drainage patterns and bump-out design must ensure existing street drainage is not negatively impacted.
- Vegetation must accommodate adequate sight distances at intersections.

Interaction with Bicyclists and Pedestrians

- Placement should avoid rerouting bicyclists.
- If placed near an intersection, care may be taken to accommodate pedestrian passage through the curb extension, which can limit its stormwater treatment capacity.
- Mid-block bump-outs should not encourage unwanted mid-block pedestrian crossings.

Urban Design Context

- May be integrated with a pedestrian seating area or transit shelter.
- The Complete Streets Design Handbook refers to these practices as Curb Extensions. Curb extensions are designated as a priority design treatment at local / local and local / major street intersections, as well as intersections wth complex geometry, by the Complete Streets Design Handbook.

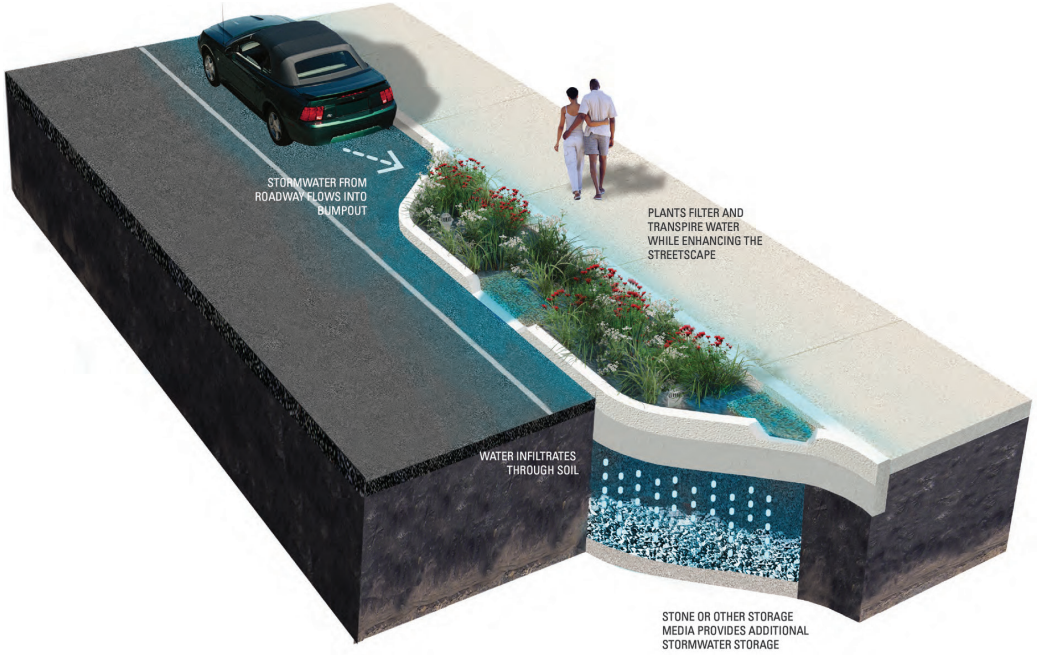
Maintenance

- Routine landscape maintenance, such as trimming, watering during droughts, weed and litter removal, etc.
- Routine cleaning of inlets and pipes is required.

Examples

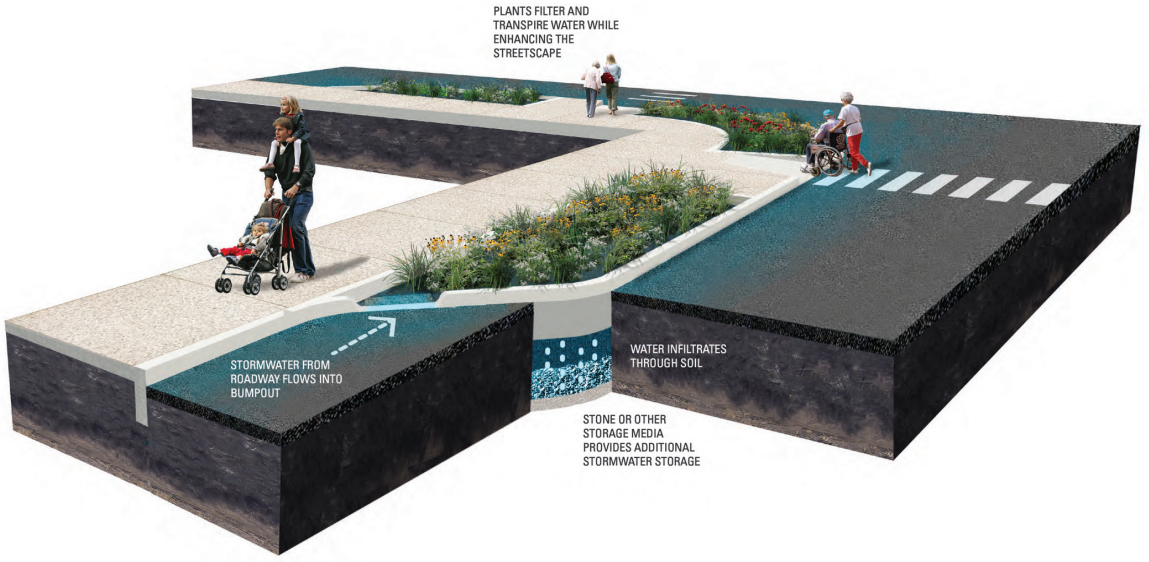
- Midblock Bump-outs: Queen Lane
- Corner Bump-outs: Shepard Rec Center at 56th and Vine; Daroff School at 57th and Haverford; 3rd and Fairmount

Figure 2.2: Three-Dimensional View of a Stormwater Bump-out



Mid-block Stormwater Bump-out

Corner Stormwater Bump-out



Stormwater Tree

Stormwater Tree Precedent

Overview

A stormwater tree is a street tree planted in a specialized tree pit installed in the sidewalk area. It is designed to manage stormwater runoff by placing the top of the planting media in the tree pit lower than the street's gutter elevation and connecting the tree pit to an inlet (types vary), which allows stormwater runoff from the street into the tree pit. Runoff from the adjacent sidewalk can flow directly into the tree pit from the sidewalk surface. Multiple tree pits can be designed in series to maximize the potential for stormwater capture and treatment. Stormwater will either infiltrate or drain to a connection to the storm sewer network. If the stormwater tree is at capacity, runoff can bypass the stormwater tree inlet and enter other downstream SMPs or a downstream storm drain.

Benefits

- Adds street trees to the streetscape.
- Requires only a small footprint and can therefore fit within a constrained site.
- Can accommodate steep topographic changes.
- Can fit between existing street furnishings such as signs, benches, hydrants and lights.

Potential Constraints and Considerations

- Limited stormwater management capacity.
- Recessed elevation of tree pit requires consideration for protecting pedestrians from step down to surface of planting media.

Interaction with Bicyclists and Pedestrians

- Street trees provide the benefit of shade and a vertical separation between pedestrians and moving traffic.
- May intrude into the walking zone a maximum width of two feet, maximum length of five feet, and minimum spacing at 30 feet. Refer to the Complete Streets Design Handbook, Section 4.3.2.

Urban Design Context

- Enhances streetscape with street trees.

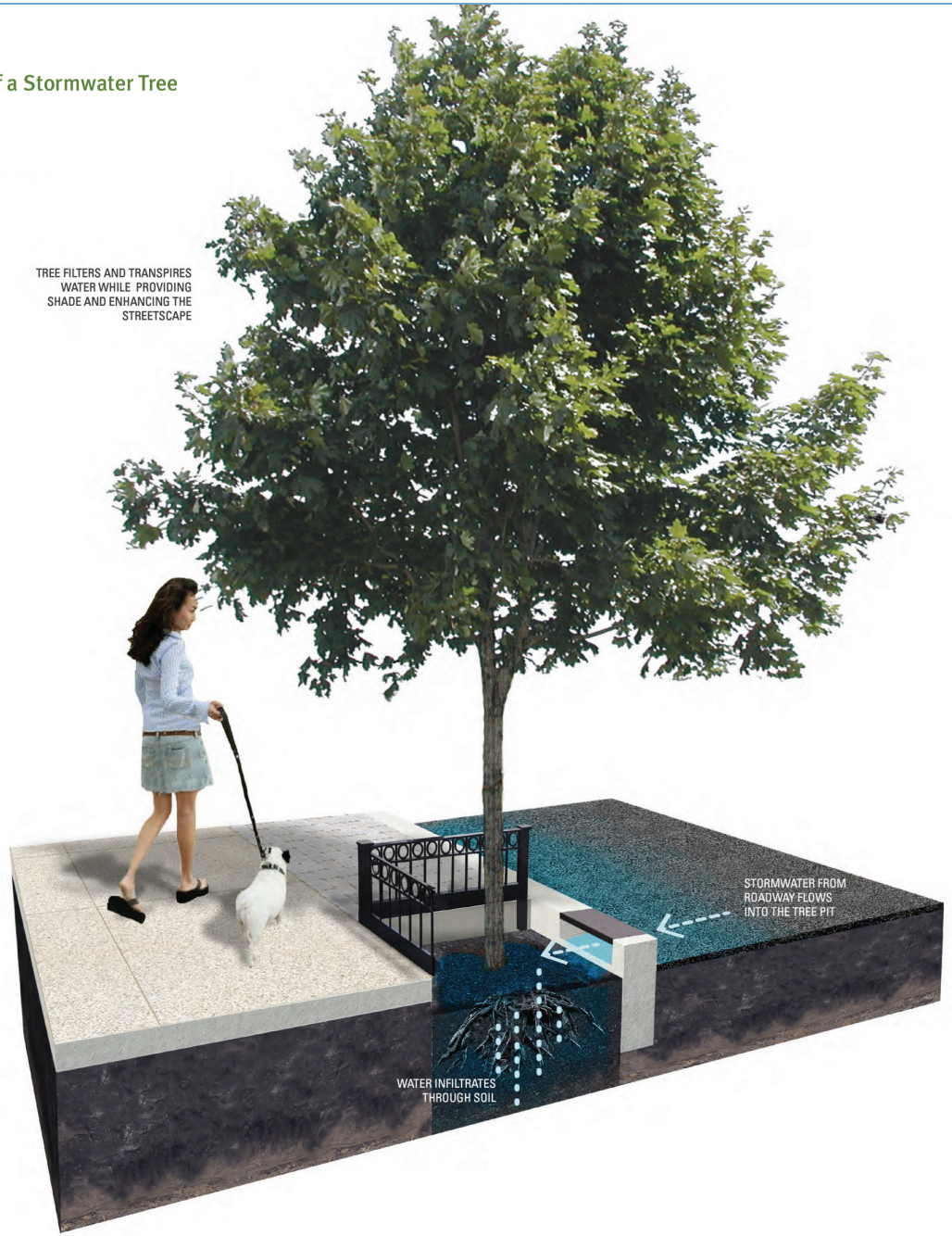
Maintenance

- Routine tree maintenance and litter removal.

Examples:

- Norris Street
- Sepviva Street
- Shissler Recreation Center

Figure 2.3: Three-Dimensional View of a Stormwater Tree



Stormwater Tree Trench

Ben Franklin Parkway

Shissler Recreation Center

Overview

A stormwater tree trench is a subsurface trench installed in the sidewalk area that includes a series of street trees along along a section or the total length of the subsurface trench. It is designed to manage stormwater runoff by connecting the subsurface trench to one or more inlets (types vary), which allows runoff from the street and sidewalk to flow into the subsurface trench. The runoff is stored in the empty spaces between the stones or other storage media in the trench, watering the trees and slowly infiltrating through the trench bottom. If the capacity of the system is exceeded, stormwater runoff can bypass the storm drain entirely and flow into an existing inlet downstream or through an underdrain system connected to the storm drain network. The surface above the trench and surrounding the street trees is restored to the elevation of the surrounding surfaces.

Benefits

- Ability to store a large volume of stormwater
- Adds street trees to the streetscape.
- Impact to existing sidewalk width, use, and surface features is similar to that of typical street tree planting because sidewalk surface is restored to grade.

Potential Constraints and Considerations

- Because flow is directed to the subsurface of the system, special attention should be paid to pretreatment.

Interaction with Bicyclists and Pedestrians

- Does not impede bicycle or pedestrian movement.

Urban Design Context

- Enhances streetscape with some or all of the following: street trees, tree grates, unit pavers.

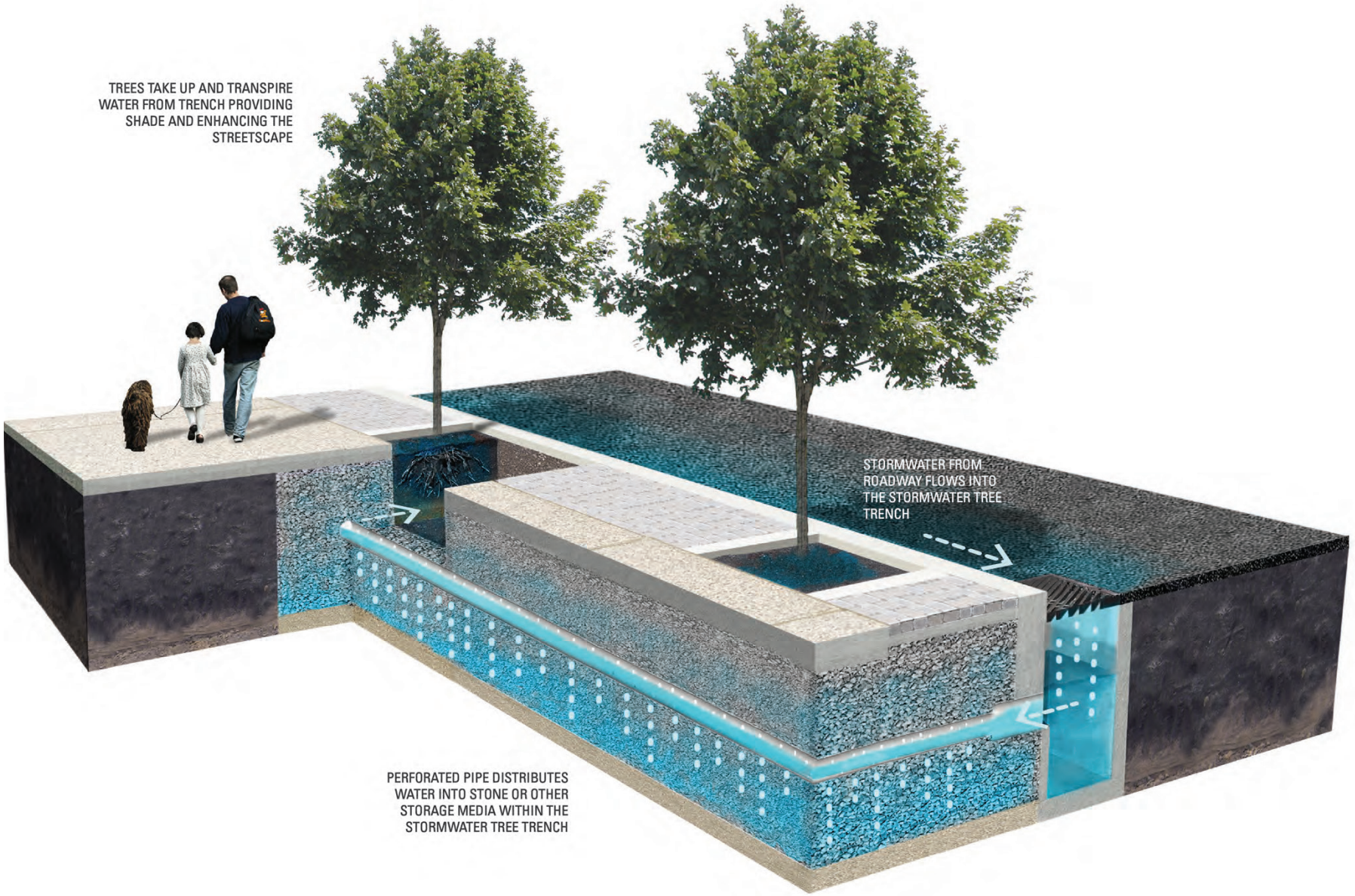
Maintenance

- Routine landscape maintenance of street trees.
- Routine cleaning of inlets and pipes is required.

Examples

- Waterview Recreation Center
- 16th and Snyder
- Ben Franklin Parkway
- Shissler Recreation Center

Figure 2.4: Three-Dimensional View of a Stormwater Tree Trench



Permeable Pavement

Percy Street

Waterview Recreation Center

Overview

Permeable pavement is a hard pavement surface consisting of materials that allow water to pass freely through the surface, thereby eliminating or reducing runoff compared to impervious paving. Permeable pavement surfaces typically include a storage media such as stone beneath the permeable surface that provides the structural support of conventional pavement and also provides temporary storage of stormwater. Permeable pavement, sometimes referred to as pervious or permeable paving/pavement, includes different types of permeable surfaces such as permeable asphalt, permeable concrete, and permeable pavers. While permeable asphalt and permeable concrete materials allow water to pass through the surface of the asphalt or concrete, permeable pavers typically allow water to pass through the joint spacing between the pavers.

Benefits

- Provides stormwater management while maintaining paved and other hardscape surfaces.
- Can be implemented in lieu of traditional pavement replacement projects.

Potential Constraints and Considerations

- Many streets in Philadelphia include an impervious concrete sub-base which would have to be removed for permeable pavement to be effective.
- Design must consider traffic loading and volume conditions.
- Designs may not allow stormwater to drain onto permeable pavements from other areas without approval by the Water Department.

Interaction with Bicyclists and Pedestrians

- Interlocking pavers should not be used in bike lanes.

Urban Design Context

- Alternating permeable paving types can help differentiate surfaces by modal use.

Maintenance

- Periodic clean out or vacuuming of surface is required.
- Ensure that no sediment builds up on the pavement. Remove sources of sediment such as erodible soils in nearby landscaped areas.

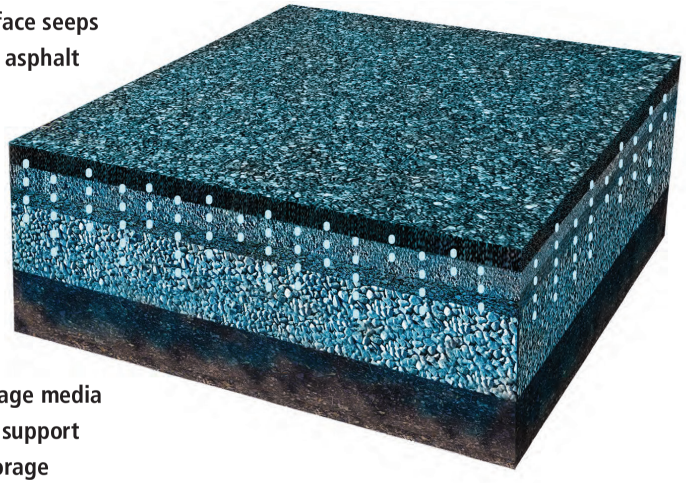
Examples:

- Percy Street (Permeable Asphalt)
- Waterview Recreation Center (Permeable Concrete)
- Queen Lane (Permeable Pavers)

Figure 2.5: Three-Dimensional View of Permeable Pavement

Permeable Asphalt

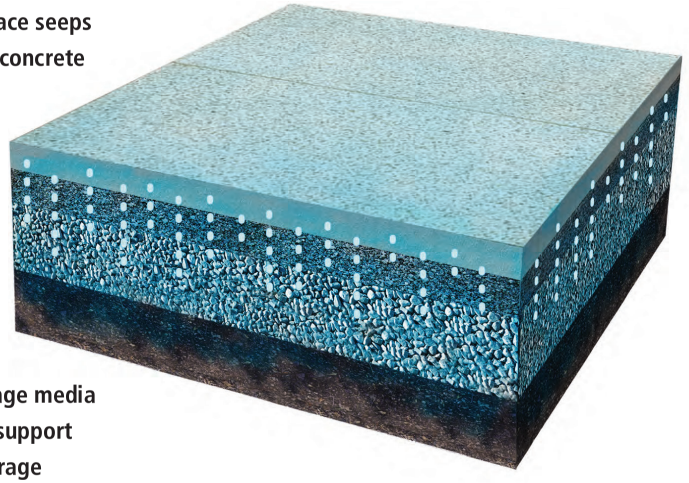
Stormwater on surface seeps through permeable asphalt



Stone or other storage media provides structural support and stormwater storage

Permeable Concrete

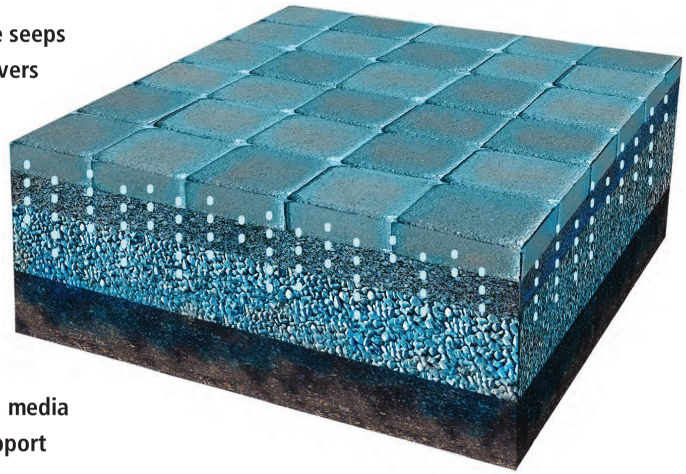
Stormwater on surface seeps through permeable concrete



Stone or other storage media provides structural support and stormwater storage

Permeable Paver

Stormwater on surface seeps through permeable pavers



Stone or other storage media provides structural support and stormwater storage

Green Gutter

Portland, OR precedent

Overview

A green gutter is a narrow and shallow landscaped strip along a street's curb line. It is designed to manage stormwater runoff by placing the top of the planting media in the green gutter lower than the street's gutter elevation allowing stormwater runoff from both the street and sidewalk to flow directly into the green gutter. An elevated curb can be used along the street side of the green gutter with openings along its length to allow runoff to flow into the green gutter. Green gutters can be designed to infiltrate and/or flow to the existing storm sewer. The system attenuates storm-water flows, provides storage and, in some cases, infiltration and evapotranspiration. In flow-through green gutters, overflow runoff can be conveyed to the existing storm drain system, either through an underdrain tied to the existing storm drain system, or as shallow concentrated flow that is conveyed downstream to an existing inlet.

Benefits

- Provides a physical buffer between pedestrians and the street when an elevated street side curb is used.
- Does not require encroachment into sidewalk area.
- Provides an area within the right-of-way for smaller plantings.

Potential Constraints and Considerations

- Must consider existing on-street parking conditions and street width.
- Landscape materials must accommodate direct impact of gutter flow velocity.

Interaction with Bicyclists and Pedestrians

- Edge treatments should prevent pedestrian and bicyclists from stepping into the green gutter area.
- Placement should occur outside of bike lanes.

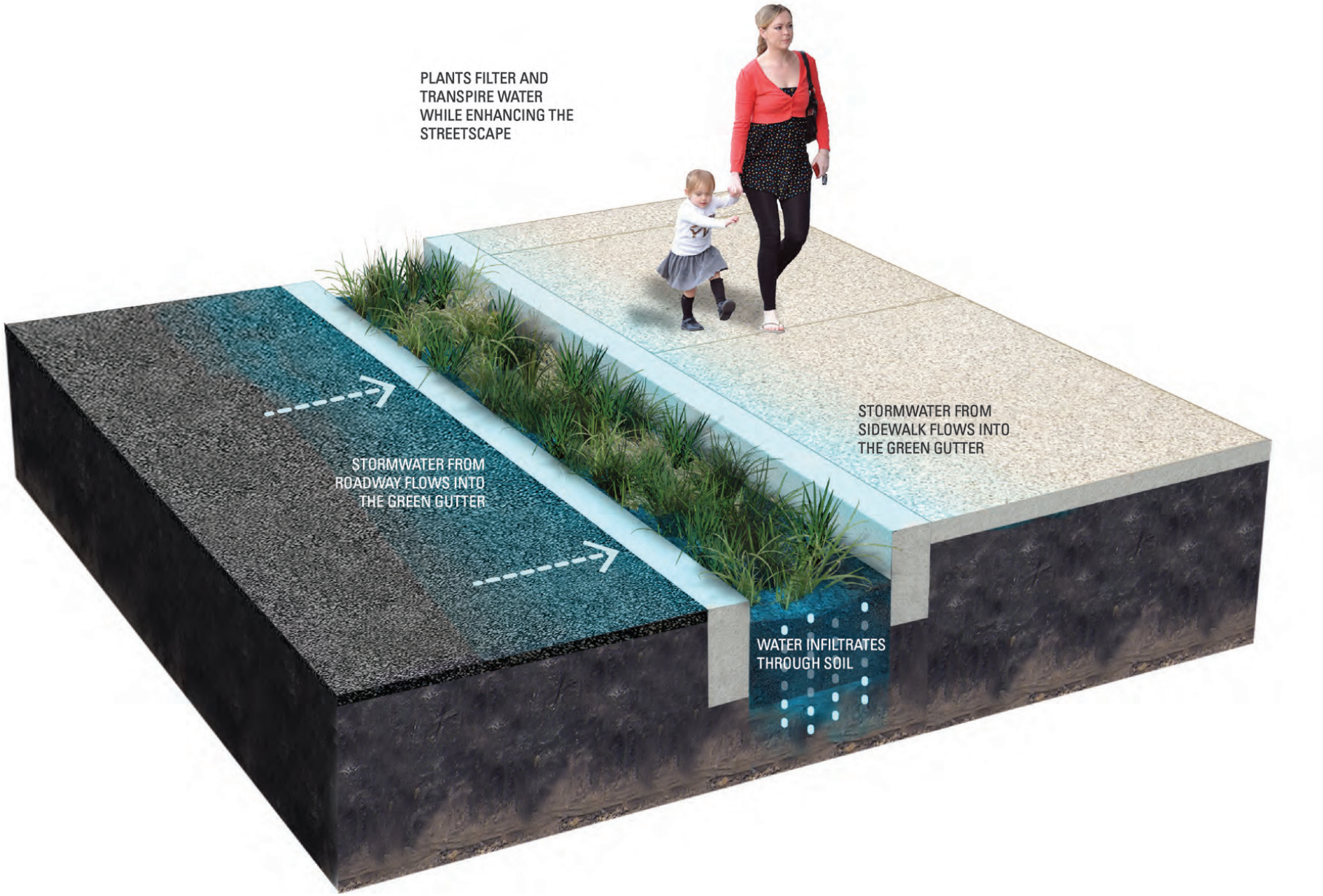
Urban Design Context

- Consider opportunities where there is no on-street parking and/or wide shoulders.
- May not be appropriate in high volume pedestrian areas.

Maintenance

- Routine landscape maintenance.

Figure 2.6: Three-Dimensional View of a Green Gutter



Stormwater Drainage Well

Overview

A stormwater dainage well is designed to manage stormwater runoff by receiving stormwater from upstream collection and pretreatment systems and then discharging the stormwater into the surrounding soils through perforations in the manhole.

Benefits

- Small footprint with potentially large storage volume.
- Potential option where other SMPs are not applicable.

Potential Constraints and Considerations

- The minimum allowable separation between the bottom of the stormwater drainage well and seasonal high ground water is two feet.
- The minimum allowable separation between the bottom of the stormwater drainage well and the top of bedrock is three feet.
- The minimum allowable separation between the stormwater drainage well and building foundations is 20 feet.
- Design sizing may be based on methods other than static storage of the runoff volume. Consult PWD for guidance.

Interaction with Bicyclists and Pedestrians

- Stormwater drainage wells would not impact bicyclists or pedestrians any differently than a normal manhole cover.

Urban Design Context

- These stormwater management practices are completely below ground with only a manhole cover on the surface; as such, stormwater drainage wells do not impact the urban design context any differently than a normal manhole.
- These SMPs can be used in combination with other SMPs to increase the stormwater management and aesthetic benefits.

Maintenance

- Designed such that stormwater introduced to the stormwater drainage well has already passed through a system that provides a high level of pretreatment, stormwater drainage wells themselves require relatively little maintenance. However, maintenance of the upstream pretreatment system, which varies, will be required.

MassDOT Solar Photovoltaic Energy Program Overview

Background Information

The MassDOT Office of Transportation Planning and Highway Division are working collaboratively to implement the state-wide Solar Photovoltaic (PV) Energy Program. The purpose of the program is to build ground-mount solar PV generation facilities at multiple state-owned properties within the state highway layout throughout Massachusetts. A minimum of 6 Mega Watts (MW) of solar power generation systems will be provided from this multi-site project.

MassDOT's development of solar PV facilities within the state highway layout is driven by the desire to:

- Create energy savings by producing electricity locally and economically
- Generate revenue by utilizing underutilized state land
- Reduce greenhouse gas emissions via renewable power generation technologies, and
- Support the Commonwealth's green and clean economy

The program began in early 2013 with an overall program design and a preliminary site feasibility study. A Request for Response was issued in the summer of 2013 to solicit best-value project proposals from interested solar developers to "design, construct, commission, finance, operate, and maintain solar PV generating facilities" at one or more locations in the Commonwealth. After an extensive and thorough procurement process, MassDOT selected Ameresco, Inc. to serve as the developer for the project in June, 2014. The two parties had jointly developed and executed the Master License Agreement / Power Purchase Agreement (MLA/PPA) by November 2014.

Project Benefits

Solar PV arrays of 6 MW aggregated capacity in the Northeast region can generate **7,800,000 kWh electricity per year**, which is equivalent to the average power consumption of 1,285 homes in Massachusetts. Replacing such amount of electricity in the current ISO-NE grid with solar power will lead to **6.8 million pound CO_2 emission reduction**. In additional to power generation and environmental benefits, MassDOT also expects considerable financial benefits from this project.

Under the negotiated power purchase rate and the current Massachusetts Net Metering policy, this project is projected to generate a total of **at least $15 million in savings/revenue** (aggregated cash flow) over the 20-year contract period. The realized savings will depend on the actual power production and the net metering credit rate of a given time.

MassDOT chose a "Public-Private partnership" business model to implement the program, which allows the agency to benefit financially in multiple ways:

- **Zero upfront capital cost for the state.** The Public-Private partnership requires that Ameresco be responsible for the development, design, construction, commission, operation and maintenance of the solar facilities. The developer will eventually recover its costs over time through federal tax incentives, the state Solar Renewable Energy Credits, and electricity sales.
- **Full utilization of Federal Corporate Tax Incentives**. The involvement of the private developer allows the project to utilize the Federal Investment Tax Credits (i.e., 30% total system costs can be directly subtracted from the system owner's income tax) as well as the Modified Accelerated Cost Recovery System (tax base deduction centered on an accelerated property depreciation schedule). These incentives bring down the overall project capital costs by more than 50%.
- **A favorable electricity rate schedule for the next 20 years**. MassDOT is committed to purchase 100% power generated from these solar facilities under a predetermined rate schedule; and the negotiated rates are significantly lower than the current utility rates.
- **Energy savings through virtual net metering.** The Massachusetts net metering policy allows qualified host customers (in this case, MassDOT) to obtain net metering credits (NMC) for exporting excess power to the grid. MassDOT will benefit from the difference between the net metering credits it receives from Utilities and the power purchase payments it makes to the developer.
- **Lease revenue**. MassDOT will receive annual rent payments for the developer's leasing of the land supporting the facilities.

Project Sites

The Phase I of the two-phased program includes a total of ten parcels, which are further divided into two groups (five in each group) based on site development stage, interconnection readiness and municipal permitting process. MassDOT approved and executed the site-specific agreements (i.e., the addenda to the MLA/PPA) for the five Phase IA sites at the end of October, 2014. Construction at these sites subsequently commenced in late November, 2014 (with the exception of the Plymouth site, where a contract amendment was necessary due to the discovery of underground utilities.) Phase IA sites that are presently under active construction and are anticipated to start power production in the summer and early fall of 2015.

Phase IB sites are currently under active development for utility interconnection, final design completion, and applicable non-administrative permit acquirement. Construction mobilization at these sites is

expected to take place in the fall of 2016, pending on the net metering rulemaking progress by the state legislature.

The table below summarizes the planned capacity, projected annual power production, and associated environmental benefits of each of the ten sites.

Phase	Location	Installed Capacity (kW DC)	Projected Annual Output (kWh)	CO_2 Emission Reduction (lbs)	Home Power Demand	Vehicle Mileage Traveled Reduction (miles)
Phase IA	Framingham I90 Interchange 13 N	649	735,706	736,840	121	794,549
	Framingham I90 Interchange 13 S	649	735,706	736,840	121	794,549
	Framingham I90 WB Service Plaza	318	360,485	360,485	59	389,317
	Natick I90 WB Embankment	271	307,206	307,206	51	331,776
	Plymouth Route 3 Exit 5	567	642,751	642,751	106	694,159
Phase IB	Salisbury, District 4 Depot	649	735,706	736,840	121	794,549
	Stockbridge I90 @ Interlacken East 1	649	735,706	736,840	121	794,549
	Stockbridge I90 @ Interlacken East 2	417	472,711	472,711	78	510,519
	Stockbridge I90 @ Interlacken West	649	735,706	736,840	121	794,549
	West Stockbridge I90 Exit 1	649	735,706	736,840	121	794,549
Total		5,467	7,107,100	6,197,391	*1,021*	*6,693,065*

Due to regulatory and site condition constraints, the attainable capacity of the ten Phase I sites totaled 5.47 MW DC. Presently, The MassDOT Office of Real Estate and Development is canvassing three additional sites within the state highway layout for Phase II sites, with the intention to achieving or surpassing the goal of a minimal 6MW solar PV generation capacity.

Contact Information

Please contact MassDOT OTP project manager Hongyan Oliver, at 857-368-9025 or Hongyan.oliver@state.ma.us, to receive more detailed information on the project.

AMERESCO, INC.

- Incorporated in April 2000, public in 2010 (NYSE:AMRC)
- The largest independent energy services provider with offices in North America and Europe
  - No parent company affiliations
  - Energy source neutral
  - Technology and equipment agnostic
- Comprehensive array of energy solutions
- Integrated approach – before, at, and after the meter
- Energy information platform for informed energy decisions
- Strategy and implementation partner for climate neutrality

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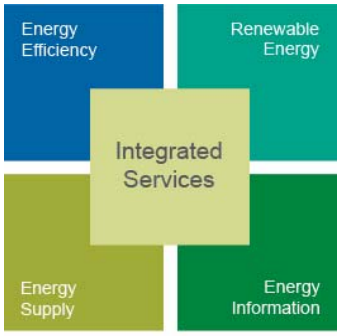

NAESCO ACCREDITED ENERGY SERVICE PROVIDER

U.S. GREEN BUILDING COUNCIL MEMBER

ENERGY STAR PARTNER

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CASE STUDY: ARIZONA STATE UNIVERSITY

Ameresco has implemented many projects at ASU over last 14 years, including:

- >17 MWdc of PV systems (47 sites) and 2 Performance Contracts
- Energy Information System database & Campus Metabolism Website
- New Central Plant, new Combined Heat and Power Plant, and many infrastructure upgrades

Resulting Energy & GHG Emissions Savings:

- 98.5 GWh/year
- 1.4 million therms/year
- 77,247 metric tons CO_2e/year

Energy & Central Plant Retrofit

First Campus PV System (184 kW DC)

Boiler & Boiler Burner Replacement

Combined Heat & Power (CHP) Plant

Polytechnic Campus Central Plant

Energy Information System

North Loop Project/ Central Plant Interconnect

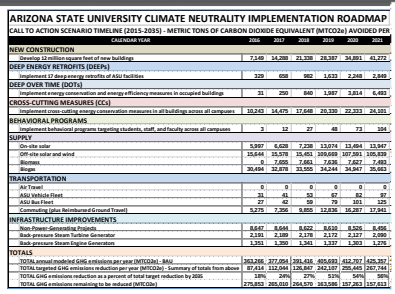
Solar PPA (17+ MWdc)

AMERESCO Green • Clean • Sustainable

ASU CLIMATE NEUTRALITY ROADMAP

ASU Arizona State University

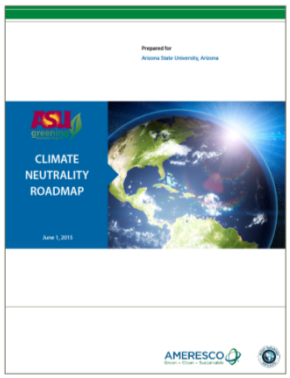
- Goals:
  - 2025: climate neutrality in buildings
  - 2035: climate neutrality including fleet, commuting, air travel
- Results:
  - Over 40 projects identified in first "living" Climate Neutrality Roadmap
  - Added $169M investment over projected $555 million energy spend by 2025 yields $74M NPV (2049)
  - Cumulative GHG emissions reduction: 21 metric tons CO_2e



ARIZONA STATE UNIVERSITY CLIMATE NEUTRALITY IMPLEMENTATION ROADMAP

CALL TO ACTION SCENARIO TIMELINE (2015-2035) - METRIC TONS OF CARBON DIOXIDE EQUIVALENT (MTCO2e) AVOIDED PER

CALENDAR YEAR	2015	2020	2025	2030	2035
NEW CONSTRUCTION					
Develop 12 million square feet of new buildings	7,149	14,288	21,338	28,387	34,891	41,272
DEEP ENERGY RETROFITS (DEEPs)					
Implement 17 deep energy retrofits of ASU facilities	329	658	982	1,633	2,248	2,849
DEEP OVER TIME (DOTs)					
Implement energy conservation and energy efficiency measures in occupied buildings	31	250	840	1,987	3,814	6,483
CROSS-CUTTING MEASURES (CCs)					
Implement cross-cutting energy conservation measures in all buildings across all campuses	10,243	14,475	17,648	20,330	22,333	24,101
BEHAVIORAL PROGRAMS					
Implement behavioral programs targeting students, staff, and faculty across all campuses	3	12	27	48	73	104
SUPPLY					
On-site solar	5,997	6,628	7,238	13,074	13,494	13,947
Off-site solar and wind	15,644	15,578	15,451	109,669	107,591	105,839
Biomass	0	7,695	7,661	7,638	7,627	7,493
Biogas	30,494	32,878	33,555	34,244	34,947	35,663
TRANSPORTATION						
Air Travel	0	0	0	0	0	0
ASU Vehicle Fleet	31	41	53	67	82	97
ASU Bus Fleet	27	42	59	79	101	125
Commuting (plus Reimbursed Ground Travel)	5,275	7,356	9,855	12,836	16,287	17,941
INFRASTRUCTURE IMPROVEMENTS						
Non-Power-Generating Projects	8,647	8,644	8,622	8,610	8,526	8,496
Back-pressure Steam Turbine Generator	2,101	2,169	2,178	2,172	2,127	2,099
Back-pressure Steam Engine Generators	1,351	1,350	1,341	1,337	1,303	1,276
TOTALS						
TOTAL annual modeled GHG emissions per year (MTCO2e) - BAU	363,266	377,054	391,438	405,693	412,707	425,357
TOTAL targeted GHG emissions reduction per year (MTCO2e) - Summary of totals from above	87,414	112,044	126,847	242,107	255,445	267,744
TOTAL GHG emissions reduction as a percent of total target reduction by 2035	18%	24%	27%	51%	54%	56%
TOTAL GHG emissions remaining to be reduced (MTCO2e)	275,853	265,010	264,570	163,586	157,263	157,613



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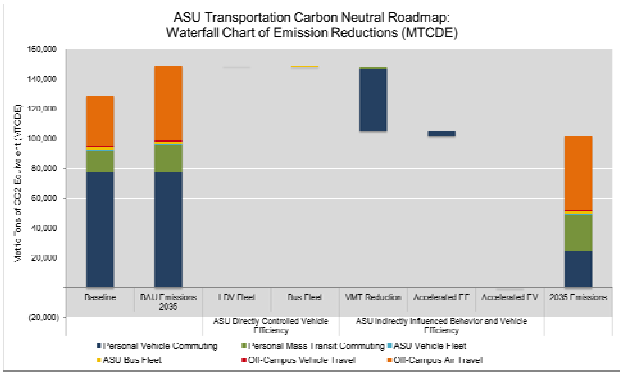
ASU TRANSPORTATION-RELATED EMISSIONS AND MITIGATION STRATEGIES

- Transportation – 38% of total MTCDE emissions (FY12)
  - Fleet 0.3%
  - Employee commuting 6.5%
  - Student commuting 19.8%
  - Directly-financed air travel 7.6%
  - Study abroad air travel 3.4%
- BAU modeling shows 17% increase by 2035
- Getting to a zero footprint by 2035 is challenging!
- Reduce transportation emissions by 33% from BAU:
  - Reduce driving need, distance
  - Influence behavior and how cars are used
  - Use more efficient vehicles for remaining demand
  - Set carbon credit or renewable energy strategy for air travel and remaining transportation footprint



AMERESCO Green • Clean • Sustainable

MAC CASE STUDY

- Minneapolis-St. Paul International Airport (MSP) governed by Metropolitan Airports Commission (MAC)
- Project details:
  - 3 MW PV on terminal 1 parking ramps
  - 8,705 PV panels and string-level inverters
  - 7,743 LED fixture conversions
  - 4 EV charging stations
  - 20 year guarantee with O&M services
  - 3-year PR/media sponsorship

- Financing:
  - 21 year muni lease financing with 0.75% net effective interest rate
  - 100% QECB funding with participation by 7 neighboring cities and counties
  - Grant from Xcel Energy
- Results:
  - 10 million kWh/year reduced energy requirements
  - 235 construction jobs
  - 6,813 metric tons CO_2e reduction per year

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MASSACHUSETTS DOT CASE STUDY

Massachusetts powers solar systems

DOT plugs cost-saving panels along highways
Sunday, May 31, 2015
By: Marie Szaniszlo

Large swaths of green pasture along Massachusetts highways are being transformed into solar power fields that state transportation officials say could ***save taxpayers $15 million over the next 20 years***.

Ten sites … along the Mass Pike have been selected for the first phase of the project. And the Department of Transportation is canvassing another three sites along state highways for the second phase, with the goal of producing at least ***6 megawatts of solar power***, said Michael Verseckes, a DOT spokesman.

"***MassDOT's development of solar (energy) facilities within the state highway layout is driven by the desire to create energy savings by producing electricity locally and economically, optimize the use of underutilized state land and reduce greenhouse gas emissions via renewable power generation technologies***," Verseckes said.

After a lengthy procurement process, the DOT selected Ameresco Inc., a Framingham renewable-energy company, last June to design, finance, construct, operate and maintain the solar panels …

PHOTO: John Wilcox
BRIGHT: Solar panel fields, such as one near the Mass Pike in Framingham, above, will help save on electricity costs.

massDOT
Massachusetts Department of Transportation

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Boston Herald, "Massachusetts powers solar systems", 5/31/2015.

GOVERNMENTAL ENTITIES HAVE MANY PRIORITIES TO ADDRESS AT ONCE

- NEEDS
  - Asset performance and management
  - Reduced operating costs
  - Reduced capital requirements
  - Modernized facilities
  - Environmental compliance
  - Resiliency
  - No technical or financial risk
  - Meet mandates
  - GHG emissions reductions from transportation

- CHALLENGES
  - Rising operating costs
  - Aging infrastructure
  - Lack of capital
  - Revenue projects are decreasing
  - Deferred maintenance
  - Issues related to rising taxes, floating bonds
  - Climate change mitigation will change transportation business models

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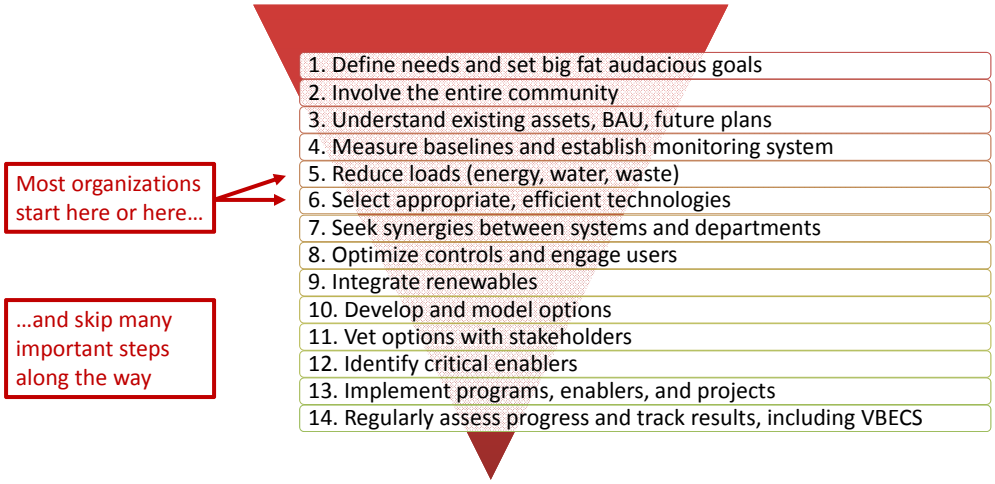
TAKE THE RIGHT STEPS IN THE RIGHT ORDER – AN INTEGRATED APPROACH



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MAKING PROGRESS TOWARD CLIMATE NEUTRALITY

- The Climate Neutrality Continuum:
  - commitment → inventory → planning → goal-setting → resources → partnering → implementation → M&V → reporting → refine & improve
- Projects:
  - Demand-side: lights, buildings, vehicles
  - Infrastructure: utilities, networks, fleets, back-up power, materials
  - Supply-side: renewables, energy storage, smartgrid
  - Transportation: reduce VMT, behavioral programs, efficient vehicles, offsets
  - Critical enablers: policies, programs, organizational & institutional initiatives
- Partnering and best practices:
  - SSTI; structured financing; P3; performance contracting; power purchase agreements; best-of-class support

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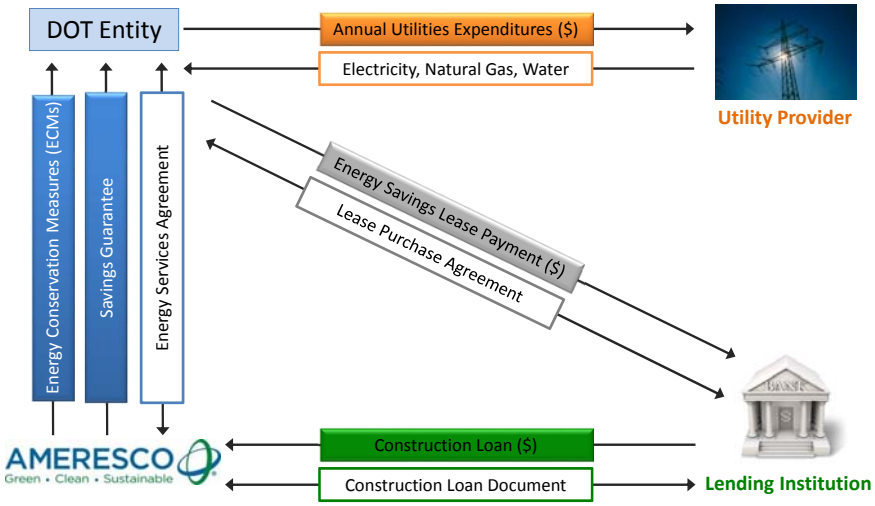
ENERGY SAVING PERFORMANCE CONTRACTING (ESPC)



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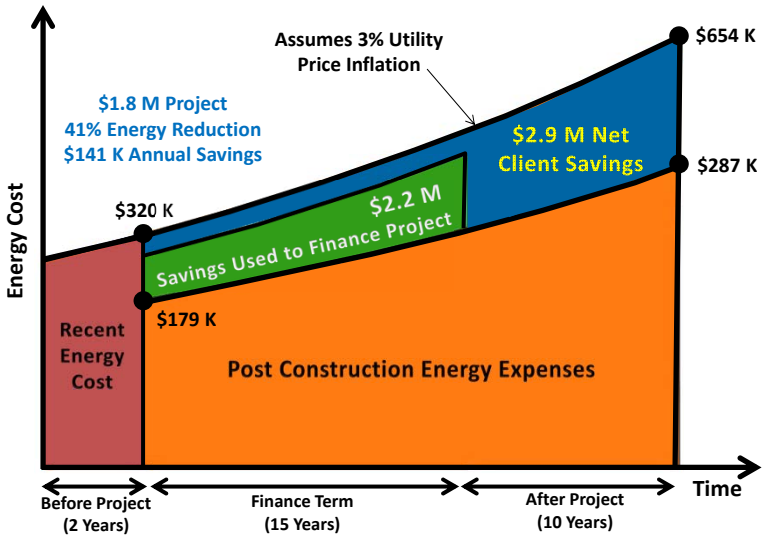
ENERGY PERFORMANCE CONTRACTING - CASH FLOW EXAMPLE



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THE ECONOMICS OF SOLAR

- Implementation cost
  - Varies by application, scale
- Investment Tax Credits (30% of system cost)
  - Expiration December 31, 2016
- Utility Incentives – Different Every Market
- Avoided cost calculations and escalation rates
  - Time of Use
  - Solutions for $0.06/kWh to $0.12/kWh, depending on escalation, technology integration and etc
- Demand Savings
  - Battery / Controls Solutions
  - Shifting Rate Structures (Energy to Demand Shift)
  - 15 minute utility data reviews

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FINANCIAL APPROACHES

- Power Purchase Agreement (PPA) – 15 to 25 year financing for solar only options in which there are no up-front costs and Customer pays for each kilowatt-hour generated by solar. The PPA rate and annual escalation may provide flexibility to achieve goals. Customer does not own solar generating assets. Customer may purchase solar assets at end of agreement for additional cost.
- Lease Purchase (Lease) – 10 to 25 year financing for all technology options included in the proposal in which lease payments are satisfied by energy savings. Customer pays low interest financing due to good credit. Additionally, Customer owns all equipment and solar generating assets. Low interest rates typically provide better return rates even without utilizing federal ITC.
- Up Front Contribution – No financing required as this utilizes available funds and/or future bond dollars to achieve highest return, own assets and potential to minimize operational dollars with capital dollars.

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FINANCIAL APPROACHES

Finance Type	PPA	LEASE	Up Front Contribution
Contract Term	15-25 years	15-25 years	N/A
Term Ownership	3rd Party/AMERESCO	Customer	Customer
Upside on over production	3rd Party/AMERESCO	Customer	Customer
End of Term Ownership	Buyout option available	Customer	Customer
Up Front Capital Investment	Not Required	Not Required	Yes
QECB Participation	Not Available	Available	Available
Ability to Blend Technologies	No	Yes	Yes
Long Term Debt on Books	No	No	N/A
Interest Rate	Based on 3rd Party/AMERESCO	Based on Customer Credit (Good)	N/A
ITC Monetized	Yes	No	No
O&M	3rd Party/AMERESCO	Customer or AMERESCO	Customer or AMERESCO

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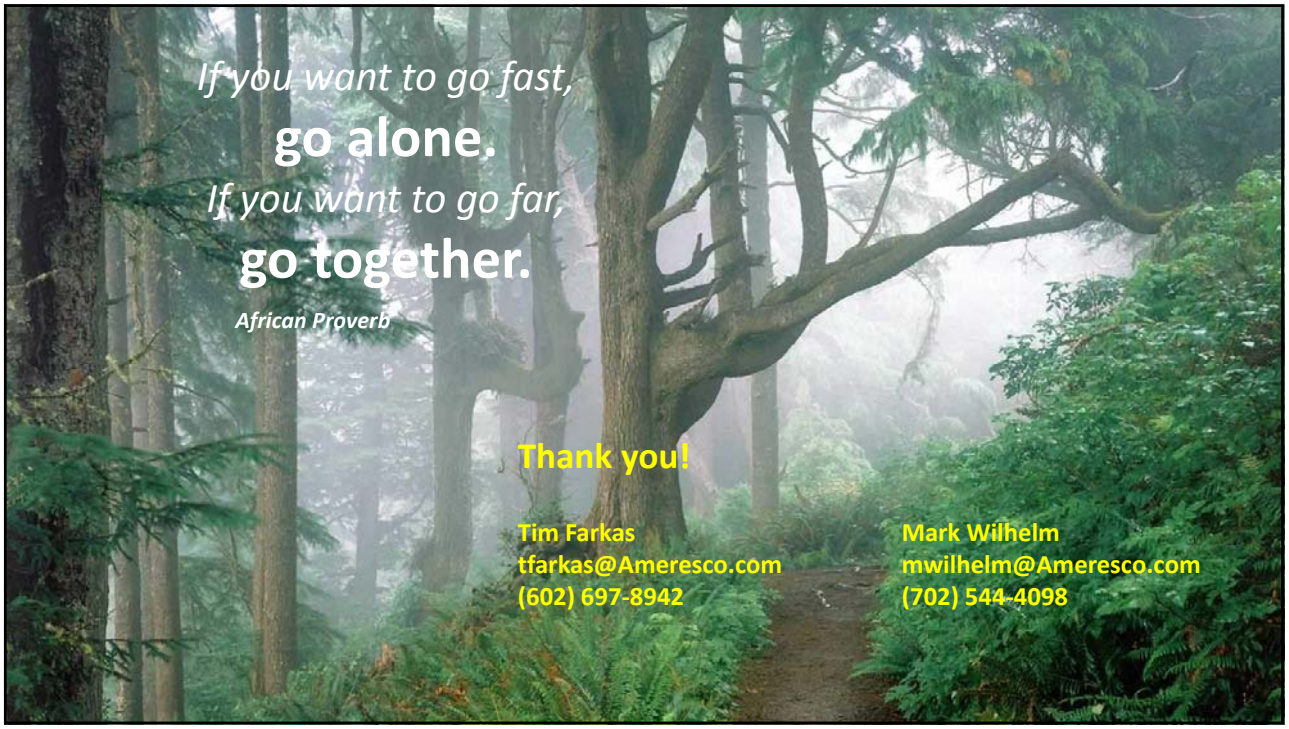


AIRPORTS TO GO GREEN, REDUCE ENERGY COSTS BY $518 MILLION
Posted on Dec 18, 2013 in Airports News, Main, News

Honolulu – Gov. Neil Abercrombie unveiled an unprecedented energy efficiency program for the Department of Transportation's (DOT) Airports Division that will cut energy use by 49 percent, saving at least $518 million in energy costs over the next 20 years.

The airports will be modernized with the latest in energy-efficient and green technology, providing a high-impact solution for the Abercrombie Administration's aggressive pursuit of 70 percent clean energy use for the state of Hawaii by 2030.

"These important upgrades at our airports will help Hawaii reach its clean energy goals," said Gov. Abercrombie. "This project is a long-term investment, which will cut the energy use at our airports nearly in half, reduce our dependence on imported energy sources, provide savings on future energy costs and add jobs to our economy."

The project will deliver results by replacing 372 transformers and 74,500 light fixtures, installing 9,100 solar photovoltaic panels; and include upgrades and replacement of chilled water and air conditioning systems, installation of smart controls, and deferred maintenance such as roof repairs to accommodate the upgrades. The $150 million contract was awarded to Johnson Controls through a state competitive procurement process for Energy Performance Contracting (EPC).

"This important project is part of a strategy and vision to reduce costs and improve energy efficiency," said DOT Director Glenn M. Okimoto. "DOT will make a large impact since the state airports system is the third largest consumer of electricity in Hawaii. This project will save the state millions of dollars and it will serve as a model for other state agencies."

"Energy efficiency is Hawaii's cleanest, fastest, and cheapest clean energy resource," said Jeff Mikulina, CEO of Blue Planet Foundation, an organization working to clear the path for clean energy in Hawaii. "Every kilowatt hour avoided is fossil fuel that we don't import–and carbon pollution that we don't export."

"It is both suiting and symbolic for Hawaii's airports–the gateways for Hawaii residents and visitors–to be models of energy efficiency," he added. "Blue Planet applauds the Governor, his Administration, and the private sector partners who are making this record-setting energy savings project a reality."

The DOT Airports Division spearheaded this project in cooperation with the state Department of Business, Economic Development, and Tourism (DBEDT). More than 400 local jobs will be created while adding $670 million in economic development. "This project uses the successful EPC model," said DOT Deputy Director for Airports Ford Fuchigami. "In just two years the

state will be reaping the energy savings and cost benefits of this program with a guaranteed savings of $15.8 million."

Hawaii leads the nation in EPC, and was recently honored with its second consecutive national Race to the Top award in this area. The Hawaii airports project is the largest EPC initiative in the country to date.

"This substantial efficiency project moves Hawaii further into the national spotlight for leadership in performance contracting and contributes to the growth of our clean energy economy," said DBEDT Director Richard Lim. "It will fulfill half of our recent Clinton Global Initiative *Commitment to Action*, in which we pledged $300 million in investment paid for through energy savings by June 2015, as well as our participation in the Obama Administration's *Performance Contracting Accelerator Program*, aimed at catalyzing public sector energy efficiency investments in the U.S."

As part of President Obama's Climate Action Plan, Hawaii is a partner in the Performance Contracting Accelerator Program under the Better Buildings Initiative, a national leadership effort calling on leaders to make substantial commitments to improve the energy efficiency of their buildings and plants, save money and increase competitiveness.

"Through President Obama's Better Buildings Initiative, our partners are committing to real change – breaking through barriers and solving common challenges across the U.S. building energy industry," said Deputy Secretary of Energy Daniel Poneman. "We applaud these partners for joining in this leadership initiative and we look forward to working with them as they help drive greater energy efficiency for industrial, commercial and public buildings – cutting harmful pollution and saving on energy bills."

Hawaii airports used an innovative financing structure by issuing certificates of participation (COPS) to finance the project, selling $167.7 million of certificates in the municipal bond market last week in New York. The financing received an overwhelming response from market investors, receiving more than $1.1 billion in orders from local Hawaii and national investors.

"This project illustrates the state's effort to diversify its financing options and capabilities, with the targeted objectives to reduce costs to taxpayers." said Finance Director Kalbert Young. The Airlines Committee of Hawaii, the consortium of airlines utilizing Hawaii airports, lauded the State's EPC initiative.

"Gov. Abercrombie's strategic efforts to invest in energy savings measures will ensure cost savings for airlines and consumers in the years to come," said Blaine Miyasato and Matt Shelby, co-chairs of the Airlines Committee of Hawaii.

To date, state and county agencies have implemented nine EPC projects impacting more than 115 buildings, hospitals, courthouses and educational campuses, with an estimated savings of $341.3 million over a 20-year period. With the airports project, Hawaii is national leader in EPC savings of $859 million over a 20-year period.

BUILDING CLIMATE RESILIENT TRANSPORTATION

CLIMATE CHANGE ALREADY DISRUPTING U.S. TRANSPORTATION

State and regional transportation agencies across the country are facing extreme weather events that damage roads and bridges and cost large sums to repair, not to mention the cost to the economy from disrupted travel. Extreme weather events—including heat waves, drought, tropical storms, high winds, storm surges and heavy downpours—are becoming more frequent and severe as the climate changes.

FHWA IS RESPONDING

These climate risks threaten the considerable federal investment in transportation infrastructure and FHWA is responding:

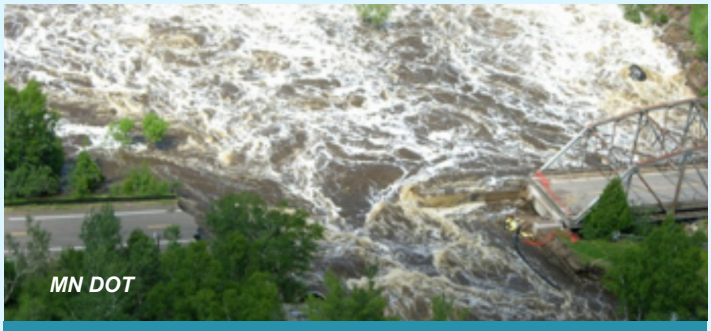
- FHWA issued an order committing the agency to integrating climate risk considerations into the delivery and stewardship of FHWA programs.
- Climate adaptation activities are eligible for FHWA funding, including vulnerability assessments and design and construction of projects or features to protect assets from damage associated with climate change.
- FHWA's updated emergency relief program guidance reflects climate resilience.
- Transportation law passed in 2012 requires states to develop risk-based asset management plans and to consider alternatives for facilities repeatedly needing repair or replacement with federal funding.
- FHWA developed tools and guidance for systematic consideration of climate risks at transportation system and project levels.

WHAT CAN TRANSPORTATION AGENCIES DO TO BUILD RESILIENCE?

Know your vulnerabilities

Departments of transportation (DOTs), metropolitan planning organizations (MPOs), and others can begin with a vulnerability assessment for their area using FHWA's Vulnerability Assessment Framework, a guidebook and online resource detailing key steps and in-practice examples. Based on the experience of pilot projects and other work, each step of the framework has tools, case studies, videos and other resources associated with it. For instance, FHWA's Climate Data Processing Tool processes publicly available, but large and unwieldy data sets into local temperature and precipitation projections tailored to transportation practitioners.

Using the FHWA framework and climate data from its local university, the Washington State Department of Transportation (WSDOT) held workshops with maintenance and engineering staff in all regions of the state. WSDOT asked participants, "What keeps you up at night?" and "What happens if the climate-related conditions get worse?" The DOT leveraged local staff knowledge and GIS overlays of climate and asset management data to develop a map showing road segments at high, medium, and low vulnerability.



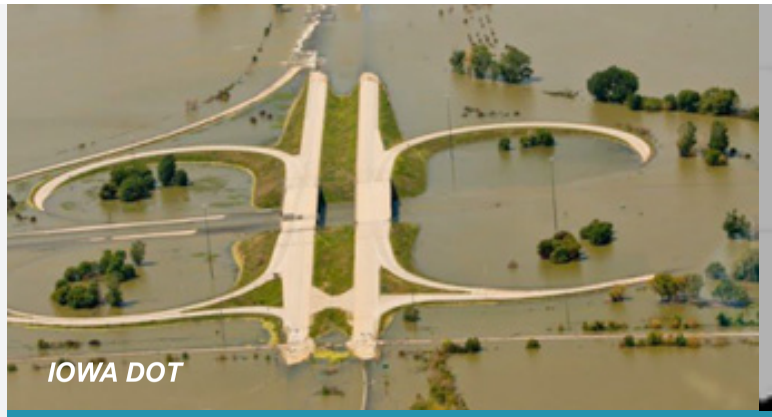
As part of an FHWA pilot, Minnesota DOT assessed vulnerability to climate change in two districts and analyzed adaptation options for two facilities at high risk of flash flooding.

Oregon purchased land and removed a levee to allow flood water to flow onto a natural floodplain. This protected the highway from flooding and provided habitat. Oregon DOT is now conducting an FHWA-funded pilot analyzing protection options for other vulnerable sites.

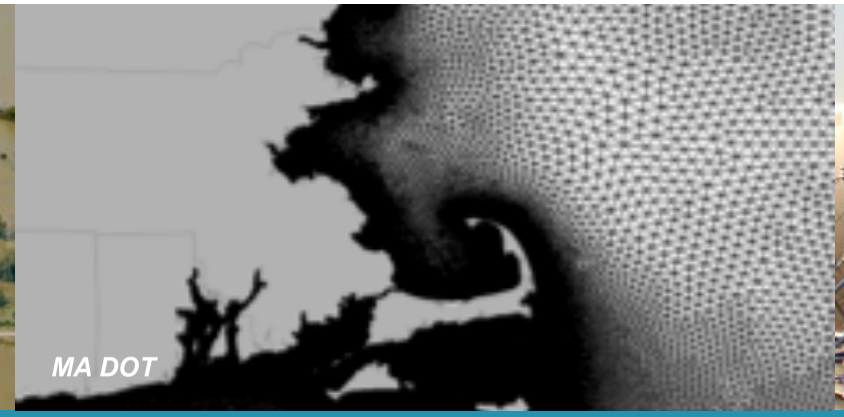
Transportation Agencies Using FHWA Resources to Build Resilience

FHWA partnered with 22 climate resilience pilots in two rounds as well as four cooperative projects in the Gulf Coast, Northeast, Southeast, and New Mexico. These 26 projects are shown in the map below. In total, at FHWA's latest count, 24 state DOTs and 30 MPOs have conducted vulnerability assessments of the highway system to address climate change and extreme weather events.

- State DOT Pilot
- MPO Pilot
- Cooperative Projects


IOWA DOT

Iowa DOT and local universities used global climate models and the state's hydrological model to project future flood frequencies and identify bridge and roadway vulnerabilities in two river basins. Iowa plans to integrate the information into its real-time warning system to protect the traveling public. The results of the pilot may also influence guidelines for the design of bridges and culverts on Iowa's primary highways.


MA DOT

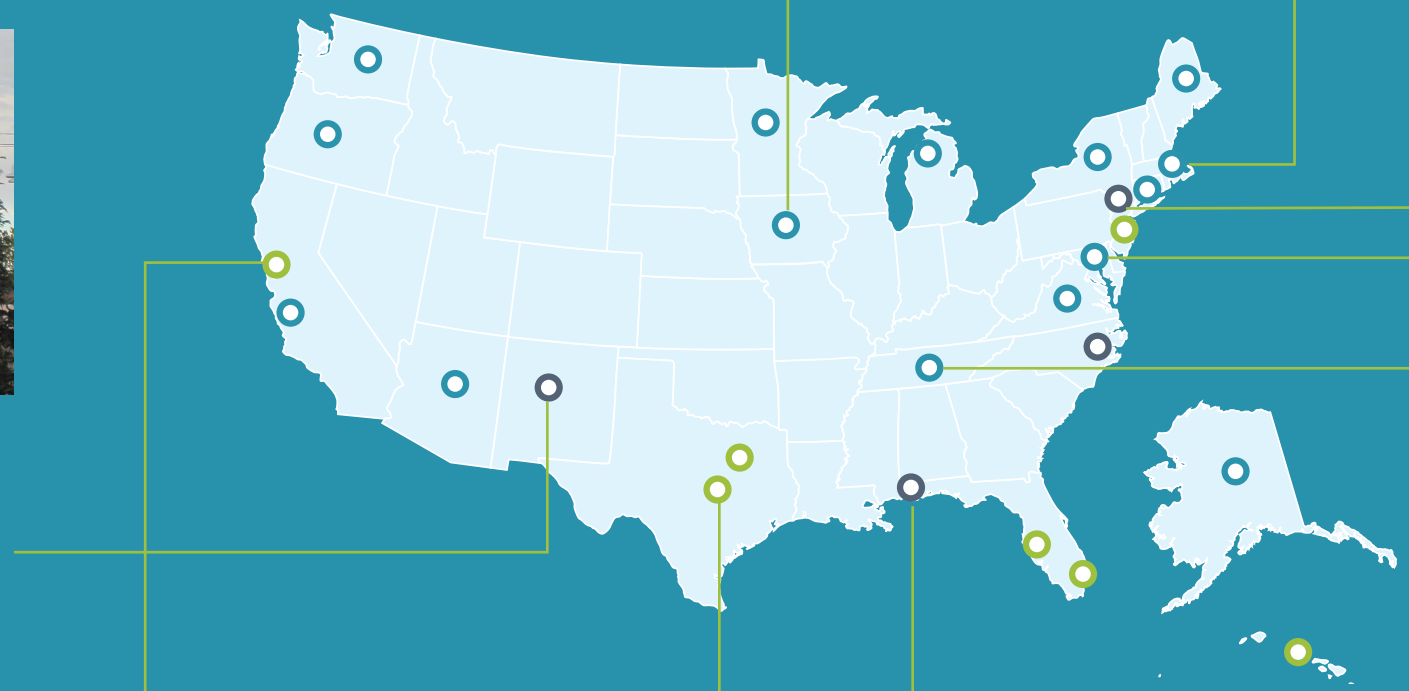
The Massachusetts Department of Transportation developed high resolution computer modeling of coastal storm inundation and risks to the Central Artery highway tunnel system in Boston.


PANYNJ

New Jersey's 2011 climate pilot analysis of which roads could flood with higher sea levels and storm surge was unfortunately validated when Superstorm Sandy hit in October 2012. Following the storm, FHWA partnered with the tri-state region on a multi-jurisdictional vulnerability assessment and analysis of adaptation solutions for particularly vulnerable assets, such as the Hugh L. Carey Tunnel and NJ 7. Photo shows flood protection installed by the Port Authority of NY and NJ.

FHWA

In Albuquerque, New Mexico, FHWA partnered with the MPO on a scenario planning process to assess the impact of growth scenarios on climate resilience and mitigation, along with other community goals. The project analyzed how different scenarios performed on development in wildfire risk areas, development in flood risk areas, water consumption, and emissions levels. During stakeholder workshops, participants discussed policies that would help achieve a preferred scenario for the 2040 metropolitan transportation plan.




Nashville MTA

Tennessee DOT conducted a multimodal vulnerability assessment for the state, obtaining key information for asset management. Landslides, tornados, and river flooding (such as that shown above in 2010), are risks.

San Francisco's Metropolitan Transportation Commission (MTC) analyzed options for protecting transportation infrastructure, including an artificial dune or living levee north of the Bay Bridge touchdown to protect the bridge.

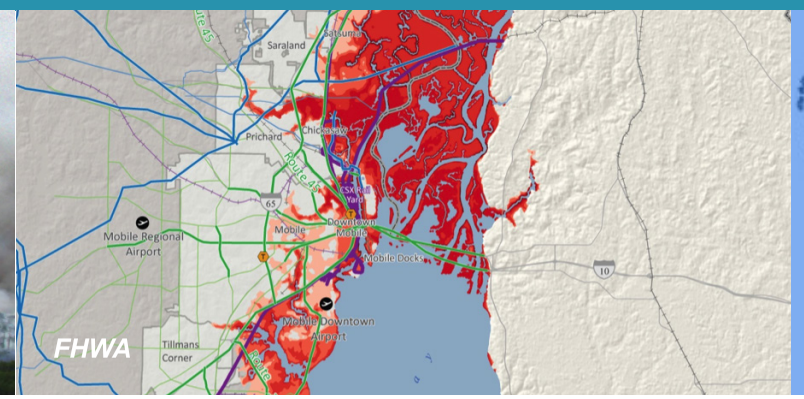
In Texas, increases in heat waves, wildfires, and droughts threaten transportation. The MPO for Austin, TX identified areas where clay soils shrink during heat waves and drought, cracking pavements.

Phase I of the U.S. DOT Gulf Coast Study, completed in 2008, found that with four feet of sea level rise, 27% of the Gulf Coast region's major highways, 9% of rail lines, and 72% of ports would be inundated. Gulf Coast Phase II focused in-depth on Mobile, Alabama and developed nationally applicable tools.

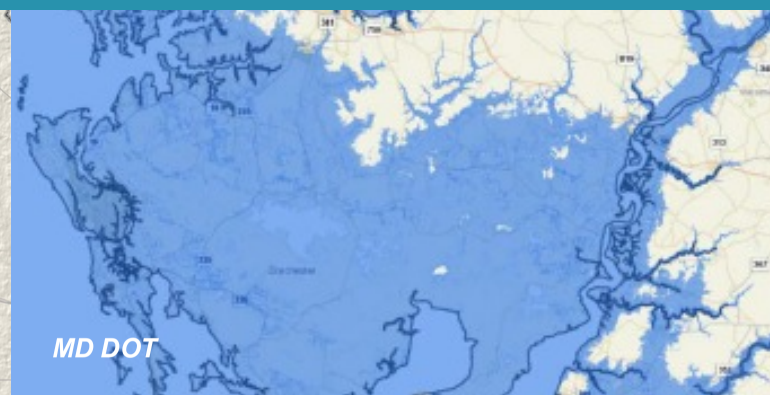
Maryland DOT used FHWA's Vulnerability Assessment Scoring Tool to prioritize climate risks to bridges, culverts, and road segments in two counties particularly exposed to sea level rise and storm surge.


EPA


CAMPO



FHWA


MD DOT

Use the transportation planning process

The metropolitan and statewide transportation planning process provides key opportunities for taking climate change into account. Resilience and sustainability should be considered early during decision-making at the system-wide level, when options and priorities are considered for transportation investments to meet multiple community goals. FHWA's report, *Integrating Climate Change into the Transportation Planning Process*, provides more information.

FHWA staff inspects a culvert in Mobile, Alabama. The culvert meets state standards under current conditions, but would be overtopped by a 25-yr rainfall under wetter climate change projections, flooding the road and the nearby Interstate highway. Using the 11-Step process, FHWA found that to avoid flooding, the DOT could widen the culvert by adding an additional cell to each side ($1.7 million cost, $6 million benefit). Alternatively, the DOT could replace the existing culvert with the largest crossing that will fit within the available space ($2.5 million cost, $6.5 million benefit).

Incorporate climate risks into design and asset management

Transportation agencies can consider climate change impacts when planning new assets or rehabilitating existing assets, especially as part of strategic asset management efforts. Risk-based asset management serves as a climate adaptation strategy by providing a platform for inventorying assets, evaluating risks to those assets, and prioritizing capital improvements.

Agencies can use FHWA's 11-step process for engineering transportation assets to be more resilient to climate impacts. Developed under Phase II of the *Gulf Coast Study*, the process includes consideration of multiple alternatives and cost benefit analysis. FHWA is now adding to this work by developing specific recommendations and approaches based on a cross-cutting analysis of a diverse set of transportation assets nation-wide.

Agencies can prioritize "no regrets" actions that improve resilience of assets to existing stressors, have co-benefits, or cost little relative to the overall value of the asset. They can build flexibility into designs to allow for changes in the future given inevitable uncertainty regarding future emissions levels and precise timing and severity of impacts. For example, agencies can design flood walls that can be heightened in the future with minimum additional expense.

FHWA's newly updated *Hydraulic Engineering Circular* (HEC) 25: Highways in the Coastal Environment, includes guidance on estimating future sea levels and storm surges along with designing protection measures such as revetments, beach nourishment, and bridge deck elevation. FHWA is also updating engineering guidance on riverine areas and hydrology. Finally, FHWA is conducting research to better pinpoint projections for the input variables transportation engineers need when designing infrastructure, including precipitation patterns, geo-hazards, and watershed sensitivity.

Operations and maintenance

Operations and maintenance strategies can also lessen climate impacts on transportation. Examples include more frequent cleaning of storm-drains, improved plans for weather emergencies, closures and rerouting, traveler information systems, debris removal, early warning systems, prepositioning materials, damage repairs, and performance monitoring. See FHWA's white paper on this topic and upcoming primer for more information.

Using FHWA Emergency Relief (ER) funds, Colorado DOT rebuilt this roadway damaged by 2013 flooding to be more resilient to future floods by shifting the road a few feet further from the river, and using grouted riprap and native vegetation to stabilize the riverbank. Betterments involving added protective features are eligible for FHWA ER funds if economically justified. In addition, repaired facilities may be built to current design standards (which may be more resilient), without being considered a betterment. Finally, states may use their regularly apportioned Federal-aid funds for incremental costs.

FHWA will continue partnering with federal, state and local agencies on the shared goal of a transportation system that provides safe mobility under current and future conditions, supporting the nation's economy and quality of life.

LEARN MORE

FHWA's climate change website offers publications, policies, guidance, webinar recordings, and tools for assessing vulnerabilities and building resilience.

http://www.fhwa.dot.gov/environment/climate_change/adaptation/

Contact: Michael Culp, Sustainable Transport and Climate Change Team Leader, michael.culp@dot.gov, 202-366-9229

National and State Level Rating Systems

System	Sponsor	Scope	Organization	Review	link
Envision™	Institute for Sustainable Infrastructure	Infrastructure	**checklist** includes 60 credits in five categories (Quality of Life, Leadership, Resource Allocation, Natural World and Climate and Risk);	Fee-based review	http://www.sustainableinfrastructure.org/rating/
GreenLITES	New York State DOT	Highways	**checklist** includes 180 criteria planning through operations and maintenance	Self-assessment	https://www.dot.ny.gov/programs/greenlites
INVEST	FHWA (USDOT Federal Highway Administration)	Highways	**checklist** includes 64 Criteria planning through operations and maintenance	Self-assessment	https://www.sustainablehighways.org/
GreenRoads™	Greenroads Foundation	Highways	**checklist** includes 48 criteria focused on design and construction	Fee based review	https://www.greenroads.org/
STARS	North American Sustainable Transportation Council (STC)	Multi-Modal Transportation	**checklist** includes 29 credits planning through operations	Fee-based review	http://www.transportationcouncil.org/
TIGER	USDOT	Transportation - All Modes	**Benefit / Cost** - dollar based valuation across many aspects of the Triple Bottom Line	Grant Program Application	http://www.dot.gov/policy-initiatives/tiger/tiger-bca-resource-guide-2014

Sustainability Rating Checklist Utility

Broaden thinking	4
Demonstrate credibility	5
Communicate ideas	4
Contrast alternatives	3
Rate projects	4
Rank projects	2
Stimulate / Structure dialog	3
“SMART” / “HARD”	3
Adaptable / Expandable / Flexible	2

INVEST
ECONOMIC • SOCIAL • ENVIRONMENTAL

Assess the Sustainability of Your Transportation Plans, Projects or Programs

The Federal Highway Administration (FHWA) developed INVEST, to help make the nation's transportation systems more sustainable – economically, socially and environmentally. INVEST was created specifically for transportation agencies to evaluate the sustainability of the full lifecycle of their highway and transportation projects and plans.

A Free, Web-based Self-Evaluation Tool

INVEST provides a collection of criteria and practices that allow transportation agencies to gauge their level of sustainability and systematically integrate sustainable practices into their actions. Using the INVEST tool is completely voluntary and free. The name INVEST came from Infrastructure Voluntary Evaluation Sustainability Tool.

Quantify, Balance, and Communicate Sustainability Benefits and Trade-offs

INVEST helps State Departments of Transportation, Metropolitan Planning Organizations (MPOs), local transportation agencies and others to identify, prioritize and communicate balanced choices between the different and sometimes competing goals of highway infrastructure programs.

With INVEST, users can balance the economic, social and environmental factors that define sustainability; identify and share sustainability best practices; and provide decision-makers with the information they need by systematically capturing criteria that affect a project's sustainability performance over time.

INVEST provides a numeric means for measuring sustainability, assessing improvement options, and tracking continuous progress. INVEST's approach unites internal groups and stakeholders around shared goals and needs and provides a collaborative platform to communicate performance.

The Sustainability Triple Bottom Line

Sustainability in Transportation: Evaluate – Score – Improve

- **Evaluate** – The collaborative process can be a very important outcome.
- **Score** – The score provides recognition for implementing sustainability best practices and helps identify gaps.
- **Improve** – The process can lead to improvements in practice and identification of cost effective measures.

"We used INVEST to measure the project's sustainability and evaluate the planning, design and construction of the Innerbelt project from the beginning. INVEST told us that we went far beyond our projected sustainability goals."

– Jocelynn Clemings, Public Information Officer, Ohio Department of Transportation (ODOT)

Created with Extensive Feedback from Transportation Experts and Projects Nationwide

FHWA partnered with 19 organizations across the country to pilot test INVEST. Based on feedback from numerous experts in the transportation community on the pilot test version of the tool, FHWA included significant enhancements in INVEST 1.0 when it launched in October 2012. INVEST will continue to evolve as FHWA receives feedback on the tool and sustainability standards of practice change.

Where INVEST Can Help

INVEST includes three modules: system planning, project development, and operations and maintenance. Examples of how these can be used include:

SYSTEM PLANNING:

- Inform the update of an MPO's long range transportation plan.
- Improve the statewide transportation planning process.

PROJECT DEVELOPMENT:

- Assess and improve the sustainability of specific transportation projects under development, or learn from projects already completed.
- Conduct a programmatic evaluation of agency construction practices and opportunities for sustainability improvements.

OPERATIONS AND MAINTENANCE:

- Review operations and maintenance programs at the district or statewide level.

Why Use INVEST?

- Evaluate your level of sustainability and pinpoint ways to improve.
- Demonstrate to the public and stakeholders a commitment to sustainability and self-improvement.
- Save your agency money by identifying practices that both reduce costs and improve outcomes.
- Use INVEST as an objective and comprehensive framework for communicating internally and with stakeholders about sustainability.
- Use as a benchmark for continuous improvement.

"INVEST showed us where we were already sustainable and it also provided inexpensive ways to promote sustainability, to help us save money and the environment."

– Rukhsana Lindsey, P.E., Deputy Maintenance Engineer, Utah Department of Transportation (UDOT)

To try the INVEST tool for yourself, visit www.sustainablehighways.org

To learn more about INVEST, contact:

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About the Guide

Over the coming century, the challenges borne by cities and the burdens placed upon their streets will multiply in quantity and complexity. Growing urban populations will demand that their streets serve not only as corridors for the conveyance of people, goods, and services, but as front yards, parks, playgrounds, and public spaces. Streets must accommodate an ever-expanding set of needs. They must be safe, sustainable, resilient, multi-modal, and economically beneficial, all while accommodating traffic.

In response to these unprecedented demands, cities around the country are developing an innovative body of practice and expertise to design for and around the special characteristics of the urban environment. From New York's Times Square to Chicago's Wacker Drive to Spring Street in Los Angeles, a better approach to and understanding of street design is taking root in our cities.

Street Design Principles

The *Urban Street Design Guide* crystallizes a new approach to street design that meets the demands of today and the challenges of tomorrow. Based on the principle that streets are public spaces for people as well as arteries for traffic and transportation, the Guide foregrounds the role of the street as a catalyst for urban transformation. It cements the tactics and techniques being pioneered by the nation's foremost urban engineers and designers.

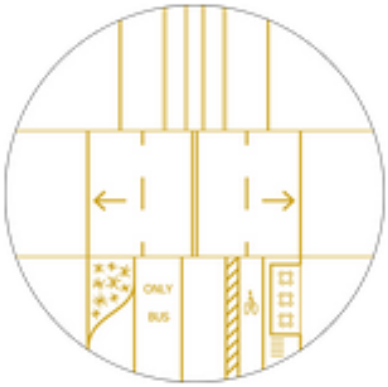
In an urban context, street design must meet the needs of people walking, driving, cycling, and taking transit, all in a constrained space. The best street design also adds to the value of businesses, offices, and schools located along the roadway.

Streets Are Public Spaces

Streets are often the most vital yet underutilized public spaces in cities. In addition to providing space for travel, streets play a big role in the public life of cities and communities and should be designed as public spaces as well as channels for movement.

Great Streets are Great for Businesses

Cities have realized that streets are an economic asset as much as a functional element. Well-designed streets generate higher revenues for businesses and higher values for homeowners.[1]



Streets Can Be Changed

Transportation engineers can work flexibly within the building envelope of a street. This includes moving curbs, changing alignments, daylighting corners, and redirecting traffic where necessary. Many city streets were built or altered in a different era and need to be reconfigured to meet new needs. Street space can also be reused for different purposes, such as parklets, bike share, and traffic calming.

Design for Safety

In 2012 in the U.S., over 34,000 people were killed in traffic crashes, which were also the leading cause of death among children aged 5–14. These deaths and hundreds of thousands of injuries are avoidable. Traffic engineers can and should do better, by designing streets where people walking, parking, shopping, bicycling, working, and driving can cross paths safely.

Streets Are Ecosystems

Streets should be designed as ecosystems where man-made systems interface with natural systems. From pervious pavements and bioswales that manage storm- water run-off to street trees that provide shade and are critical to the health of cities, ecology has the potential to act as a driver for long- term, sustainable design.

Act Now!

Implementing projects quickly and using low-cost materials helps inform public decision making. Cities across the U.S. have begun using a phased approach to major redesigns, where interim materials are used in the short term and later replaced by permanent materials once funding is available and the public has tested the design thoroughly.

Lane widths of 10 feet are appropriate in urban areas and have a positive impact on a street's safety without impacting traffic operations.

DISCUSSION

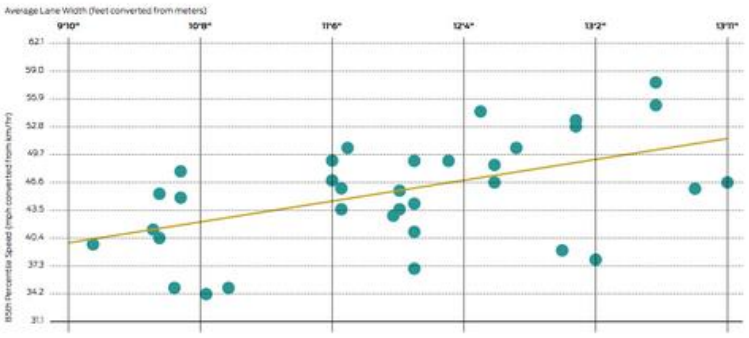
Travel lanes are striped to define the intended path of travel for vehicles along a corridor. Historically, wider travel lanes (11–13 feet) have been favored to create a more forgiving buffer to drivers, especially in high-speed environments where narrow lanes may feel uncomfortable or increase potential for side-swipe collisions.

Lane widths less than 12 feet have also historically been assumed to decrease traffic flow and capacity, a claim new research refutes.[1]

+ More Info

The relationships between lane widths and vehicle speed is complicated by many factors, including time of day, the amount of traffic present, and even the age of the driver. Narrower streets help promote slower driving speeds which, in turn, reduce the severity of crashes. Narrower streets have other benefits as well, including reduced crossing distances, shorter signal cycles, less stormwater, and less construction material to build.

Wider travel lanes are correlated with higher vehicle speeds.



"As the width of the lane increased, the speed on the roadway increased... When lane widths are 1 m (3.3 ft) greater, speeds are predicted to be 15 km/h (9.4 mph) faster."

Chart source: Fitzpatrick, Kay, Paul Carlson, Marcus Brewer, and Mark Wooldridge. 2000. "Design Factors That Affect Driver Speed on Suburban Streets." *Transportation Research Record* 1751: 18–25.

Wider travel lanes are correlated with higher vehicle speeds.

For multi-lane roadways where transit or freight vehicles are present and require a wider travel lane, the wider lane should be the outside lane (curbside or next to parking). Inside lanes should continue to be designed at the minimum possible width. Major truck or transit routes through urban areas may require the use of wider lane widths.

Lane widths of 10 feet are appropriate in urban areas and have a positive impact on a street's safety without impacting traffic operations. For designated truck or transit routes, one travel lane of 11 feet may be used in each direction. In select cases, narrower travel lanes (9–9.5 feet) can be effective as through lanes in conjunction with a turn lane.[2]

Design Speed

Speed plays a critical role in crashes and the severity of their outcomes. Traditional street design was grounded in highway design principles that forgive driver error and accommodate higher speeds. This approach based the design speed and posted speed limit on 85th percentile speeds —how fast drivers are actually driving—rather than how fast drivers ought to drive. By designing for a faster set of drivers, crashes increase and drivers actually traveling the speed limit are put at risk.

This passive use of design speed accommodates, and indirectly encourages, speeding by designing streets that account for the worst set of drivers and highest potential risks. Higher design speeds, moreover, degrade city streets and walkable neighborhoods by mandating larger curb radii, wider travel lanes, guardrails, streets with no on-street parking, and generous clear zones.

- Speed Reduction Mechanisms

DISCUSSION

Lowering injuries and fatalities remains a crucial goal for our cities. In 2011, 4,432 pedestrians were killed and 69,000 injured in motor vehicle crashes, according to the National Highway Traffic Safety Administration (NHTSA). Of the fatalities, 73% occurred in urban areas. This equates to 146 people killed or injured in cities everyday.

To counteract these gruesome and unnecessary injuries and fatalities, cities should utilize speed control mechanisms that influence behavior, lower speeds, and in turn, reduce injuries and fatalities. Embracing a proactive design approach on new and existing streets with the goal of reducing speeds "may be the single most consequential intervention in reducing pedestrian injury and fatality."[1]

Speed plays a critical role in the cause and severity of crashes. There is a direct correlation between higher speeds, crash risk, and the severity of injuries.[3]

SPEED (MPH)	STOPPING DISTANCE (FT)*	CRASH RISK (%)†	FATALITY RISK (%)†
10–15	25	5	2
20–25	40	15	5
30–35	75	55	45
40+	118	90	85

* Stopping Distance includes perception, reaction, and braking times.
† Source: Traditional Neighborhood Development: Street Design Guidelines (1999), ITE Transportation Planning Council Committee 5P-8.

Driving Speed Fatality Risk Chart
Click to enlarge

On city streets, designers should select a design speed to use in geometric decisions based on safe operating speeds in a complex environment.

Higher design speeds often mandate larger curb radii, wider travel lane widths, on-street parking restrictions, guardrails, and clear zones. Lower design speeds reduce observed speeding behavior, providing a safer place for people to walk, park, and drive.

Conventional Highway Design:

Operating Speed = Design Speed = Posted Speed

Proactive Urban Street Design:

Target Speed = Design Speed = Posted Speed

Mass differential between street users results in more severe injuries to the lighter of the two colliding bodies.

Bus
24,000 lbs

Car
2,000 lbs

Cyclist/ Pedestrian
30–250 lbs

the planning and visualization techniques described above are available to assess the effectiveness of these project elements. Additionally, environmental monitoring and modeling techniques for noise, vibration, and air quality can be helpful.

- **Accessibility** – The federal Americans with Disabilities Act requires that public entities such as the Commonwealth and municipalities provide accessible sidewalks and curb cut ramps. Access features are an important part of any MassHighway project that includes pedestrian facilities.

3.6 Speed

Speed is an important factor considered by travelers in selecting a transportation mode or route. Speed can also influence the physical characteristics of the transportation infrastructure. Many design elements such as horizontal and vertical curvature and superelevation are directly related to speed. Other features, such as lane and shoulder width, and the width of the roadside recovery clear zones for errant vehicles, can vary with, but are not a direct function of the design speed.

The objective in the planning and design of a roadway is to determine a speed that is appropriate for the context (as described in Section 3.2), results in a safe facility for all users, is consistent with the community's goals and objectives for the facility, and meets user's expectations. Once an appropriate speed is selected, the designer needs to tailor design elements to that speed.

Speed is defined as the distance traveled by an object in a certain period of time. Speed is commonly expressed in miles-per-hour or feet-per-second in the context of transportation planning and design. Several measures and characteristics of speed are important to understand when designing a roadway, as described in the following sections. These measures are most often used to describe motor vehicle operations, although they are also applicable to pedestrian and bicycle movement.

3.6.1 Speed Limits

Speed limits in Massachusetts are determined in accordance with Section 17 and Section 18 of Chapter 90 of the Massachusetts General Laws. Speed limits are established in one of two ways:

- Section 18 addresses how ***posted speed limits*** are established. The posted speed limit is generally determined based on an evaluation of the observed operating speeds according to the criteria in the *Manual on Uniform Traffic Control Devices*. (The current accepted practice is to establish the posted speed based on existing speed information. The posted speed should be the speed at which the majority of existing motorists are traveling at or below.)
- Section 17 defines ***"reasonable and proper" speed limits*** for roadways not otherwise posted. For these roadways, the speed limit is as follows:
  - 50 mph on a divided highway outside of a thickly settled district or a business district;
  - 40 mph on any other roadway outside of a thickly settled district or a business district; and
  - 30 mph within a thickly settled district or a business district.

According to Chapter 90 of the Massachusetts General Laws, a "thickly settled district" is an area in which houses or buildings are, on average, less than 200 feet apart for a distance of one-quarter mile or more.

3.6.2 Motor Vehicle Running Speed

Running speed characterizes the time necessary to travel a predetermined distance along a roadway (incorporating both time while moving and stopped delays). Measures of running speed can vary substantially by day of week and time of day based on traffic conditions. Average running speed is usually used to characterize conditions on a roadway for analytical (planning, route selection, air quality analyses, etc.) purposes rather than for the design of roadway geometrics.

3.6.3 Motor Vehicle Operating Speed

Operating speed is the measured speed at which drivers are observed operating their vehicles in fair weather during off-peak hours. Operating speed is measured at discrete points along a roadway. Operating speeds are usually reported using percentile speeds with the 50^{th} percentile (average) and 85th percentile (the speed at which 85 percent of vehicles are traveling at or below) speeds are often used to characterize the operating speed on a roadway.

The roadway's features such as curves and topography, width, access to adjacent properties, presence of pedestrians and bicyclists, parking, traffic control devices, lighting, etc., affect the operating speed. During

peak periods, when traffic congestion or intersection operations are controlling movement along a corridor, observed operating speeds may be substantially lower than the operating speed measured during off-peak conditions when the roadway's design and context are controlling speed. Numerous studies have indicated that drivers will not significantly alter what they consider to be a safe operating speed, regardless of the posted speed limit unless there is constant heavy enforcement.

3.6.4 Target Speed for Motor Vehicles

The ***target speed*** is the desired operating speed along a roadway. The appropriate target speed is determined early in the project development process, and should consider:

- The context of the roadway including area type, roadway type, and access control;
- The volume, mix, and safety of facility users; and
- The anticipated driver characteristics and familiarity with the route.

The designer should balance the benefits of high speeds for long-distance, regional motor vehicle travel with environmental, community, right of way, and cost constraints. When high speeds are selected, the designer should also include design elements to maintain the safety of pedestrians and bicyclists, as described in Section 3.6.7.

3.6.5 Selecting Motor Vehicles Design Speed

Design speed is the selected speed used to determine various geometric features of the roadway. The design speed should be a logical one with respect to the target speed and existing operating speed. When selecting a design speed, understanding the existing operating speed and target speed addresses: (1) the need to meet the expectations of drivers based on the roadway environment, and (2) the ways in which the setting influences the desired speed.

It is important to understand the inter-relationship between speed and roadway geometry. Selection of a design speed influences the physical geometrics of the roadway. Similarly, the physical geometrics of the roadway are important determinants of the operating speeds that will result on the facility.

Typically, the higher the functional classification, the higher the design speed. Exhibit 3-7 provides recommended ranges of values; however, where significant constraints are encountered, other appropriate values may be employed. The relatively wide range of design speeds recognizes the range of roadway types, context, and topography. The provision of a range in design speeds, combined with general guidance on selection of a design speed as noted above, represents perhaps the greatest flexibility afforded the designer. Designers should exercise judgment in the selection of an appropriate design speed for the particular circumstances and conditions. In general, an appropriate design speed should be within approximately 5 mph of travel speeds.

When determining the appropriate design speed the designer should also consider the volumes and composition of the expected non-vehicular and vehicular traffic, the anticipated driver characteristics, and driver familiarity with the route. The designer should consider expected operations throughout the day, including both peak and non-peak hours. Indeed, non-peak traffic flow will generally control the selection of a reasonable design speed. The design speed may vary for any given route as it traverses rural, suburban, and urban areas.

Once these factors have been evaluated and an appropriate design speed determined, the geometric elements should be designed consistently to that level. The designer should document the factors leading to the selection of an appropriate design speed. This documentation is particularly important for selected design speeds below the existing posted speed limit, below the “reasonable and proper” speed for the type of roadway and area as discussed in Section 3.6.1, or below the measured operating speed. Where it is not possible to meet the selected design speed for one location or design element along a corridor, a design exception and appropriate warning signage may be justified, as discussed later in this section.

Exhibit 3-7
Design Speed Ranges (Miles per Hour)

	Roadway Type					
		Arterials		Collectors		Local
Area Type	Freeway	Major*	Minor	Major	Minor	Roads
Rural Natural	50 to 75	40 to 60*	35 to 60	30 to 60	30 to 55	20 to 45
Rural Developed	50 to 75	40 to 60*	35 to 60	30 to 60	30 to 55	20 to 45
Rural Village	N/A	30 to 45	30 to 40	25 to 40	25 to 35	20 to 35
Suburban Low Intensity Development	50 to 75	30 to 60*	30 to 55	30 to 55	30 to 55	20 to 45
Suburban High Intensity Development	50 to 75	30 to 50*	30 to 50	25 to 50	25 to 40	20 to 40
Suburban Town Center	N/A	25 to 40	25 to 40	25 to 40	25 to 35	20 to 35
Urban	50 to 75	25 to 50	25 to 40	25 to 40	25 to 35	20 to 35

N/A Not Applicable
* A higher design speed may be appropriate for arterials with full access control
Source: Adapted from A Policy on Geometric Design of Highways and Streets, AASHTO, 2004 – Chapter 3 Elements of Design

Higher design speeds impose greater challenges and constraints on designers. Designers faced with difficult or constrained conditions may consider selecting a lower design speed for an element or portion of the highway. This practice can cause problems in that a large number of drivers may not "behave" as the designer desires or intends them to. Designs based on artificially low speeds can result in inappropriate geometric features that violate driver expectations and degrade the safety of the highway. The emphasis should be on the consistency of design so as not to surprise the motorist with unexpected features. Therefore, the design speed should only be based on the speed limit if the speed limit is consistent with existing operating speeds or physical constraints of the built environment.

Designers should not propose an alternative design speed for a highway or segment of a project as a design exception. A serious fundamental problem with accepting or allowing a design exception for design speed is based on its importance relative to all features of the highway. A reduction in the design speed may be unlikely to affect overall operating speeds. It will potentially result in the unnecessary reduction of all of the speed-related design criteria rather than just the one or two features that led to the need for the exception. The acceptable alternative approach to a design speed exception is to evaluate each geometric feature individually, addressing exceptions for each feature within the context of the appropriate design speed.

Occasionally, projects retain geometric elements, such as tight curves, superelevation, or restricted sight distances that are designed for a speed lower than the design speed for the corridor. This may be due to adjacent land use, or to environmental or historic constraints. In these cases, the designer should recommend a posted speed consistent with the geometric features. Where it is desirable to maintain a higher consistent speed throughout a corridor, the designer should install appropriate cautionary signing at locations with design elements that do not meet the criteria for the posted speed.

3.6.6 Design Speed and Traffic Calming

The term traffic-calming refers to a variety of physical measures to reduce vehicular speeds primarily in residential neighborhoods. The lowering of operating speeds is often the appropriate solution to addressing safety problems. Such problems typically involve vehicle conflicts with pedestrians, bicyclists, and school children.

Research has shown that measurable reductions in operating speeds are possible through traffic-calming. A local road or street, and in some instances other roadways that function as a local road or street, may have an existing operating speed far in excess of the speed limit or the target speed. In these cases it may be acceptable, and consistent with good engineering practice, to develop a design that will lower the operating speed.

Generally, the design speed selected for traffic calming elements should be consistent with the target speed for the corridor as a whole. The traffic calming elements should not result in operating speeds substantially lower than the target speed at certain points along the corridor and higher speeds elsewhere. Selection of a reasonable design speed for traffic calming elements, selection of type of elements, and the spacing of traffic calming elements can help achieve the desired uniform reduction in operating speed along a roadway.

Great care must be exercised to ensure that the proposed design will actually reduce the operating speeds to levels consistent with the design. The burden is on the individual designer of a traffic-calming feature to document a reasonable expectation that the proposed measures will reduce the operating speed. Once traffic calming has been implemented, monitoring of the performance of the project should be undertaken to assure that speeds have indeed been reduced, and to provide valuable lessons for future traffic-calming

projects. Chapter 16 provides more detail on tools and techniques for traffic calming.

3.6.7 High Speeds and Safety for Pedestrian and Bicyclists

In every case, the designer should seek to maintain or improve safety for all user groups. Safety is often measured both in terms of the likelihood of a crash and the expected severity of a crash. As motor vehicle speeds increase, the severity of crashes between motor vehicles and bicycles or pedestrians increases. In the high speed environment, safety for pedestrians and bicyclists can be enhanced by reducing the exposure of bicyclists and pedestrians to motor vehicle traffic, thereby reducing the likelihood of crashes.

Along roadway segments, greater separation of motor vehicle and non-motorized users can be provided by including shoulders, bicycle lanes, or buffered sidewalks. These design elements are explored in more detail in Chapter 5. At crossings, the exposure of bicyclists and pedestrians to high speed motor vehicle traffic can be mitigated through signal-controlled crossings, grade separation, and installation of crossing islands or medians. These measures are explored in Chapters 6 and 16.

3.6.8 Selecting Bicycle Design Speed

Bicycle design speed is also an important consideration. In most cases, the design speed for bicycles is no more than 20 mph; thus, for on-road travel, the design speed chosen for motor vehicles appropriately accommodates bicycles. Shared use paths should be designed for a selected speed that is at least as high as the preferred speed of the faster bicyclists. Current practice suggests a design speed of 20 mph for bicyclists. (Although bicyclists can travel faster than this, to do so would be inappropriate for this type of shared use setting.) Design and traffic controls can be used to deter excessive speed and encourage faster bicyclists to use the roadway system; however, lower design speeds should not be selected to artificially lower user speeds. When a downgrade exceeds four percent, or where strong prevailing tailwinds exist, a design speed of 30 mph is advisable. Downgrades in excess of six percent should be avoided on shared use paths.

On unpaved paths, where bicyclists tend to ride more slowly, lower design speeds of 15 mph for most conditions, and 20 mph where there are grades, are appropriate.

3.6.9 Selecting Pedestrian Design Speed

Much like other roadway users, the speed at which people walk varies considerably; however, walking speed usually does not have a substantial influence on the geometric design of roadways. A critical exception to this is the pedestrian's influence on the design of intersections and crosswalks, and the timing of traffic signals. The choice of walking speed for intersections and traffic signal design is discussed in the *Manual on Uniform Traffic Control Devices (MUTCD)* and is further discussed in Chapter 6.

3.7 Sight Distance

Sight distance is the length of roadway ahead that is visible to the roadway user. In most cases, specific sight distance measures apply to motor vehicles and bicyclists. The four following aspects are commonly discussed for motor vehicle sight distance:

- Stopping sight distance,
- Passing sight distance,
- Decision sight distance, and
- Intersection sight distance.

All of these sight distances are related to the design speed of the roadway. The designer should refer to AASHTO's *A Policy on Geometric Design of Highways and Streets* for detailed information for the use and calculation of sight distances.

3.7.1 Stopping Sight Distance

The provision of adequate *stopping sight distance* (SSD) is a critical sight distance consideration for design and is described in more detail below.

3.7.1.1 Motor Vehicle Stopping Sight Distance

Stopping sight distance is the distance necessary for a vehicle traveling at the design speed to stop before reaching a stationary object in its path. The sight distance at every point along a roadway should be at least the stopping sight distance. Exhibit 3-8 provides stopping sight distances for a range of design speeds and grades.

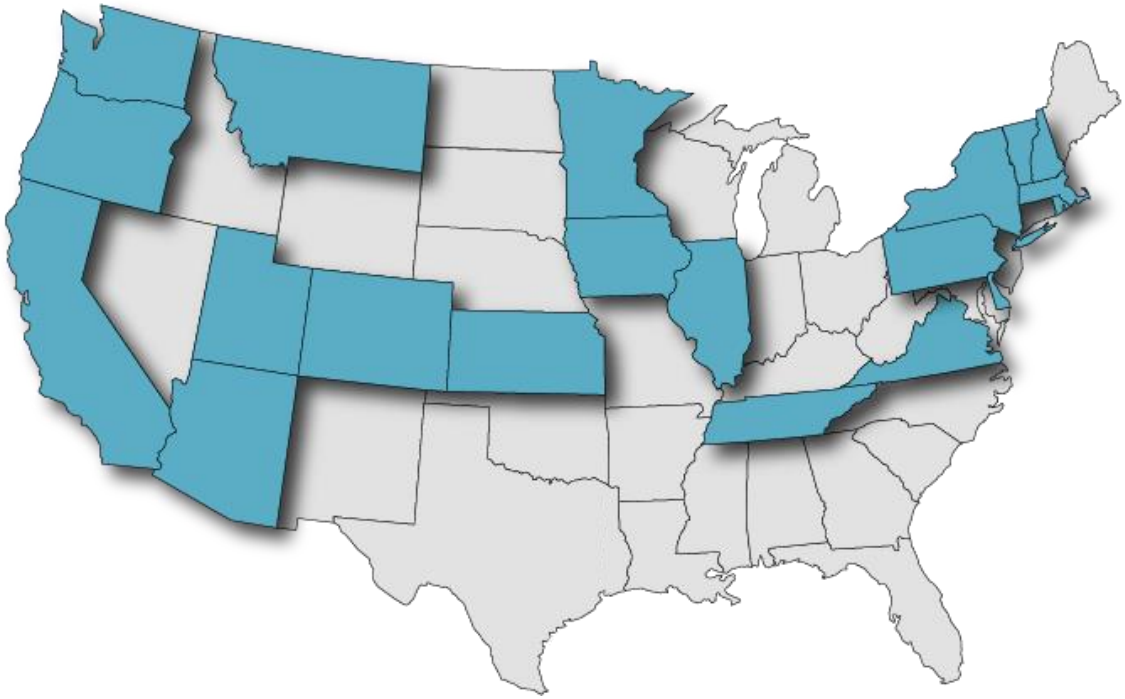
State
Smart Transportation
Initiative

Practical Solutions to Move America Forward

Improving access to destinations with TDM and "Big Data" analysis

Eric Sundquist, SSTI
Laura Schewel, StreetLight Data
May 20, 2015

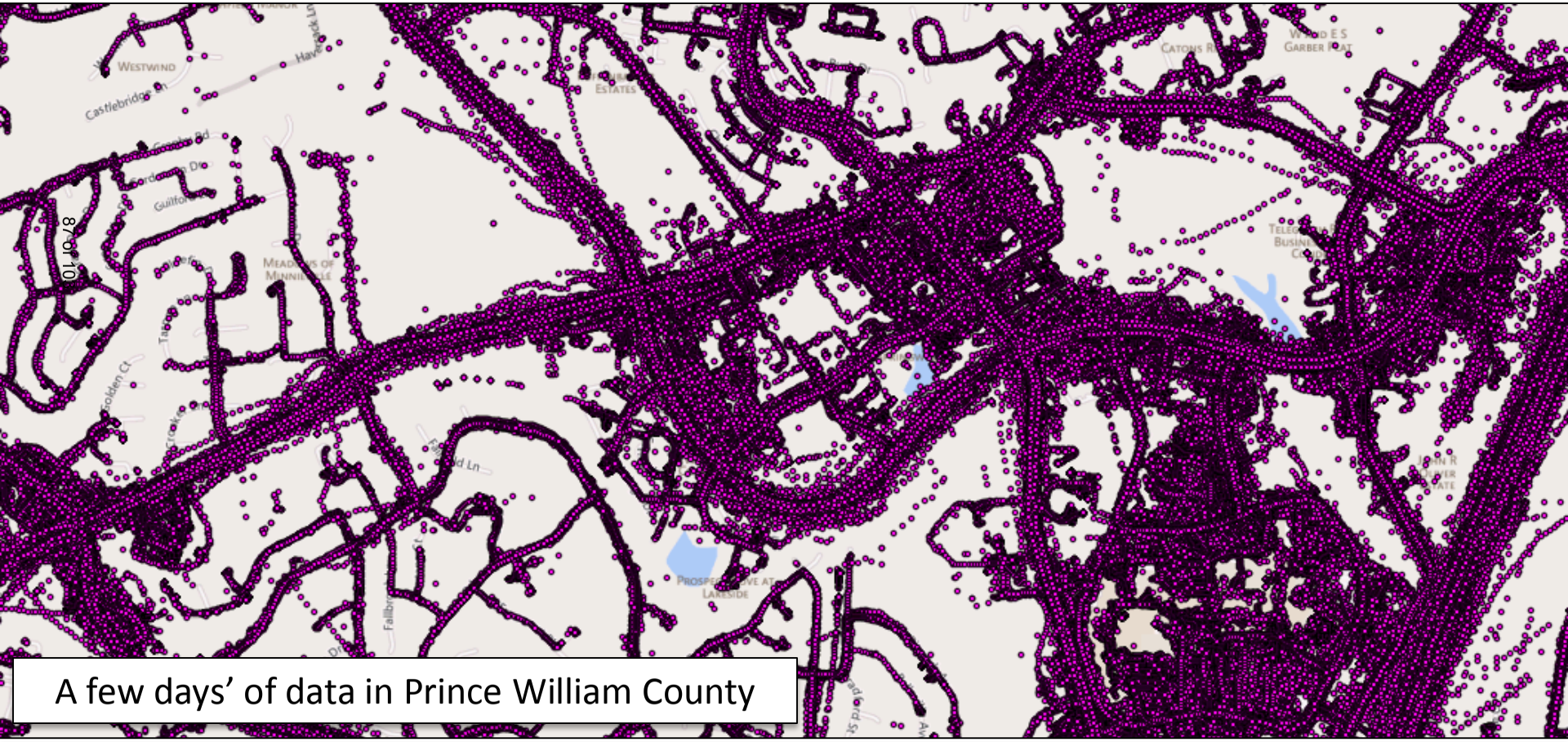
SSTI



The State Smart Transportation Initiative promotes transportation practices that advance environmental sustainability and equitable economic development, while maintaining high standards of governmental efficiency and transparency.

StreetLight Data

We process anonymous, archival cellular and GPS data to understand how people actually move around cities and regions.



A few days' of data in Prince William County

Northern Virginia project

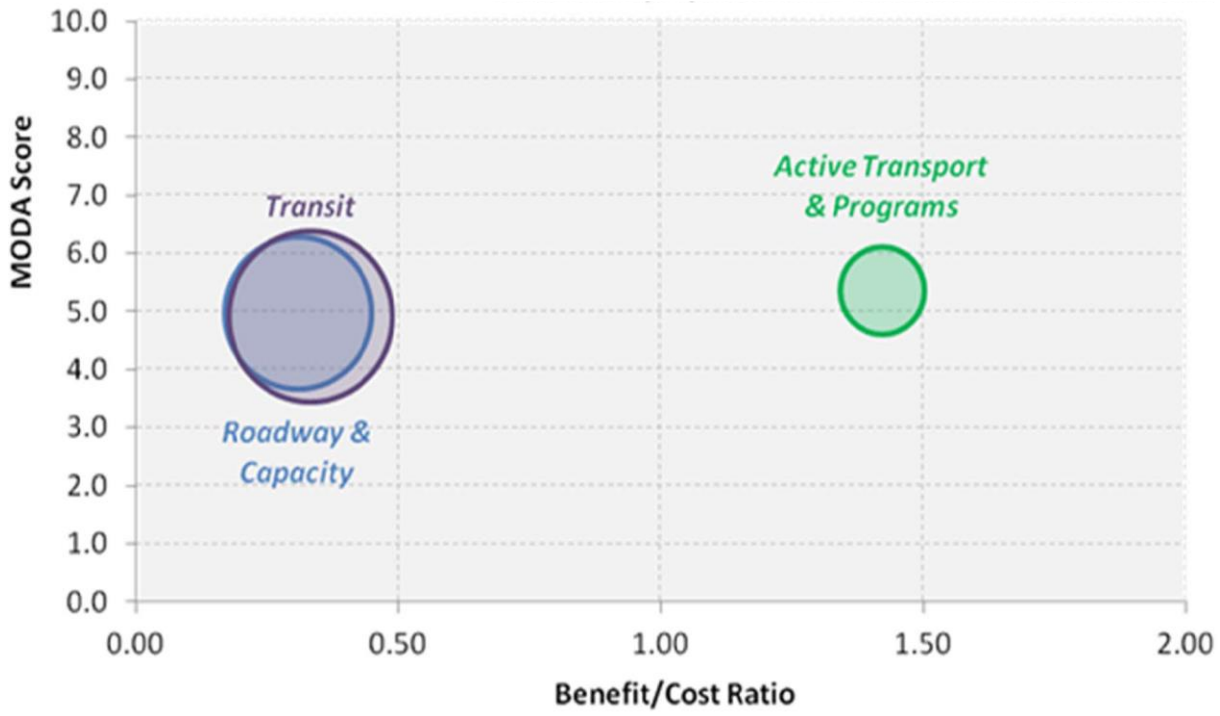
- Focus on demand-side
  - Complements other work on big transit/highway capacity
- Focus on accessibility
  - Considers trip-making rather than just speed
- Focus on personal trip-making
  - Short and long trips have equal utility
- Rely on “big data”-driven analytics
  - For origin-destination, travel time, circuitousness, reliability, etc.
- Use data as integral part of extensive stakeholder outreach
  - Visualizations, prioritization, iterative feedback from community
- Deadline: September 2015

Discussion today

- The Transportation Demand Management (TDM) opportunity
- How big data helps
- Anticipated results and co-benefits

Why focus on TDM?

- Supply solutions alone can be “free lunch.”
- Demand solutions, by themselves or in concert with capacity projects, can add efficiency to the system, more options for travelers – and are often much cheaper.



CH2M Hill,
Oregon DOT

What is TDM?

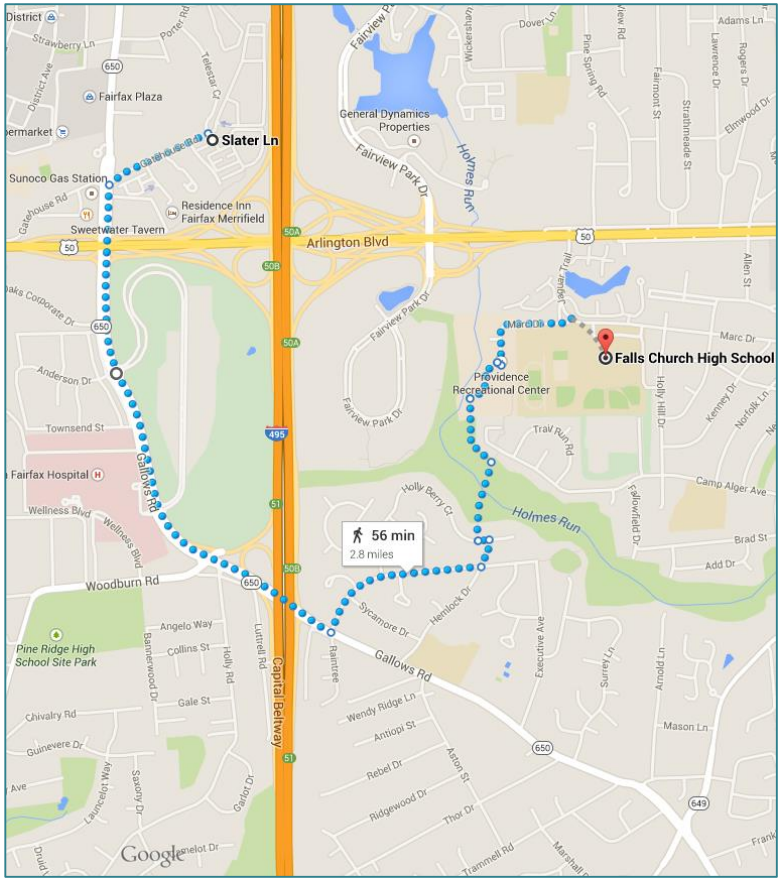
For the project purposes, solutions that involve demand side management, including:

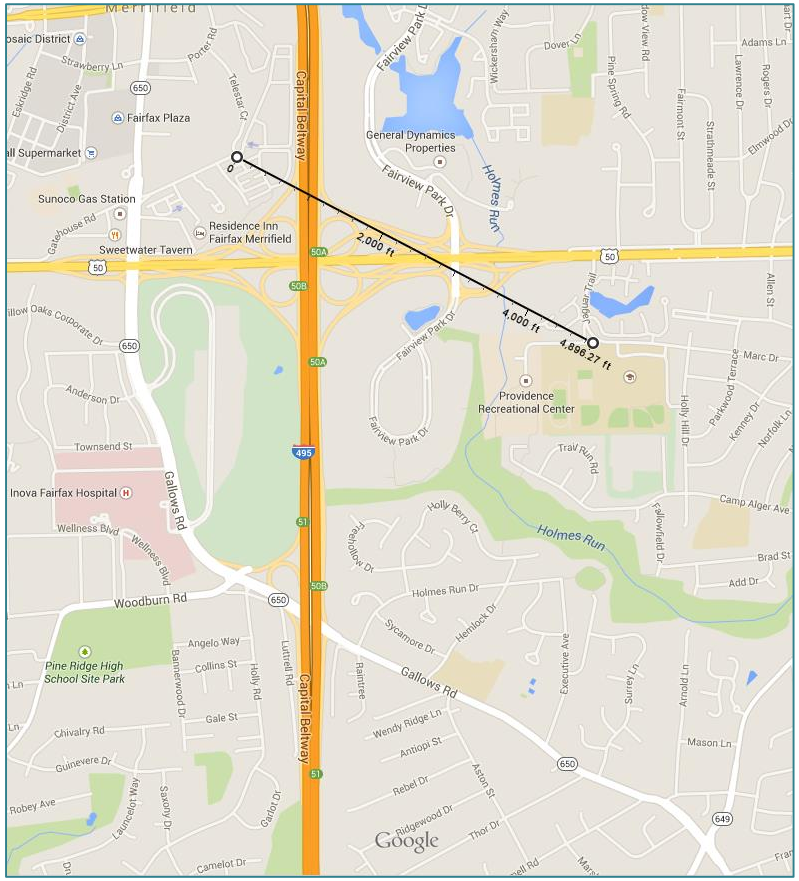
- Destination-based programs
- Connectivity
- First- and last-mile solutions

Destination-based programs

- "Conventional TDM"
  - Transit passes
  - Vanpools
  - Ride-matching
  - Bike lockers
  - Alternative work schedules
- Other measures
  - Parking availability and pricing
  - Sharing
  - Land use

Connectivity

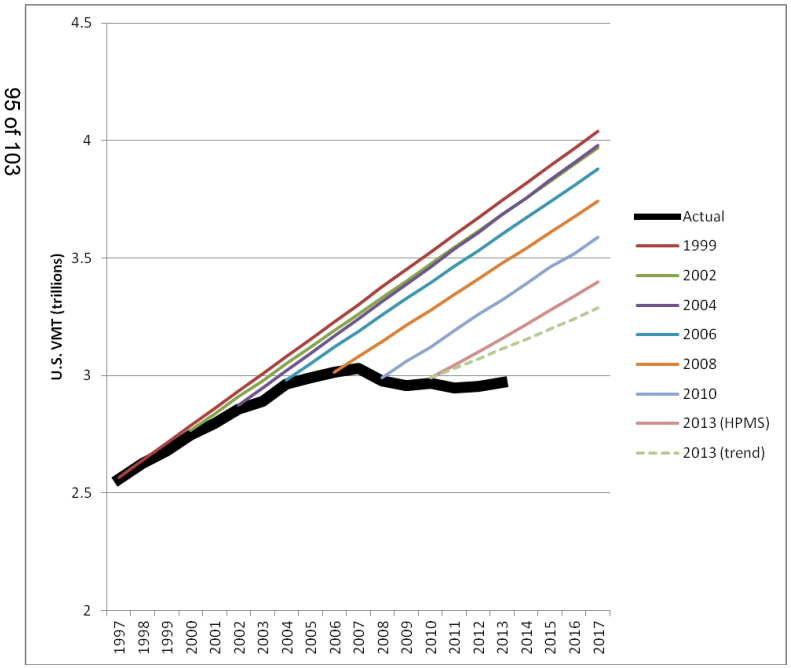




First- and last-mile solutions

Why are we doing this now?

- TDM undersupplied
- New methods allow for better analysis



Location	Internal-external	Internal	Through	Total
US 1 A	10,809	607	1,204	12,620
US 1 B	14,450	9,856	3,388	27,694
US 1 C	7,262	11,797	3,233	22,293
US 1 D	10,524	7,307	2,358	20,189
US 1 E	15,279	8,402	3,860	27,541
US 1 F	8,123	3,970	3,115	15,208
Average	**11,075**	**6,990**	**2,860**	**20,924**
Share of traffic	**52.9%**	**33.4%**	**13.7%**	**100.0%**

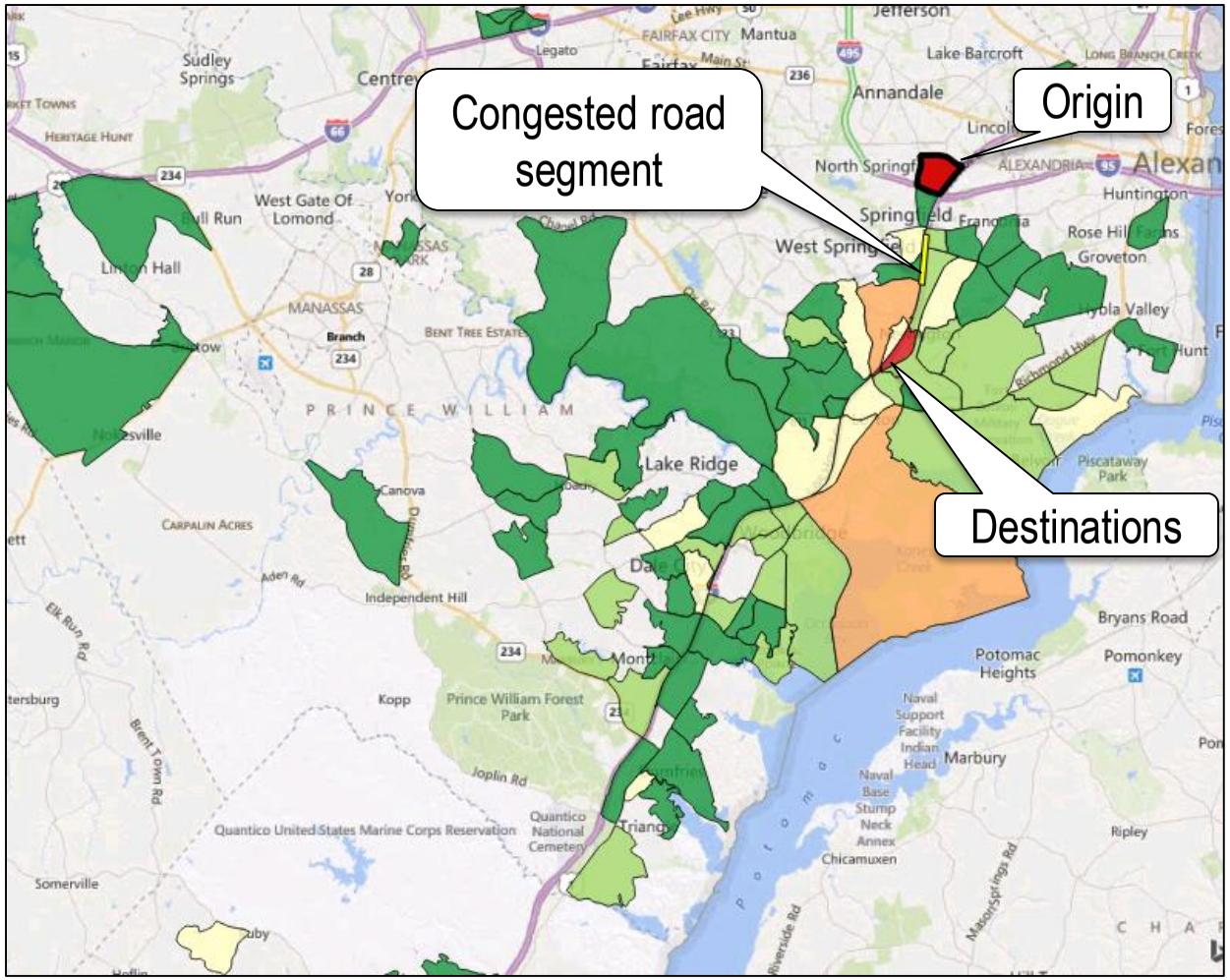
Goals of Big Data for TDM

- **Big Data IS NOT**
  - A robot that dictates policy and investment
  - A perfect forecaster of the future

- **Big Data IS**
  - A way to educate and communicate with stakeholders with visualizations and more
  - A way to improve the effectiveness of planners and policy makers:
    - Scan for problem areas, successful areas, and areas of opportunity
    - Suggest types of solutions
  - A way to measure the impact of actions

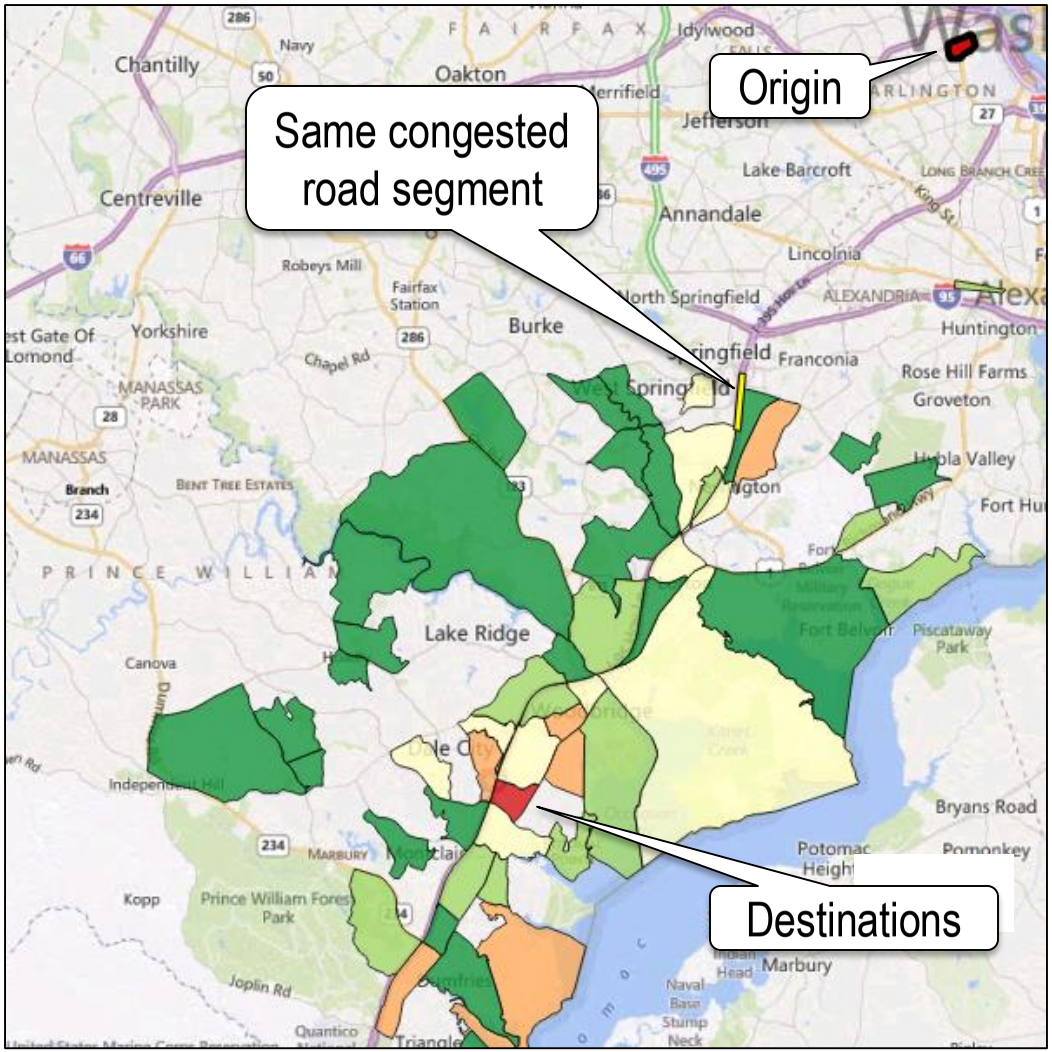
Example – Demand Solution

- This map shows some of the Origin/Destination pairs frequently used by people contributing to rush hour traffic jams on one segment of I95 SB.
- The red pair is a strong targets for Demand solutions. The trips are ~5km, opening up options for biking, circular shuttles, etc.



Example – Demand Solution

- This map shows another of the Origin/Destination pairs frequently used by people contributing to rush hour traffic jams on one segment of I95 SB.
- The red pair are very far apart from each other, pointing to solutions like employee van pools, utilization of transit options, etc.

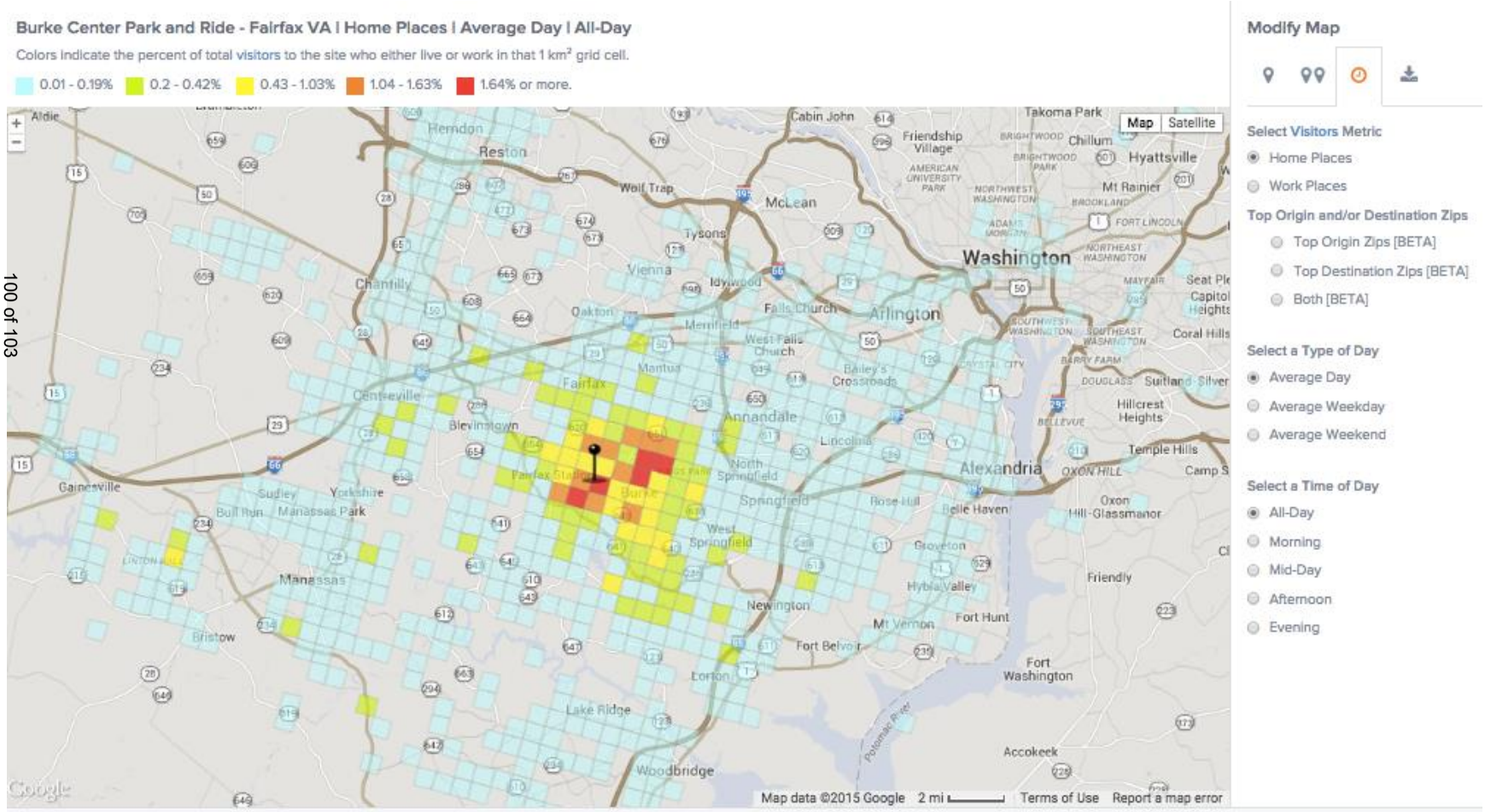


Example – Connectivity

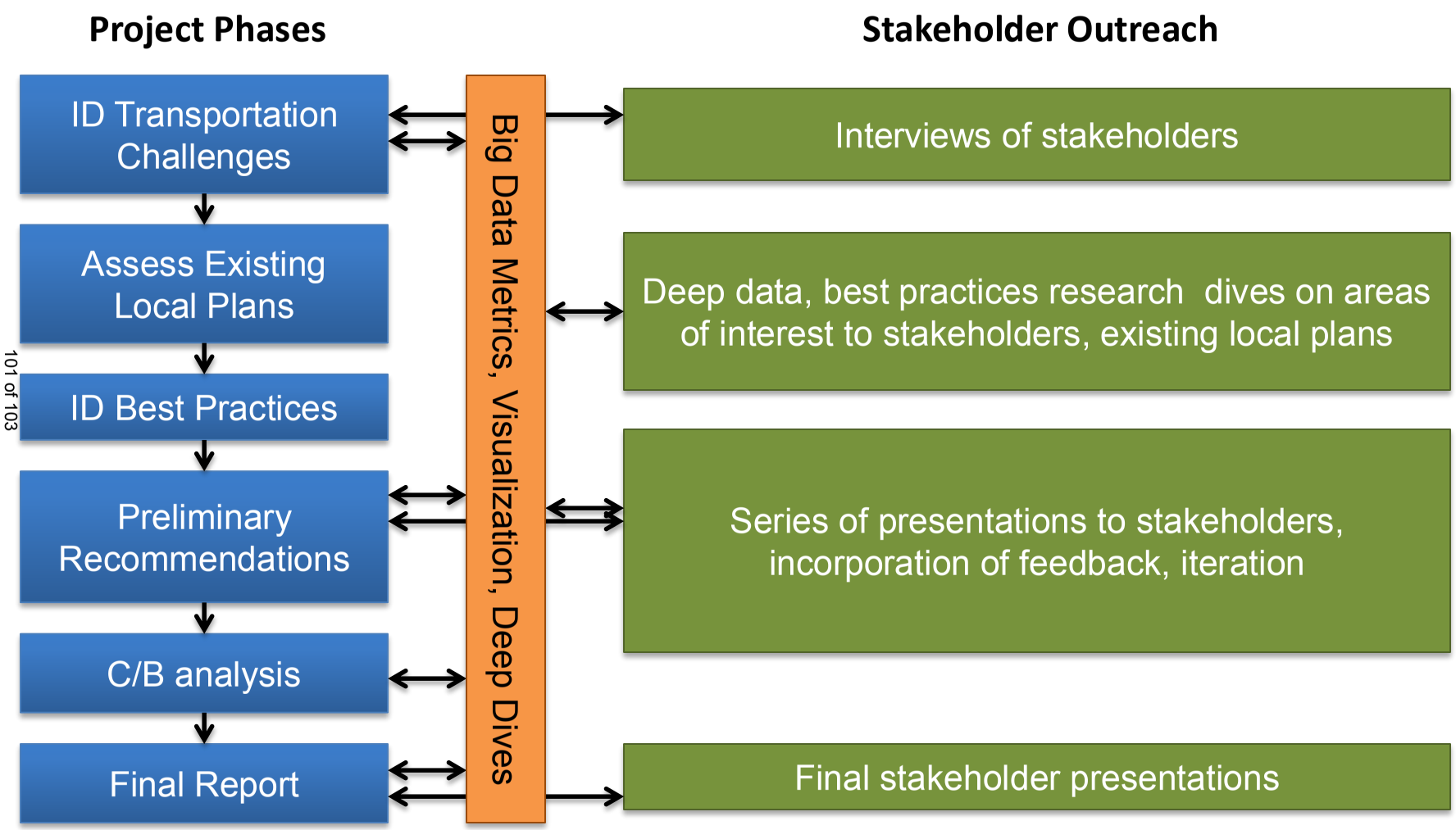
This map shows the average indirectness (or circuitousness) of trips on various road segments around Tyson's Corner. This Metric can help planners find locations where better connectivity, two-way streets, or easier parking my reduce driving and congestion.

Example – First/Last Mile Solution

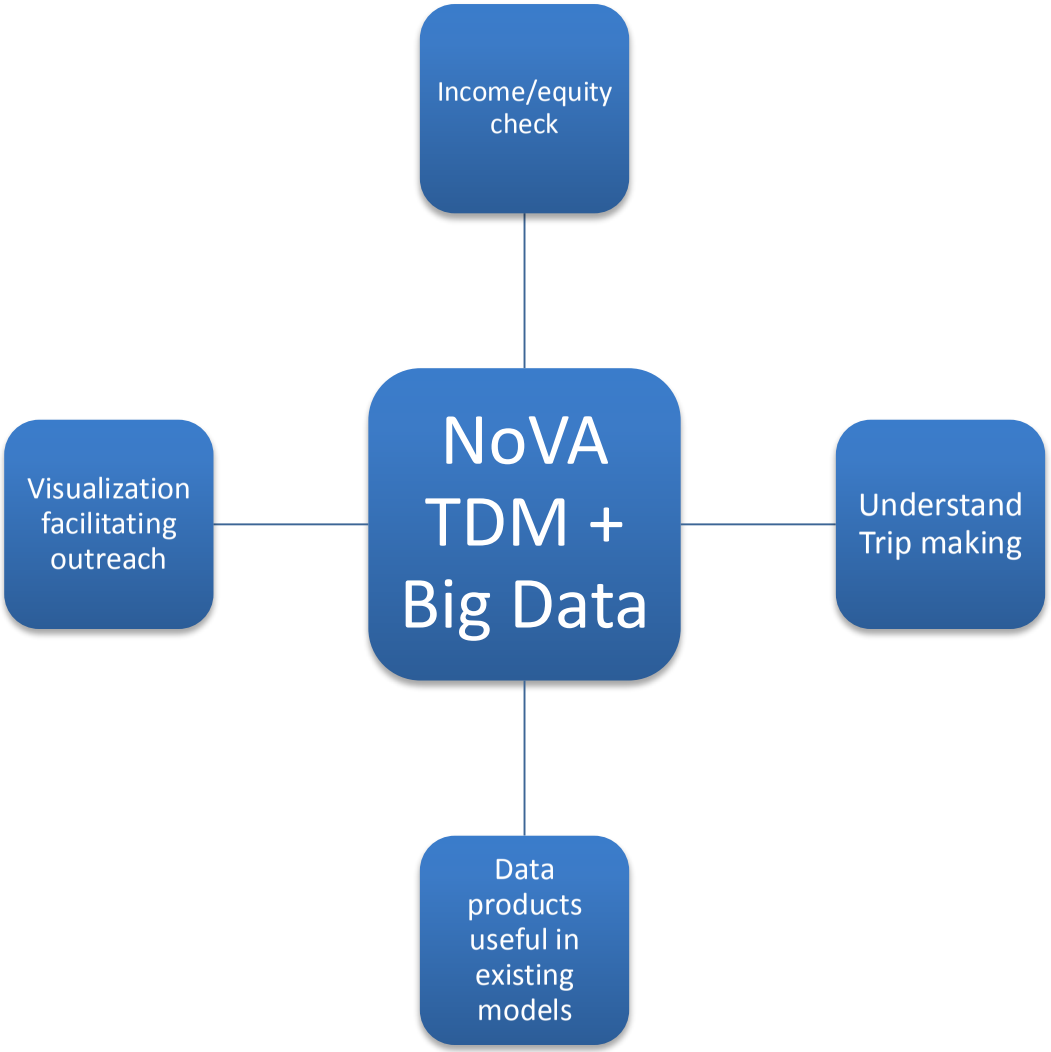
This image shows origination points for people using the Park-and-Ride at Burke Center and can help direct planning for options that improve service and mitigate excess parking demand.



Outreach Plan



Co-Benefits


Income/equity check
Visualization facilitating outreach
NoVA TDM + Big Data
Understand Trip making
Data products useful in existing models

US 36 Express Lanes Project Phase I

Overview

The US 36 Express Lanes Project is a multi-modal project led by the Colorado Department of Transportation (CDOT) and the Regional Transportation District (RTD) to reconstruct US 36 from Federal Boulevard to 88th Street in Louisville/Superior.

CDOT selected the Ames Granite Joint Venture team as the design-build contractor for the $317 million project, and they began construction in July 2012. The project will open to the public in 2015.

Project Details:

- Add an express lane in each direction of US 36 for Bus Rapid Transit (BRT), High Occupancy Vehicles (HOV) and tolled Single Occupancy Vehicles (SOV);
- Widen the highway to accommodate 12-foot-wide inside and outside shoulders;
- Replace the Wadsworth Parkway, Wadsworth Boulevard (at 112th Avenue), Lowell Boulevard and Sheridan Boulevard bridges, and the US 36 bridge over the Burlington Northern Santa Fe Railway.
- Add Bus Rapid Transit (BRT) improvements, including new electronic display signage at stations and bus priority improvements at ramps. The improvements also will allow buses to operate on the shoulders of US 36 between interchanges to decrease bus travel time;
- Install Intelligent Transportation Systems (ITS) for tolling, transit and traveler information, and incident management;
- Install a separate commuter bikeway along much of the corridor; and
- Improve RTD stations along the corridor, including new canopies with enhanced weather protection.