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**Standing Committee on the Environment**

**Improved Environmental Performance of Highway  
Maintenance**

**Final Report**

Prepared for  
AASHTO Standing Committee on the Environment

Prepared by  
Gary R. McVoy, Ph.D., Principal Investigator  
Parsons Brinckerhoff, Inc., Marie Venner and Mark Sengenberger

Washington DC, New York, and Denver

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SPECIAL NOTE: This report IS NOT an official publication of the National Cooperative Highway Research Program, Transportation Research Board, National Research Council, or The National Academies.

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Role	Name	Title	Affiliation
Chair	Mr. Timothy Hill	Administrator	Ohio DOT
Member	Mr. William R. Hauser	Administrator, Office of Stewardship & Compliance	New Hampshire DOT
	Mr. Jeff P. Heilman	Director of Environmental Planning	Parametrix
	Mr. Lacy Love	Director of Asset Management	North Carolina DOT
	Mr. Steven M. Lund	State Maintenance Engineer	Minnesota DOT
	Mr. Michael J. Markow	Consultant	
	Ms. Debra A. Nelson	Assistant to Director	New York State DOT
	Ms. Dianna Noble	Environmental Affairs Director	Texas DOT
	Mr. Steve Varnedoe	Associate Director	National Center for Pavement Preservation
FHWA Liaison	Ms. Connie Hill	Environmental Protection Specialist	FHWA

The project was managed by Nanda Srinivasan, NCHRP Senior Program Officer.

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## **ABSTRACT**

With the build-out of the National Highway System, the environmental footprint of DOT's and their ability to contribute to a sustainable society fall increasingly to maintenance and operations activities. This study found that DOT maintenance organizations have a strong environmental ethic and support sustainability precepts. However, as reflected in maintenance staffing, training, and management, the focus is on compliance. This report details these findings and offers links to information that DOT maintenance organizations can use in their continuing efforts to improve their environmental compliance, stewardship, and sustainability performance.

## **EXECUTIVE SUMMARY**

This report evaluates (a) how state DOTs are addressing existing environmental requirements and stewardship in their highway maintenance programs, (b) how personnel are trained so staff are aware of and understand compliance with environmental requirements, (c) stewardship policies and practices that are in place and how the notion of stewardship is engendered in the agency, and (d) how DOTs are measuring compliance and stewardship accomplishments through the use of comprehensive audits and assessments.

Three general methods were employed to achieve the research objectives:

1. A review of AASHTO's maintenance manual and other literature in order to develop a matrix of maintenance activities as related to environmental stewardship and sustainability,
2. A survey of state DOTs on how maintenance and environmental stewardship policies, procedures, and practices have been institutionalized; and
3. Detailed case studies of 10 states to study a range of practices.

In the United States, aside from widening and modernization improvements, most of the highway system is already built, placing increasing importance on its preservation and maintenance. While the ways in which transportation agencies preserve, maintain, and renew the current road system can have significant impacts on environmental quality and sustainability, the documentation of environmental performance resulting from current state DOT maintenance practices is incomplete regarding planning, management, and assessment.

With increasing acceptance of the precepts of sustainability as defined by the Brundtland Convention and Triple Bottom Line framework; it is becoming increasingly important to consider sustainability as related to highway maintenance.

The review of AASHTO-'s *Maintenance Manual for Roadways & Bridges, 4th ed.* and its comprehensive listing of maintenance activities with other literature and in particular the September 2004, NCHRP Project 25-25, Task 4 "Environmental Stewardship Practices, Procedures, and Policies for Highway Construction and Maintenance" led to the development of Tables A.1 and A.2 from which excerpts follow:

**Table A.1 Excerpt – Typical Maintenance Activities**

[1] Activity	[2] Examples of Selected Best Management Practices	[3] Examples of Some Potential Environmental Offsets	[4] Examples of Probable Environmental, Social, and Economic Benefits	[5] AASHTO Maintenance Manual for Roadways and Bridges (Links)	[6] AASHTO Compendium (Links)
<b>Traveled Way</b>		Energy usage in all cases, plus impacts noted below		2.1.2 Maintenance of Roadway Surfaces	5.0 Pavement, Materials, and Recycling
Sweep and vacuum roads and bridges	Remove dust and sediments from roadways and bridges	Air and water pollution, waste generation	Reduce impacts to water from sediment loading; improve air quality		10.10 Sweeping and Vacuuming Roads, Decks, Water quality Facilities, and Bridge Scuppers
Maintain pavement markings	Restore pavement stripes and markings	Air pollution, waste generation, hazmat disposal	Improve traveler safety		5.5 Pavement Marking
Patch deteriorated pavements	Cold patch potholes	Waste generation	Extend the pavement life; reduce waste and energy consumption		
Seal cracks and joints	Clean and fill cracks and joints	Waste, noise, dust and odor generation	Extend the pavement life; reduce waste and energy consumption		

**Table A.2 Excerpt –Triple Bottom Line Linkages**

(--) potential environmental impact

(+) potential for minimization, mitigation, or enhancement

(X) potential for material cost or benefit

Maintenance Activities	Environmental						Social			Economic		
	Air Resources	Water Resources	Noise Effects	Waste Reduction /Recycling	Wildlife Habitat	Energy Conservation & Efficiency	Access	Safety	Equity	Costs	Jobs	Mobility
<b>Traveled Way</b>												
Sweep and vacuum roads and bridges	--	+										
Maintain pavement markings	--							+				
Patch deteriorated pavements				+						X		
Seal cracks and joints				+						X		
Resurface pavements	--			+			X	X				X

As evident from the tables, maintenance activities on the existing highway system can and do have profound effects on the environment, and have bearing on a wide range of sustainability factors.

State DOT maintenance directors interviewed believe in an environmental ethic and are receptive to the Triple Bottom Line of Sustainability as it relates to the social and economic value of their work. Still, the realities of the typical maintenance situation dictate that there be a focus on compliance as a priority. As a rule, DOT maintenance organizations employ a formal hierarchical structure with clear lines of authority. Maintenance divisions within state DOT agencies focus on providing high-quality service within the limitations of budgetary constraints, and as stewards of the highway system, care for public property is central to the culture of maintenance. Judging from survey results and interview data, as stewards of public property; maintenance organizations are predisposed to acceptance of an environmental ethic

In keeping with this, DOTs have incorporated environmental priorities and guidance into mission statements and procedures while programming their activities in keeping with budgetary capacity. DOTs have also invested in environmental staffing for maintenance in a variety of creative ways, sometimes with mixed results. Typically, this includes tapping environmental specialists in other branches or divisions and, in a few cases, hiring dedicated environmental staff into maintenance.

Almost 90% of the 27 responding DOTs surveyed provide some form of environmental training specifically for maintenance and operation personnel. Links to particular offerings are provided in this report (Table A.3) as an aid to practitioners and an excerpt from the table follows. The preponderance of programs stress housekeeping, stormwater, and herbicide courses and training courses in such fields as ecology, wetlands, water quality, materials and waste management, and cultural resources, tend to be lacking.

**Table A.3 Excerpt – Maintenance Training by State**

State	Training Programs	Focus	Participants, Frequency and Methods	Training Links
California - Caltrans				
	General Housekeeping Training	Staff receives training on the importance of General Housekeeping BMPs and their relation to overall environmental compliance. New environmental requirements are incorporated into Division of Maintenance policy and training, the materials for which are revised as needed.	Training is delivered to the Maintenance Division's 3,600 employees by various means, including external resources and Division of Maintenance staff. New mandates that require immediate compliance are presented in Tailgate Meetings and a Maintenance Bulletin is prepared to provide information to Maintenance field supervisors. Staff members are required to receive classroom or on-line training on various minimum intervals depending on the type of training. In addition, Tailgate training sessions are held every two weeks or whenever there is a change in work activity.	<a href="http://www.dot.ca.gov/hq/env/stormwater/pdfs/maintain/m6_99.pdf">http://www.dot.ca.gov/hq/env/stormwater/pdfs/maintain/m6_99.pdf</a>  <a href="http://www.dot.ca.gov/hq/env/">http://www.dot.ca.gov/hq/env/</a>

As indicated by interviews, the most effective training approaches tend to be systematic, practical, and focused. On site, “just in time” training delivered by peers or experts who work in maintenance was deemed to be especially effective. Many states employ an annual cycle of environmental awareness training that addresses compliance. DOTs also note that “learnable, teachable moments” occur when specific comprehensive training is required as a result of an immediate violation.

Many DOTs base their environmental programs in maintenance around housekeeping at maintenance yards, water-quality permitting, pesticide management, spill prevention, and other statutory requirements. Annual audits for violations at yards are now common, but systematic management of “green assets” such as habitat and natural water-quality treatment capacity is rare. Table A.4 lists an array of these programs; and again, page 1 of the table is included here for convenience:

**Table A-4 Excerpt – Measuring Compliance, Stewardship Accomplishments and Metrics**

Program	Purposes	Audit/Self-Evaluation	Reporting Results
<b>California - Caltrans</b>			
<p>Caltrans' Integrated Maintenance Management System (IMMS) provides the principal accountability mechanism for the Division of Maintenance.</p>	<p>The Division of Maintenance has an audit of its activities conducted in the roadside environment and at yards and stations.</p>	<p>Environmental performance evaluations are conducted in accordance with The Maintenance Activities Compliance Review Plan at <a href="http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-05-999_99_2.pdf">http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-05-999_99_2.pdf</a> and the Maintenance Facilities Compliance Review Plan at <a href="http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-05-999_99_3.pdf">http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-05-999_99_3.pdf</a>. Each document contains the evaluation criteria.</p>	<p>The Division of Maintenance tracks its environmental compliance activities and generates the following databases. They're summarized and reported annually to the State Water Resources Control Board and other regulatory agencies.</p> <ul style="list-style-type: none"> <li>• Erosion Inventory Database,</li> <li>• Storm Drain System Inventory Database,</li> <li>• Illegal Connection/Illicit Discharge Database,</li> <li>• Pesticide Use Database,</li> <li>• Maintenance Facility and Activity BMP Implementation Database,</li> <li>• Facilities Pollution Prevention Plans (FPPPs) Database,</li> <li>• Training Database,</li> <li>• Level of Service (LOS) -- a performance-based system designed to measure progress on departmental goals.</li> </ul>

Figure 0.1, shown as follows and explained in more detail in the Case Study Section, connotes the state of environmental compliance, stewardship, and sustainability in Maintenance as derived from an analysis of information on attitudes, activities, training, and measurements as practiced by 10 leading state DOTs and detailed in this report. The levels of development depicted here represent a summation of full and partial point values used to characterize each topic area, i.e., Structure/Staffing/Ethic; Training/Communications; and Quality Assurance/Metrics.

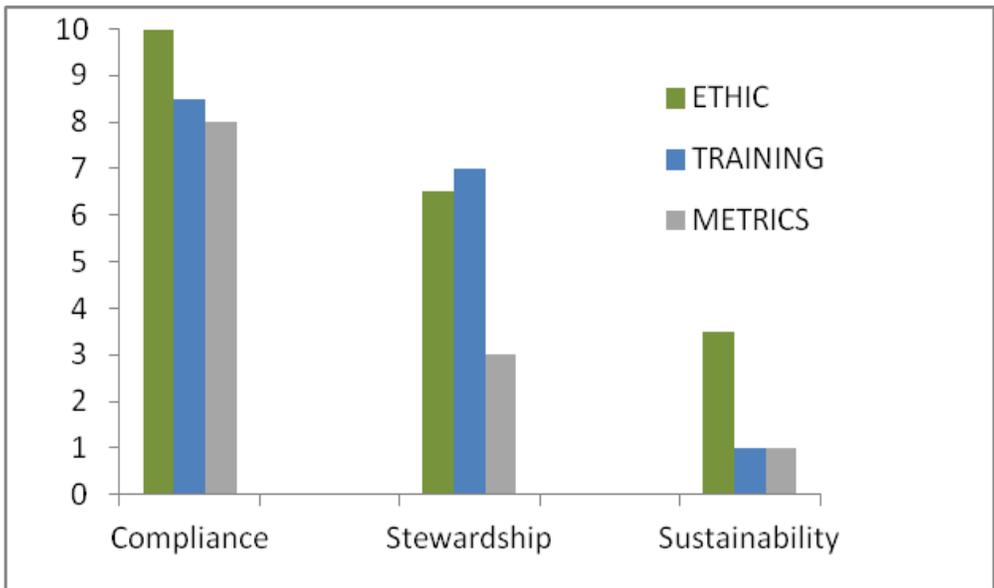


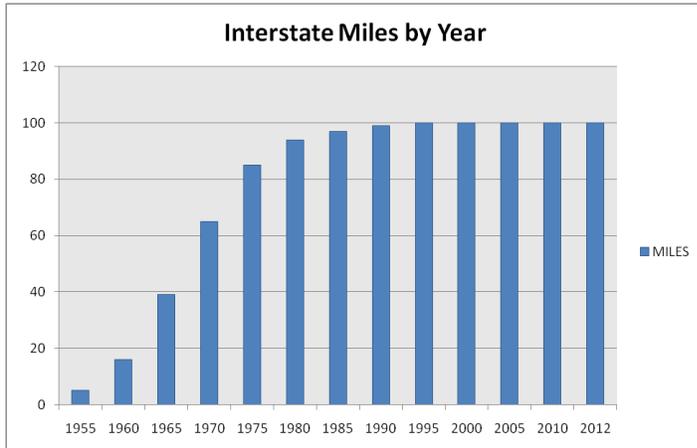
Figure 0.1: Environmental Compliance, Stewardship, and Sustainability

As one might expect, regulatory compliance is essentially universal, environmental stewardship (enhancement of the environment beyond compliance -- as practicable) is common, and sustainability in support of additional economic and social concerns is emerging. In all these areas, policy objectives seem to lead to training and then measurement as institutionalization progresses.

DOT Maintenance and Operations have a profound effect on the environment and their work is essential to the sustainability of society. With improved access to management tools and training, there are ample opportunities for further development. A clearinghouse for the types of tools and training resources described in this report could do much to facilitate progress.

## SECTION 1. INTRODUCTION

The US Interstate Highway System is essentially complete for the time being and has been for some 30 years.



From <http://www.publicpurpose.com/hwy-intmiles.htm>

Similarly, the National Highway System is growing at a rate of only about one quarter of one percent per year, according to USDOT statistics

<http://www.fhwa.dot.gov/policyinformation/statistics/2010/vmt422.cfm>.

Increasingly, attention is shifting to maintaining the system and preserving critical assets. While the “environmental footprint” of the system that underpins our economy and influences the shape of our communities, ranges over some 3.9 million lane miles on 5 million acres of right-of-way<sup>xxiv</sup> this right-of-way is also shared with utilities, streams, wetlands, habitats, cultural resources, and communities. Between the build out of the interstate highway system and an increase in environmental awareness, it is not surprising that DOTs are focusing more and more on managing and maintaining the existing infrastructure in support of a sustainable society. The

purpose of this report is to benchmark the current state of DOT maintenance activities as they relate to environmental stewardship and sustainability programs, awareness, training, and performance metrics; and to provide a convenient reference to facilitate the spread of successful practices across the country.

### **Some Legacy Transportation Systems and Utilities**

Transcontinental Road-Lincoln Highway- 1913 (Times Square, N.Y. to Lincoln Park, San Francisco)

Transcontinental Telephone-1915

Coast to coast fiber optics- 1980s

Coast to coast Interstate completed 1986

San Francisco to New York

Interstate System completed 1992

**Total U.S. Lane Miles = 3.9 million miles**

*From Mark Cacamis, VDOT, State Construction Engineer, August 2012 presentation to AASHTO Construction Subcommittee*

**In addition, many state DOTs maintain hundreds of thousands of acres of right-of-way** (e.g., Iowa DOT: 216,300 acres, MoDOT 385,000 acres).

**The National Highway System contains about five million acres of right-of-way nationwide**, and local and county roads may add another seven million acres managed by transportation agencies. These include important habitats and cultural and natural resources.

## Background

DOTs have been working to improve environmental practices for decades, from dealing with spills and creating wildlife crossings, to incorporating shingles and fly ash in pavement mixes. DOTs undertake maintenance activities while protecting water quality, recycling signs, and using retro-reflective sheeting to boost safety, and eliminate unnecessary lighting expenses. They maintain stormwater facilities, minimize salt application, install LED signals and are shifting to green products in rest areas, garages, and roadsides. These and many other practices are recorded in NCHRP 25-25/04, Environmental Stewardship Practices, Procedures, and Policies for Highway Construction and Maintenance<sup>xx</sup>; and NCHRP 25-25/60, Increased Use of Environmentally Preferable, Non-Toxic Products to Reduce Costs, Liabilities, and Pollution at DOT Offices, Maintenance and Operations Facilities and Rest Stops<sup>xv</sup>.

Recognizing that studies like these have already examined a broad range of existing environmental stewardship practices, procedures, and policies for highway construction and maintenance, Task 73 was intended to explicitly consider how state DOTs are assuring that maintenance operations are taking into account environmental requirements and stewardship in its process improvements, practices, and infrastructure investments.

Accordingly, this report examines how DOT maintenance managers and environmental leaders have adopted an environmental ethic, incorporated environmental stewardship, and are beginning to address sustainability in their policies, practices, training, and measurements. Additionally, it provides ready reference links to successful practices, effective tools, and information based on proven practices. As used in this document, the term “stewardship” means sensitive management and enhancement of the natural and cultural environment beyond regulatory compliance, “sustainability” refers to the “Brundtland Definition,” i.e., meeting the needs of the present without compromising the ability of future generations to meet their own needs; as reflected in the Triple Bottom Line of Environment, Economy, and Society.

### Study Method:

The study was conducted in three phases:

1. A review of AASHTO’s maintenance manual and other literature in order to develop a matrix of maintenance activities as related to environmental stewardship and sustainability
2. A survey of all DOTs,
3. Case-study interviews with 10 selected states.

## SECTION 2. LITERATURE REVIEW / MAINTENANCE ACTIVITIES

A literature review was conducted for this study to outline the basic factors to be addressed in this research, starting with the *AASHTO Maintenance Manual for Roadways & Bridges, 4th ed.*<sup>iii</sup> which lists many of the routine activities undertaken to preserve and operate our nation’s highway system. These activities were then keyed to the AASHTO Compendium of *Environmental Stewardship Practices, Procedures, and Policies In Maintenance and Construction (NCHRP 25-25/Task 04)*<sup>xx</sup> and Table A.1 was prepared as a cross-walk between these two documents to facilitate linkage between activities, impacts and best practices. This 13 page matrix of maintenance activities as related to environmental stewardship and sustainability is located in Appendix 1 and an excerpt follows:

**Table A.1 Excerpt – Typical Maintenance Activities**

[1] Activity	[2] Examples of Selected Best Management Practices	[3] Examples of Some Potential Environmental Offsets	[4] Examples of Probable Environmental, Social, and Economic Benefits	[5] AASHTO Maintenance Manual for Roadways and Bridges (Links)	[6] AASHTO Compendium (Links)
<b>Traveled Way</b>		Energy usage in all cases, plus impacts noted below		2.1.2 Maintenance of Roadway Surfaces	5.0 Pavement, Materials, and Recycling
Sweep and vacuum roads and bridges	Remove dust and sediments from roadways and bridges	Air and water pollution, waste generation	Reduce impacts to water from sediment loading; improve air quality		10.10 Sweeping and Vacuuming Roads, Decks, Water quality Facilities, and Bridge Scuppers
Maintain pavement markings	Restore pavement stripes and markings	Air pollution, waste generation, hazmat disposal	Improve traveler safety		5.5 Pavement Marking
Patch deteriorated pavements	Cold patch potholes	Waste generation	Extend the pavement life; reduce waste and energy consumption		
Seal cracks and joints	Clean and fill cracks and joints	Waste, noise, dust and odor generation	Extend the pavement life; reduce waste and energy consumption		

However, as touched on by column 4 of Table A.1 and described more fully in the literature, maintenance activities affect much more than the environment, and the industry is becoming ever more sensitive to the Triple Bottom Line of Sustainability Brundtland Commission report first defined sustainable development in 1987 as development “meets the needs of the present without compromising the ability of future generations to meet their own needs.”<sup>ii</sup>

AASHTO’s *Best Practices Background Paper on Transportation and Sustainability* for the *Sustainability Peer Exchange* defines sustainability as:

- An overarching conceptual framework that describes a desirable, healthy, and dynamic balance between human and natural systems.
- A system of policies, beliefs, and best practices that will protect the diversity and richness of the planet’s ecosystems, foster economic vitality and opportunity, and create a high quality of life for people.<sup>v</sup>

AASHTO has voiced strong support for both sustainability and a triple bottom line approach, as evidenced in both this report and statements by organizational leaders.

NCHRP Report 708 -- “A Guidebook for Sustainability Performance Measurement for Transportation Agencies”<sup>1</sup> presents an extensive treatment of sustainability precepts and metrics in transportation and in keeping with most literature embraces the concepts of equity between generations and differing groups within our society as reflected in the Triple Bottom Line of Environment, Economy, and Society. The report proposes sustainability performance metrics for maintenance and operations, as well as other DOT program areas.<sup>viv</sup>

Table 2.3 highlights the linkages between regular maintenance activities and potential environmental, social, and economic aspects; and begins to illustrate the scope and scale of DOT maintenance and operational impacts and benefits.

**Table 2.3: Effects of Maintenance Activities on Environmental, Social, and Economic Concerns**

Maintenance Activities	Environmental Aspects	Social Aspects	Economic Aspects
<b>Traveled Way</b>			
Sweep and vacuum roads and bridges	Could adversely impact air resources and have a positive impact on water resources		
Maintain pavement markings	Could adversely impact air resources	Could positively impact safety	
Patch deteriorated pavements	Could result in reduced waste		Impact on costs
Seal cracks and joints	Could result in reduced waste		Impact on costs
Resurface pavements	Could adversely impact air resources		
Control snow and ice	Could adversely impact air, water, and wildlife habitat resources	Impacts on access to facilities and safety	Effects on cost, jobs, and mobility
<b>Shoulders/Side Road</b>			

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Clean shoulders	Possible adverse impact on air resources	Positive impact on safety	
Repair/replace shoulder pavements	Could adversely impact air and water resources and impact waste reduction	Positive impact on safety	
Re-seed and mulch grass shoulders	Positive impact on wildlife habitat and water resources		
<b>Roadsides</b>			
Restore erosion controls	Positive impacts on wildlife habitat and water resources		
Maintain vegetation	Positive impacts on water resources and potential adverse impact on wildlife habitat	Positive impact on safety	Positive impacts on cost
Maintain guiderail		Positive impact on safety	Positive impacts on cost
Maintain/enhance cultural resources		Impact on cost	Impact on mobility
Improve Public Access		Positive impact on safety and equity issues	Impacts cost and mobility
Develop/maintain Safety Rest Areas	Impacts on energy conservation	Impacts on safety	Impacts on jobs, costs, and mobility
<b>Drainage</b>			
Improve drainage facilities	Impacts on water resources		
Reduce erosion and sedimentation	Impacts on water resources		
Reduce runoff/Improve infiltration	Positive impact on water resources		
<b>Structures</b>			
Maintain deck surfaces	Potential adverse impact on environment and positive impact on waste reduction and energy conservation	Impact on safety	Impact on cost
Repair substructures	Potential adverse impact on water resources and positive impacts on waste reduction	Impact on safety	Impact on cost
Protect watercourses and embankments	Positive impact on water resources and impact on waste reduction		
Clean bridge bearings	Adverse impacts on water resources and energy conservation		
Wash bridges	Potential adverse impacts on air and water resources		Impact on cost
Paint bridges	Potential adverse impacts on air and water resources, but could cause reduction in wastes and conservation of energy		Impact on cost
Minimize habitat and stream impacts	Positive impact on water resources and wildlife habitat		

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Clean culverts	Impact on water resources and wildlife habitat		Impact on cost
Replace culverts	Impact on wildlife impact and energy conservation.		Expensive to replace culverts
<b>Traffic Control and Service Facilities</b>			
Maintain regulatory & information signs		Impact on safety	
Maintain/install signals and street lighting	Positive impact on energy conservation	Impacts on safety	Impacts on cost
Maintain safety rest areas	Potential adverse impact on water resources and positive impacts on waste reduction and energy conservation	Impacts on access and safety	Impacts on costs and jobs
<b>Waste Management/Recycling</b>			
Reduce waste	Waste reduction impact and consequently energy reduction		Impact on costs
Reuse excavated/blasted materials	Potential adverse impacts on water resources and positive impacts on waste reduction and energy conservation.		Impact on costs
Recycle demolition materials	Impacts on air resources, water resources, waste reduction and energy conservation		Impact on costs
Dispose of hazardous wastes	Potential adverse impacts on air and water resources	Impact on safety	
Store and use toxic materials	Potential adverse impacts on air and water resources	Impact on safety	
Control vehicle fluid spills and wash water	Potential adverse impacts on air and water resources	Impact on safety	Impact on costs
<b>Energy Conservation/Efficiency</b>			
Conserve energy		Impact on energy conservation	
Improve energy efficiency		Impact on energy conservation	
<b>Other Environmental Aspects</b>			
Improve aesthetics and visual quality			
Maintain wildlife habitat	Impact on wildlife habitat		
Improve air quality	Impact on air resources		
Reduce noise impacts	Impact on noise effects	Impacts on safety and equity	
Protect wetlands and streams	Impacts on water resources and wildlife habitat		

A more complete presentation of this information is presented in the 7 pages of Table A.2, an excerpt from which is found below.

**Table A.2 Excerpt –Triple Bottom Line Linkages**

(--) potential environmental impact

(+) potential for minimization, mitigation, or enhancement

(X) potential for material cost or benefit

Maintenance Activities	Environmental					Social			Economic			
	Air Resources	Water Resources	Noise Effects	Waste Reduction /Recycling	Wildlife Habitat	Energy Conservation & Efficiency	Access	Safety	Equity	Costs	Jobs	Mobility
<b>Traveled Way</b>												
Sweep and vacuum roads and bridges	--	+										
Maintain pavement markings	--							+				
Patch deteriorated pavements				+						X		
Seal cracks and joints				+						X		
Resurface pavements	--			+			X	X				X

Sustainability and long-term benefit calculation are now high level objectives at both AASHTO and FHWA. In 2009, President Allen Biehler included sustainability among AASHTO’s critical areas of emphasis, explaining: “Transportation’s mission is no longer about just moving people and goods. It’s much broader. Transportation fundamentally allows us to achieve economic, social, and environmental sustainability. Transportation supports and enhances our quality of life<sup>ii</sup>”.

Similarly, FHWA’s Sustainability Guide contains the following:

As stated on the sustainability page of the American Association of State Highway and Transportation Officials (AASHTO), the sustainability of the transportation system is critical because the sector is responsible for 10 percent of the world's gross domestic product, 22 percent of global energy consumption, 25 percent of fossil fuel burning, and 30 percent of global air pollution and greenhouse gases. Transportation agencies generally do not have processes and tools to gather and sort through information on such system interactions in order to make more effective investment decisions.

*Sustainable transportation* is a term generally used to refer to transportation that contributes to the sustainable development of the community that owns, operates and/or uses the system. A principal component of sustainable development, sustainable transportation tends to be defined in different ways by different agencies depending on specific priorities or constraints. However, it essentially includes effective and efficient system performance, with positive impacts on the social quality of life, economic competitiveness and the preservation of the natural environment.

To this end, recent reports from NCHRP conclude that:

DOTs have been working to improve environmental practices for decades, from dealing with spills and creating wildlife crossings, to incorporating shingles and fly ash in pavement mixes. (NCHRP 25-25/Task 04 *Environmental Stewardship Practices, Policies, and Procedures for Road Construction and Maintenance*)

DOTs are also protecting water quality, recycling signs, and using retro-reflective sheeting to boost safety, and eliminating unnecessary lighting expenses while they maintain stormwater facilities, minimizing salt applications to cut contamination, adding more equipment control and monitoring systems, installing LED signals and advanced timing technology, and shifting to green products in rest areas, garages, and roadsides. (NCHRP 25-25/Task 60 *Increase Use of Environmentally Preferable, Non-Toxic Products to Reduce Costs, Liabilities, and Pollution Maintenance Facilities and Rest Stops and Task 63 Transportation Corridor Environmental Management Framework*)

To accomplish integration of maintenance and environmental stewardship, DOTs are implementing sustainability programs and training. As part of the growing national awareness of environmental and stewardship considerations, DOTs are incorporating asset management and life-cycle cost analyses into decision-making and quality-assurance processes. (NCHRP 25-40 *Long-Term and Life-Cycle Costs of Stormwater Best Management Practices*, NCHRP 14-25 *Guide for Selecting Level-of-Service Targets for Maintaining and Operating Highway Assets*)

Sustainability rating systems have also been developed which speak to transportation Maintenance and Operations, including NYSDOT GreenLITES Operations Certification Program.<sup>xiv</sup> Other states, such as Oregon, have relied on Environmental Management Systems or Sustainability Plans. The 2008 Oregon DOT Sustainability Plan includes strategies to manage both internal agency operations and the statewide transportation system towards sustainability. The plan contains strategies for achieving sustainability goals, indicators for tracking progress, and a description of implementation activities.<sup>xvii</sup>

In October 2012, FHWA rolled out their revised INVEST sustainability rating tool which also has an Operations section, which gives credit for maintenance environmental stewardship. The system is structured to give points for Environmental Management System (EMS) type elements, like planning, goal-setting, metric development, implementation tracking, and auditing.

In addition to rating systems, Benefit / Cost Analysis and Sustainable Return on Investment / Sustainable Life Cycle Costing models have been available for some time and used to varying degrees in a variety of applications including the US DOT TIGER Program. The concept is simple and elegant. To achieve flexibility, transparency, and objectivity on a quantitative basis, all of the relevant factors are first translated into dollar equivalents so that an initial rough tradeoff analysis can be developed using standard econometric techniques.

For example, Figure 2.1 illustrates how sustainability life cycle costing might apply to maintenance activities for a range of potential maintenance activities.

Figure 2.1 Maintenance Activities and the Triple Bottom line

MAINTENANCE -- TRIPLE BOTTOM LINE TABULATION																		
Program	Activity	Cycle (Yrs)	#	# YR TARGET	# STATE FORCES	# CONTRACT	CAPITAL \$	STATE CASH \$	LIFECYCLE \$	MOBILITY \$	JOBS \$	AIR \$	WATER \$	HABITAT \$	SAFETY \$	ACCESS \$	LIVABILITY \$	BENEFIT / COST
Bridges	Bridge Cleaning						X	x	y									X
	Bridge Painting						X	x	y									X
	Deck Sealing						X	x	y									X
	Deck Treatment						X	x	y									X
	Joints						X	x	y									X
	Bearing Restoration						X	x	y									X
	Punch list From Inspection						X	x	y									X
	Environmental Protection								y	x	x	x						X
	Storm Water Facility								y	x	x	x						X
	Stream Channel								y	x	x	x						X
	Check for Invasive Species									y	x	x	x					X
	Regulatory Cost (Fines)						x		y	x	x	x						X
	Safety								x	y				x	x	x		X
	Public Parking / Access								y					x	x	x		X
Historic / Cultural Signing								y					x	x	x		X	
Pavement																		
Drainage																		
Signals & Lighting																		
Roadside																		
Guiderail																		
Signs																		
SNOW & ICE																		
Facilities																		
<b>\$\$ TOTAL</b>																		

## SECTION 3. NATIONWIDE SURVEY OF DOTs

A survey on how DOT maintenance and environmental organizations have institutionalized an environmental ethic and incorporated environmental stewardship practices, policies, and procedures into their existing maintenance and preservation programs. In particular, the survey was principally used to determine what the DOTs are currently doing in the areas of training, auditing, and evaluation. 50 states were sent surveys and 27<sup>1</sup> responded over the course of two months.

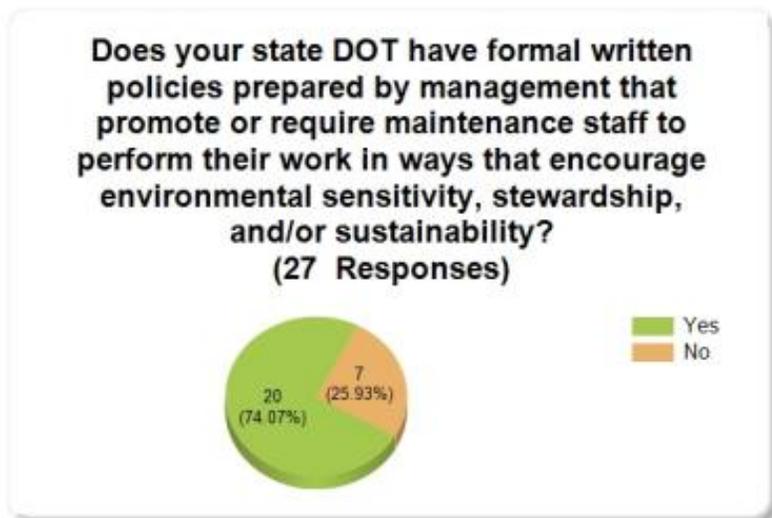
Sample survey questions were initially presented to the oversight panel, along with the amplified work plan. Comments were received and the survey was revised and simplified, mainly to yes/no questions with a self-assessment table for DOTs to fill out. Individual follow-ups were conducted with agencies that said they had resources related to environmental performance measurement, auditing, or training for maintenance forces. A copy of the questionnaire may be found in Appendix A.

### Survey Results

Twenty-seven state DOTs responded to the online survey conducted in the final quarter of 2011.

#### Institutionalization of a Sustainability Ethic

It appears that DOT staff understand the potential environmental impacts and/or ecological value and benefits of their work activities; 92% (25) of responding DOTs affirmatively. Just over 7% (2) felt this was not understood or conveyed, a testimony to awareness-building. Senior DOT management were seen to reinforce an environmental ethic by providing encouragement at staff meetings, training sessions, or conferences, according to over 80% (22) of responding DOTs.



<sup>1</sup>It is possible that responding states encompassed those more likely to be pursuing improved environmental performance in highway maintenance. Nevertheless, these percentages alone suggest that the majority of DOTs see a role for themselves as environmental stewards despite stringent budget pressures that tend to force attention away from anything perceived as “extra.”

Formal written policies supplement such guidance materials; 74% of responding state DOTs said management had prepared such policies to promote or require maintenance staff to perform their work in ways that encourage environmental sensitivity, stewardship, or sustainability.

Asked if they thought Maintenance & Operations staff see environmental stewardship as something extra to do in their agency; 59% (16) of respondents do not consider it “extra,” an indication of progress. Conversely, around 40% (11) of DOTs say their maintenance forces do consider ecological sensitivity to be an “extra” burden. One state clarified that although staff continue to see it as something extra, it has been incorporated into their work procedures. Thus, it seems that environmental stewardship is becoming has an accepted agency expectation.

### **Environmental Training for Maintenance and Operations**

Twenty-four (89%) of the responding DOTs provide environmental training specifically for maintenance and operation personnel. The same number and percent said Maintenance and Operations (M&O) staff understand the potential environmental impacts and/or ecological value of their work activities.

Environmental training for maintenance staff is typically in-house and includes manuals or other internal guidance documents. Ninety percent have environmental guidance materials readily available in maintenance shops and trucks. Several respondents also indicated that additional environmental training should be offered in such areas as wetlands, water quality, waste management, species concerns, local agency permits, and cultural resources.

Appendix A, Table 3 -- “Maintenance Environmental Training” – shows the range of training programs offered and illustrates the importance of establishing a general stewardship ethic rooted in compliance, as reflected in the preponderance of housekeeping, stormwater, and herbicides courses offered on a systematic basis. Leading examples include Colorado DOT’s annual weeklong Maintenance Academy, Maryland’s mandatory environmental ethics training, New York State’s GreenLITES budgeting/messaging/communications program, and California’s Frequent “Best Management – Tailgate Sessions.”

Fifteen of the responding DOTs noted areas in which they believe additional environmental training is required, as listed below.

- Water quality: Erosion control and BMPs for stormwater runoff, NPDES permit compliance, understanding TMDLs, and effluent limitations guidelines
- Materials and waste management: stockpile storage, hazardous materials, spill prevention (SPCC) plan development, and monitoring and documentation
- Wetlands
- Species concerns

- Local agency permits
- Cultural resources.

Topics mentioned most frequently include water quality, erosion, and materials management.

The research team asked DOTs if funding and time were specifically budgeted for environmental training. While this question might have generated different responses if questions about funding and time were asked separately, funding and time were specifically budgeted for environmental training in over half (58%) of responding DOTs.

Training resources shared by the DOTs included the following:

- *Environmental Handbook for Transportation Operations: A Summary of the Environmental Requirements and Best Practices for Maintaining and Constructing Highways and Transportation Systems* (NYSDOT, June 2011)
- AASHTO Guidelines for Vegetation Management
- Asbestos Awareness Manual/training (MassDOT, 2011)
- Wetland training (MassDOT, 2011)
- NHI also offers free “self-paced” web-based training in the following areas:
  - FHWA-NHI-134108D: TCCC Plan Reading: Erosion and Sediment Control Plans
  - FHWA-NHI-134109E: Maintenance Training Series: Roadway Drainage
  - FHWA-NHI-134109F: Maintenance Training Series: Outdoor Advertising and Litter Control
  - FHWA-NHI-134109G: Maintenance Training Series: Roadside Vegetation Management
  - FHWA-NHI-134109H: Maintenance Training Series: Weather-related Operations
  - FHWA-NHI-134109J: Maintenance Training Series: Underground Storage Tanks
  - FHWA-NHI-134109K: Maintenance Training Series: Cultural and Historic Preservation
  - FHWA-NHI-135086: Stream Stability Factors and Concepts (Prerequisite)
  - FHWA-NHI-142052: Introduction to NEPA and Transportation Decision making
  - FHWA-NHI-151045: Highway Performance Monitoring System: An Introduction
  - FHWA-NHI-380079: AASHTO Roadside Design Guide

## Internal Audits

Two-thirds (66.67% or 18) of the responding DOTs said their DOT conducts internal audits of maintenance programs or activities for conformance with environmental policies and guidance. Nearly three-quarters (74% or 20 DOTs) of respondents also participate in external audits

performed by regulatory agencies. Stormwater, erosion and sedimentation control, and spill prevention were the most commonly audited areas.

DOTs also follow up on identified deficiencies; 90% of responding DOTs said they take follow-up actions to see if deficiencies identified in audits are indeed corrected. Over 80% said internal policies, guidance documents, or training materials were modified to address the cause and prevention of the deficiencies. Some think more frequent audits would be helpful, as would sensitivity training for field activities. Individual DOTs suggest the following areas where they think audits would be useful to assess environmental compliance or sustainability:

- Pesticide use
- Wildlife crossings
- Bridge scour maintenance
- Stream bank erosion
- Drainage maintenance
- BMPs for stormwater runoff, especially outside of those areas regulated by MS4s (Municipal Separate Storm Sewer Systems)
- Maintenance building and grounds
- Maintenance yard materials management system
- Roadside construction and maintenance activities performed by in-house forces
- Compliance with permits that cover maintenance actions, including NPDES, ESA, HPA programs
- Energy Conservation/Efficiency

Other DOTs believe that informal audits take place in the form of visual inspections or “windshield tours” performed by regulators. At least one DOT thought it would be helpful to provide a “checklist” that maintenance staff could use as items are completed to track such things as whether a specific problem has been contained or reduced, BMPs have been implemented and/or maintained, disturbance kept to a minimum, vegetation left undisturbed or reseeded after project, etc. Some thought audits would be difficult to implement in maintenance, “as the work type varies along with the timing.”

## Measurement

Less than one-third of respondents (8 states, 30% of respondents) said they had specific measurement tools or metrics in place to assess efforts to improve environmental conformance with state and federal regulatory requirements. Examples of such performance tools include WSDOT’s MAP and NYSDOT’s GreenLITES for Maintenance and Operations. A small number of

states have begun to develop environmental management systems in maintenance, including Oregon and Massachusetts. Only NYSDOT responded when asked to describe any measurable goals it had for its facilities. The goals identified by NYSDOT were for energy conservation, energy efficiency, waste reduction, spill containment, handling of hazardous wastes, recycling, use of “green” cleaning products, compliance with state and federal water quality/stormwater regulations, and directing funds and resources for voluntary environmental betterments, including water quality, wildlife crossing, and vegetation management.

Notably, seven state DOTs (about a quarter of respondents) said that its DOT has asset-management tools that focus on environmental costs and benefits of improvements to pavements, roadsides, drainage, lighting, signing, and other traffic-control facilities. Four DOTs said they allocate funds for environmental improvements or “betterments.”

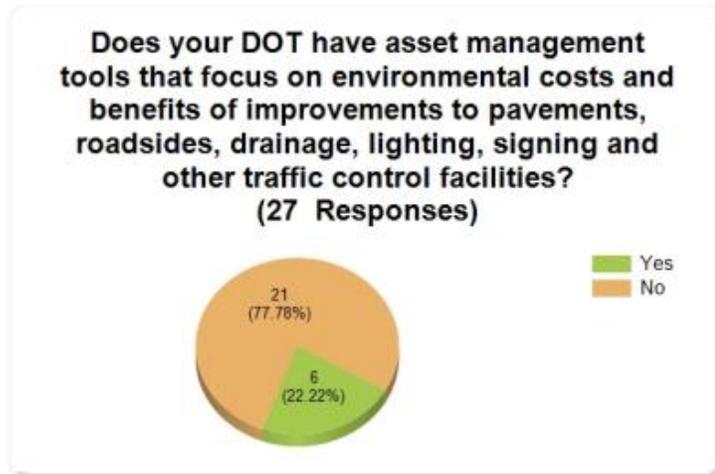


Figure 2.3 Asset Management Tools

DOTs identified the following environmental betterment projects and, in some cases, shared how such projects were tracked and measured.

- Noxious weed/invasive species control
- Perched culvert repair/fish passage restoration
- Rest area landscaping
- Bike path installation and maintenance
- Wildlife crossings
- Wildlife barriers/fencing
- Wildlife habitat
- Wildflower plantings
- Raptor nesting
- Solar rest areas
- Wetland development

About one-third of DOTs (8 respondents, 30%) said their agency had a component in group or individual performance evaluations related to improving the environmental performance of the DOT.

## Survey Conclusions:

### Structure, Staffing, Ethic

- Almost three-quarters of responding DOTs (74% or 20 states) said they had formal written policies prepared by management that promote or require maintenance staff to perform work in environmentally responsible ways.
- Most DOT maintenance forces (60% of responding DOTs) no longer see environmental stewardship as something “extra” to do; rather, environmentally sensitive approaches are considered integral to the maintenance activities at hand.
- Approximately 90% of responding DOTs believe their staff understand the environmental impacts and ecological value of their work activities.

### Training and Communications

Twenty-four (89%) of the responding DOTs provide environmental training specifically for maintenance and operation personnel.

Twenty-four (89%) said M&O staff understand the potential environmental impacts and/or ecological value of their work activities.

Environmental training for maintenance staff is typically in-house and includes manuals or other internal guidance documents.

Ninety percent have environmental guidance materials readily available in maintenance shops and trucks.

Several respondents also indicated that additional environmental training should be offered in such areas as wetlands, water quality, waste management, species concerns, local agency permits, and cultural resources.

## Quality Assurance / Metrics

### Internal and External Audits

- Two-thirds (66.67% or 18) responding DOTs said they conduct internal audits of their maintenance programs or activities for conformance with environmental policies and guidance.
- When audits are performed, results are shared with maintenance and operations managers as well as with staff so they can improve future performance.

- Nearly three-quarters (74% or 20 DOTs) of respondents also participate in external audits performed by regulatory agencies. Stormwater, erosion and sedimentation control, and spill prevention are the most common audit areas.
- Results of external audits are shared with staff 90% of the time. DOTs also follow-up on identified deficiencies; 90% of responding DOTs said they take follow-up actions to see if deficiencies identified in audits are indeed corrected.
- Over 80% said internal policies, guidance documents, or training materials are modified to address the cause and prevention of the deficiencies.

## Measurement

Less than one-third of respondents (8 states, 30% of respondents) said they have **specific measurement tools or metrics** to assess efforts to improve environmental conformance with state and federal regulatory requirements.

Twelve states or 44% of responding DOTs said they have specific **written benchmarks or goals** related to improving environmental performance or stewardship.

Six state DOTs said they have **asset management tools** that focus on environmental costs and benefits of improvements to pavements, roadsides, drainage, lighting, signing, and other traffic-control facilities.

Four DOTs said they **allocate funds** for environmental improvements.

Eight DOTs said their agency has **a component in individual or group performance evaluations** that relates to improving environmental performance.

## SECTION 4. CASE STUDIES

Ten leading state DOTs from across the U.S. (at least two from each AASHTO region, as called for by the Panel, plus two more to include leading states) related their experience in improving environmental performance and tracking progress. Materials and documents were reviewed and interviews conducted to get “the back story” from these leading organizations.

The case-study group included geographically diverse states that were early environmental ethic adopters, as well as other highly accomplished practitioners. All demonstrated successes in some aspect of evaluation and training for sustainability, environmental stewardship, and/or environmental compliance in highway maintenance. The selected DOTs are diverse in many important aspects, from the high percentage of contracted work in Florida, to the more typical mixture of in-house and contracted programs at other DOTs across the country. Some states addressed Triple Bottom line concerns but did not emphasize sustainability, while still others have department-wide sustainability plans underway. Quotes from, unless otherwise noted are taken from the primary interviews that occurred on the following dates, with the parties noted in the case studies:

Representatives of the research team conducted interviews with both environmental/sustainability program and maintenance managers. The research team also chose to have a member present in many of these states in person and expanded the number of states from eight to 10. The interviews explored how environmental and sustainability programs have become institutionalized in DOTs and, perhaps more importantly, why they haven't. Each DOT was consulted on the state of current practice, and researchers flagged programs that might be emulated by peers. All DOTs candidly related their views and experience, and generously shared available references and materials.

Each case study documents stewardship implementation programs underway at a specific DOT, including: processes to track progress, training, auditing/self-evaluation programs, and ways of systematizing environmental management. The case studies provide information on the effectiveness of programs in achieving environmental compliance, measuring success, planning for sustainability, and improving environmental performance. Wherever possible, the case

### **List of Interviews**

- California DOT (Caltrans) – March 19, 2012
- Colorado DOT (CDOT) – April 13, 2012
- Florida DOT (FDOT) – March 6, 2012
- Maryland DOT (MDOT) and State Highway Administration (SHA) – March 7, 2012
- Michigan DOT (MDOT) – April 9, 2012
- Minnesota DOT (MnDOT) – February 15, 2012
- New York State DOT (NYSDOT) – April 11, 2012
- North Carolina DOT (NCDOT) – February 29, 2012
- Oregon DOT (ODT) – February 22, 2012
- Washington State DOT (WSDOT)

studies also provide insight on how further improvements are being implemented as a means of assisting others who may want to adapt and apply these approaches.

Following an introductory overview on maintenance environmental Structure, Culture, and Staffing, a significant portion of the interviews and case studies are devoted to Training and Communications, Systems, Practice, Quality Assurance, and Accountability.

The following section provides a summary of the case-study results. The detailed questionnaire used for the interviews and state by state summaries may be found in Appendix C and *Appendix A* lists much of this information in tabular form.

## Structure, Culture, and Staffing

Maintenance staff numbers are not increasing; rather, it's considerably more common for Maintenance & Operations staffing to be going down while system demands increase. Despite these pressures and tradeoffs, DOT managers are providing leadership regarding their agency's expectations on environmental matters and Maintenance leaders interviewed feel that an environmental ethic in maintenance is well established.

### Mandates Support Environmental Programs

Many of the DOTs began their environmental programs in maintenance around water-quality permitting, herbicide and pesticide management, spill prevention, and other statutory requirements. In the 1990s, Oregon DOT achieved national prominence for its 4(d) exemption under the federal Endangered Species Act (ESA). Its Water Quality and Habitat Guide Best Management Practices for Routine Road Maintenance was a key feature and became a standard of practice. As part of this work, ODOT developed color-coded GIS mapping of restricted area management zones for various maintenance activities; these noted which activities were restricted or subject to caution in sensitive environmental areas.

California's Caltrans reported that the statewide Stormwater Permit was fundamental in creating awareness in maintenance, and its compliance mandate helped the culture evolve. Now, with its budget austerity, Caltrans is most able to implement green practices when such approaches offer efficiencies as well. Caltrans is using more rubber and recycled materials in pavement, including researching using asphalt shingles. The maintenance program is moving toward LEDs (Light Emitting Diodes) to reduce electric power usage, greenhouse gas emissions, and need for maintenance staff to be exposed to traffic while changing bulbs. And, Caltrans is now trying to move to grassed swales for stormwater treatment where right-of-way is available, because they're more cost-effective and easier to maintain than concrete basins.

At Caltrans, each maintenance facility and transfer location either has, or will have, a facility management plan that includes stormwater management and solid waste plans. Caltrans is also under a state mandate to reduce energy use. Its goal is to reach Silver LEED status, or 50%

reduction in energy usage, at facilities. It also has an aggressive program to put solar panels on the roofs of facilities.

Virtually all the 10 state DOTs have engaged their maintenance forces in environmental stewardship and significantly improved environmental housekeeping at maintenance yards, shops, and rights-of-way. This can be driven by the need to address environmental violations or audits, mandatory compliance requirements, or by an increasingly rigorous stewardship ethic within the Agency. Maintenance staff seem to clearly understand how their housekeeping activities and core functions affect the environment, particularly regarding water quality, stormwater, wildlife habitat, waste reduction, hazardous materials, recycling, and fuel efficiency. They have a good understanding of the economics involved and support the environmental benefits.

### **Interpreting and Implementing Sustainability**

NCHRP 25-25/Task 04 *Environmental Stewardship Practices, Policies, and Procedures for Road Construction and Maintenance*<sup>xx</sup> described the many environmental stewardship and ethic statements DOTs were beginning to develop, but DOTs continue to define and evolve their notions of sustainability today. Table A-5: “Stewardship and Sustainability – Policies and Practices” reports on the range of stewardship and sustainability programs and policies that have emerged among 10 leading states. Among these, the term “sustainability” seems to enjoy general support in the DOT maintenance world, though there’s some confusion about its meaning. At most DOTs, it seems to include factors such as lifecycle cost and safety, while in others it seems to mean “green,” irrespective of cost.

Sustainability in maintenance is sustainable maintenance to many DOT Maintenance and Operations (M&O) staff. For Washington State DOT maintenance field staff, the bottom line is whether potential activities are practical. To them “sustainable transportation is maintainable transportation.” To most maintenance forces, sustainable maintenance tends to pertain more to their ability to provide needed maintenance as they strive to maintain a “healthy system.”

Many state DOT maintenance and environmental leaders believe it’s essential to address safety, practicality, and cost issues in explaining why environmental work matters. Still, some DOT maintenance managers believe that at the crew level, staff are often uncertain what to make of the term “sustainability.” However, they do understand that most day-to-day activities are already contributing to the DOTs sustainability efforts and programs. Crews are quick to relate better yard and right-of-way housekeeping, as well as accompanying resource savings, to sustainability.

Minnesota DOT acknowledges the three legs of the sustainability stool Triple Bottom Line and understands the environmental and economic benefits. The primary focus has had to be saving money, while identifying where environmental benefits may be achieved in tandem. At Maryland SHA, maintenance staff understands sustainability to mean “being smart and conscious of how you manage your resources.” It involves minimizing work, assessing cost-

effectiveness of operations, and being aware of life-cycle costs. To improve sustainability awareness in Maintenance, NYSDOT looks for inexpensive, practical “win-win” ideas from maintenance workers themselves.

At WSDOT a working committee of program directors in five areas is working to define and educate agency personnel on sustainability by creating awareness of sustainable practices and organizational expectations, and by encouraging sections to identify opportunities and set attainable goals.

NYSDOT posted a Sustainability Vision – (<https://www.dot.ny.gov/programs/greenlites/sustainability>). This has helped make the concept of sustainability more understandable and raised awareness.

Sustainability is viewed positively at Michigan DOT, where Triple Bottom Line issues such as improving mobility and minimizing delays (social and economic costs and benefits) and reducing greenhouse gas emissions (environmental considerations) are driving the agency’s decisions. Michigan’s environmental and maintenance leaders say maintenance forces “well understand that their maintenance and operations activities support the economic leg of the triple bottom line.” (MDOT) is focused on the economic impact of transportation decisions and the desire to use technology to become more efficient and effective in supporting the state’s economy. In the I-94 Corridor from Chicago to Detroit, they’re tracking user-delay costs, and new software is measuring real-time travel speeds.

To the maintenance staff at Florida DOT (FDOT), environmental stewardship means protection of air, water, vegetation, and wildlife resources. Environmental stewardship also means conserving energy and reducing emissions by using 20% E10 biodiesel fuel in their vehicles. “Tourism and the natural environment are key industries in Florida, and everyone understands this,” leaders say. In Maryland, stewardship and sustainability have particular meaning in the natural resource area. Maryland’s governor has specific initiatives for environmental improvement, including such goals as planting 1 million trees, creating 200 acres of wetlands, and restoring five miles of streams.

### **Dedicated Environmental Staff in Maintenance**

The small number of DOTs interviewed among case-study states that have embedded environmental support staff in maintenance have found this practice to work particularly well when integrating the two areas. In the late 1990s, New York State realized that addressing environmental issues in the permitting design phase didn’t guarantee environmental compliance in construction, nor ensure that maintenance could follow through on environmental commitments in subsequent years. Because more support was needed, NYSDOT created environmental positions in both Construction and Maintenance. Regional staffing for Construction Environmental Coordinators (CECs) and Maintenance Environmental Coordinators (MECs) has been ongoing and highly successful in integrating environmental stewardship into maintenance and operations.

Washington State DOT also employs Regional Maintenance Environmental Coordinators (RMECs) to support maintenance forces and provide technical assistance. RMECs serve as contacts for WSDOT's Environmental Compliance Assurance Procedure (ECAP) for Maintenance Work Activities and have done much to improve interagency relations.

In Oregon, ODOT staffs a Maintenance Environmental Section Manager who is exclusively devoted to assisting Maintenance. This position supports ODOT's Maintenance environmental initiatives, including Maintenance Environmental Management Systems (EMS), and is involved in ODOT's sustainability planning. The Maintenance Environmental Section has environmental staff focused on roadside Integrated Vegetation Management (IVM), two foresters for hazard tree identification and timber sales, and three water-quality specialists. These staff members provide training on winter de-icing materials, MS4, and EMS. ODOT remarked that the Maintenance Environmental Section particularly enjoys working with the maintenance staff because they're eager for, and appreciative of, the environmental support.

In other states, environmental support comes from outside maintenance. The Maryland DOT Environmental Compliance Division works with the district maintenance staff in this relatively small state and four District Environmental Coordinators effectively support highway maintenance and operations in the seven districts.

State DOTs with dedicated environmental staff for maintenance operations said the staffing helped them to provide collaborative and accessible technical solutions that satisfy both maintenance and environmental needs in a timely fashion. Specifically, they felt that the benefits included:

- Increased in-house training to improve crew sensitivity to environmental issues and to put work activities into a stewardship and sustainability framework and understanding.
- Quicker analysis of real-time field maintenance problems and implementation of long-lasting, effective, environmentally sound solutions.
- Better coordination with regulatory/resource agencies, improving trust and facilitating programmatic agreements.
- Stronger feedback from maintenance to design and construction staff to improve future project designs and construction practices.
- Increased likelihood that environmental commitments made in the capital project permitting stages will be followed through in construction and maintenance.
- More low-cost enhancement activities by maintenance forces, e.g., placement of bird/bat houses, limiting mowing during ground nesting periods, construction of hiking/fishing access parking areas, pedestrian/bicyclist/handicapped access facility improvements, and better context sensitive solutions.
- Better understanding of environmental concerns by maintenance field staff.

## Partnerships with Other Agencies and Organizations

Some case-study state DOTs have entered into programmatic agreements with other state and federal agencies, NGOs, universities, and other stakeholders to address regional environmental issues such as watershed management, invasive species control, wildlife passage, and connectivity. The length and lineal nature of DOT rights-of-way means that DOT infrastructure, maintenance, and operations activities can, and do, have a direct influence/impact on these issues, in both positive and negative ways. In many states, having maintenance staff at the table brings knowledgeable and effective participation by staff who understand the natural and man-made resources involved and the capabilities of the DOT to be a partner in implementing potentially broader solutions to avoid, minimize, and mitigate impacts. FDOT, for example, worked with The Nature Conservancy (TNC) on a property that TNC owned and wanted to restore. FDOT is also working with the Florida State Forest Service to determine ways to improve forest health and wildlife habitat, and to provide storm damage mitigation within the highway ROW.

Florida, New York State, and other DOTs have developed partnerships with other agencies to control invasive species. FDOT is a leader in prescribed burning within the highway ROW. Florida has more prescribed burning than any other state, an effort for which FDOT has received awards. FDOT has demonstrated that prescribed burning can be done safely along its roadway.

## Leadership – Interpreting and Implementing Sustainability

DOT maintenance leaders can actively address environmental issues through procedural manuals and agency notebooks. Oregon’s DOT Maintenance & Operations Leadership Team stated in its March 2009 letter that ODOT’s Environmental Management System (EMS) Policy and Procedures Manual represents a commitment by them and the Agency. “The EMS is a cornerstone of the Maintenance commitment in the ODOT Sustainability Plan, identifying and implementing recycling options, increasing the use of recycled materials, and expanding the use of alternative products.” ODOT’s State Maintenance and Operations Engineer expressed pride in “the incredible strides Maintenance has made to identify and make appropriate changes to how we do business. ODOT Maintenance is consistently out front in minimizing impacts to natural resources.”<sup>iii</sup>

Washington State DOT noted that leadership at the top sets the tone as environmental stewardship has evolved. WSDOT has adopted a policy of “no environmental violations period.”<sup>iv</sup> With more progressive leadership and increasing public expectation, WSDOT responds to the environmental standards of a very aware populace and reports its performance to environmental agencies, the public, and the press with the Agency’s nationally acclaimed *Gray Notebook*.

Competition sometimes helps as well. In Colorado, the nine Maintenance Superintendents provide leadership and “really push” the environmental ethic. The nine Regional Organizations

compete for the Executive Director’s Cup every year, and part of that competition is the effectiveness of their environmental program.

## Training and Communications

State DOTs have increased efforts to train maintenance forces over the past decade. While training isn’t available for all subjects, DOTs are training for topics such as maintaining stormwater management facilities. *Appendix A, Table 3* shows the range of training programs offered, illustrating the importance of establishing a general stewardship ethic rooted in compliance. An excerpt from this 7 page table follows:

**Table A.3 Excerpt – Maintenance Training by State**

State	Training Programs	Focus	Participants, Frequency and Methods	Training Links
California - Caltrans				
	General Housekeeping Training	Staff receives training on the importance of General Housekeeping BMPs and their relation to overall environmental compliance. New environmental requirements are incorporated into Division of Maintenance policy and training, the materials for which are revised as needed.	Training is delivered to the Maintenance Division’s 5,600 employees by various means, including external resources and Division of Maintenance staff. New mandates that require immediate compliance are presented in Tailgate Meetings and a Maintenance Bulletin is prepared to provide information to Maintenance field supervisors. Staff members are required to receive classroom or online training on various minimum intervals, depending on the type of training. In addition, Tailgate training sessions are held every two weeks or whenever there is a change in work activity.	<a href="http://www.dot.ca.gov/hq/env/stormwater/edfs/maintain/m6_99.pdf">http://www.dot.ca.gov/hq/env/stormwater/edfs/maintain/m6_99.pdf</a>  <a href="http://www.dot.ca.gov/hq/env/">http://www.dot.ca.gov/hq/env/</a>

## Training

According to interviewees, maintenance training programs at DOTs are most effective when they have the following characteristics:

- Sessions lead by DOT managers or staff respected for their knowledge and expertise.
- Hands-on field training activities, whenever possible, particularly with installation and maintenance of stormwater and erosion and sediment control measures.
- Written guides, handbooks, and other materials that can be readily taken into the field.

- Participation in training sessions by people with interdisciplinary responsibilities and expertise, including staff from other DOT program areas (design, construction, environmental), other regulatory and resource agencies, NGOs, and other stakeholders.
- DOTs also use technologies such as teleconferences, webinars, online courses, CDs, and other methods to link staff in different geographical and organizational levels for interdisciplinary training, communication, and coordination. One agency has monthly hour-long webinars available statewide, held at the same day of the week, time, and call-in number. The convenience of the regular schedule increases the dialogue among staff about current and common issues and practical strategies.

Colorado DOT takes 1,500 employees through its Maintenance Academy on an annual basis. They review CDOT's environmental ethic and cover a wide variety of areas, including Hazmat training. New hires receive two weeks of training, and existing staff receive one week. At daylong sessions, headquarters staff teach field staff how to properly install BMPs, with hands-on opportunities to install BMPs, such as hay bales, slope runoff protection, and silt fence in the field, and how to evaluate their performance under simulated precipitation run-off conditions.<sup>v</sup> These training sessions are also open to non-CDOT employees and industry professionals who have completed the CDOT Environmental Certification training.

Maryland DOT also provides mandatory environmental ethics training, along with the annual customer-service training for all employees. Environmental topics are on the agenda at its annual Highway Maintenance Seminar, where selected district maintenance shops are recognized for compliance. They also hold an annual Awards Day that acknowledges environmental contributions.

The NYSDOT GreenLITES program is also focused on an annual cycle. A comprehensive list of stewardship activities is tied to the budget, and Earth Day performance awards are tied to results as a messaging/communications tool. NYSDOT also has an Environmental and Landscape Architecture Training Series (ELATS), which occurs monthly at the same time in the form of a statewide webinar available to regional staff. ELATS Coordinators in every region assist facilities, generate attendance lists, and award CEU and PDH credits. The topics, which are selected from ideas solicited from both management and staff, are focused on maintenance, construction, and design.

## **Communications**

Washington State DOT leaders commented on the importance of good communications mechanisms and structure. WSDOT has six Regional Maintenance Engineers in addition to headquarters staff. They meet every few months for a full day and discuss programs and policies, as well as performance.

In California, knowledge, participation, and communication are required at all levels of the organization, from executive staff to the employee working in the roadside environment. Caltrans maintenance and environmental leaders believe this is key in successfully implementing their environmental program, and Caltrans shares this by participating in federal, state and local conferences and associations. Caltrans has extensive resources online, including a variety of bulletins and stormwater resources <http://www.dot.ca.gov/hq/construc/stormwater/>.

Florida DOT also has an online environmental procedure manual: <http://>

## **Maintenance Staff Participation**

DOT leaders all seem to make a particular effort to listen to maintenance staff and respond to their suggestions. For North Carolina DOT, surveying staff about their current sustainability practice, their good ideas, and what sustainability means to them is an important place to start. Leaders said they ask staff to respond to challenges, but they also listen, share results, and offer support.

NYSDOT Maintenance has developed “Communities of Practice” or CoPs. As noted on NYSDOT’s internal website, Communities of Practice (COPs) are DOT’s “brain trust” for their particular subject area. With their cross-section of leading experts, they tend to be chaired by a Central Office Program Manager and develop policy, procedures, training, expectations, performance metrics, quality assurance programs, budgets, contracts, and staffing patterns in cooperation with the people they work with on a daily basis. Regional COPs members typically also serve as the region’s subject lead and may chair a regional COP for the subject. Relevant environmentally related COPs include Drainage COPs, Petroleum Bulk Storage COPs, Facilities COPs, Vegetation COPs, and Snow and Ice COPs.

Washington State DOT also makes a special effort to include employees’ input, commenting, “It’s helpful to explain what it’s going to be used for, and how it’s going to be used, and to use some of the (gathered) performance measurement information in the budget allocation process; then it starts meaning something more to them.”

NYSDOT leaders noted that maintenance staff members need to understand why they’re required to meet certain regulations and recognize the benefits. If people don’t appreciate it, they may be less likely to do extra. So continually raising awareness of how their M&O activities can affect the environment, positively and negatively, is important.

Likewise, Caltrans leaders said, “Some training is developed not just to familiarize staff with the regulations but also to focus on why the effort was being done, [including] the health effects to the worker and their family.”

## Instruction by Maintenance Peers

California, Colorado, and other DOTs mentioned the importance of involving maintenance staff in delivering training; for example, Caltrans has found that “employees relate and tend to be more focused when peers are an integral part of the instruction.” At NYSDOT, environmental trainers are embedded in Maintenance. At Caltrans, Division of Maintenance training videos use District Maintenance staff to illustrate best-management practices for roadside and facility activities.

## Training in the Field

Caltrans Maintenance Division requires frequent Tailgate Meetings to cultivate field crews’ awareness of the best-management practices for their work. Caltrans has developed tailgate resources (one-page fact sheets or monthly bulletins) on stormwater for maintenance that have been national models. These are available on Caltrans’ website - <http://www.dot.ca.gov/hq/env/stormwater/publicat/maintain/>.

At NYSDOT, maintenance staff has developed – and actively participate in – training that improves the environment, including courses on how to design and install living snow fence, stream restoration, hazardous tree and tree skills, and safe and productive herbicide use. Many courses are structured so maintenance staff can learn by doing, and maintenance peers explain the techniques he.

## Quality Assurance / Metrics

Several DOTs have developed evolved structures for environmental performance measurement, reporting, and management. These include agencies with offices for performance excellence or continuous improvement, such as those in Maryland, North Carolina, and Washington State, often with highly public reporting mechanisms. Some of these and other states have also developed Environmental Management Systems (EMS) that systematically assess which environmental aspects of an operation’s work are most significant, how well controlled they are, and how any adverse environmental impacts should be handled. These are described in some 14 pages of detail in *Appendix A, Table 4* an excerpt from which follows.

**Table A-4 Excerpt – Measuring Compliance, Stewardship Accomplishments and Metrics**

Program	Purposes	Audit/Self-Evaluation	Reporting Results
<b>California - Caltrans</b>			
<p>Caltrans' Integrated Maintenance Management System (IMMS) provides the principal accountability mechanism for the Division of Maintenance.</p>	<p>The Division of Maintenance has an audit of its activities conducted in the roadside environment and at yards and stations.</p>	<p>Environmental performance evaluations are conducted in accordance with The Maintenance Activities Compliance Review Plan at <a href="http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-05-999_99_2.pdf">http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-05-999_99_2.pdf</a> and the Maintenance Facilities Compliance Review Plan at <a href="http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-05-999_99_3.pdf">http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-05-999_99_3.pdf</a> Each document contains the evaluation criteria.</p>	<p>The Division of Maintenance tracks its environmental compliance activities and generates the following databases. They're summarized and reported annually to the State Water Resources Control Board and other regulatory agencies.</p> <ul style="list-style-type: none"> <li>• Erosion Inventory Database,</li> <li>• Storm Drain System Inventory Database,</li> <li>• Illegal Connection/Illicit Discharge Database,</li> <li>• Pesticide Use Database,</li> <li>• Maintenance Facility and Activity BMP Implementation Database,</li> <li>• Facilities Pollution Prevention Plans (FPPPs) Database,</li> <li>• Training Database,</li> <li>• Level of Service (LOS) -- a performance-based system designed to measure progress on departmental goals.</li> </ul>

## Audits

Many DOTs began their environmental programs in maintenance, around housekeeping at maintenance yards, water quality permitting, herbicide and pesticide management, spill prevention, and other statutory requirements. Annual audits for violations at yards are common, but “green asset management” is rare. Comprehensive performance tracking for the complete range of maintenance activities in keeping with potential environmental impacts, as detailed in *Appendix A, Table 4*, is approached by exception. Quantitative assessment of maintenance program impact across the Triple Bottom Line (TBL) of sustainability is just beginning to emerge.

Oregon DOT M&O bases metrics on audits of the seven priority areas, which they conduct every three years for each of the 103 maintenance yards. Every maintenance yard is audited at least once every three years, with about 35 of the 103 yards audited each year. The audits focus on oil use and management, fuel, aerosols, lighting, winter maintenance chemicals, drainage, and pesticides.

New York State DOT does self-audits for measuring compliance with all NYS Department of Environmental Conservation (DEC) environmental regulations. The audits are implemented regionally, and the Maintenance Environmental Coordinator or MEC is usually the audit coordinator. MECs and/or Maintenance staff go through a variety of environmental compliance checklists and report non-compliances to DEC. MECs are also responsible for scheduling corrective action on identified items.

## Plans

The NYSDOT GreenLITES system ties environmental as well as sustainability performance to its budget and resourcing plans and conducts an annual review of results. Maryland SHA has a Performance Excellence Division in the SHA Administrator's Office which oversees business planning on a three-year cycle. Plentiful objectives and strategies for the agency's priorities populate the SHA's FHY 2012-2015 business plan.<sup>vi</sup> Performance is then reported in the agency's Annual Attainment Report, which reports not only on the measure but provides bulleted highlights addressing "Why did performance change?" and "What Are Future Performance Strategies?"

In the 1990s, Oregon DOT began focusing much attention on compliance with stormwater regulation and the federal Endangered Species Act (ESA), conducting systematic plans to support these objectives. ODOT has added a Sustainability Plan <http://cms.oregon.gov/ODOT/SUS/pages/index.aspx> to Volume 2 of its EMS focusing on the seven key areas covered by an internal audit the Agency performed. This plan provides support and direction for sustainability efforts. ODOT has incorporated sustainability goals for maintenance in the larger Agency Plan, supported by a formal EMS in Maintenance <http://egov.oregon.gov/ODOT/HWY/OOM/EMS.shtml>.

## Metrics

Maryland DOT measures the annual number of violations on permits to meet its 100% compliance goal. In its most recent Annual Attainment Report, MDOT reported that the agency is now tracking and estimating pounds of various pollutants released as runoff every year. Maryland State Highway Administration (SHA) is also tracking:

- Number of pounds per year of nitrogen pollution abated.
- Number of pounds per year of phosphorus pollution abated.
- Number of pounds per year of sediment abated.
- Number of acres of untreated pavement retrofitted for stormwater management (SWM) controls each fiscal year.
- Combined annual cost in dollars of total maximum daily load (TMDL) program.

SHA's strategies in these areas include:

Addressing water quality and natural resources goals through development and implementation of a green asset management plan.

Developing watershed implementation plans (WIP) to comprehensively reduce pollutant loads from SHA right-of-way.

Communicate SHA environmental initiatives and accomplishments for Chesapeake Bay restoration to internal and external customers through effective use of training and web-based messaging and other social media.

Pursuing banking opportunities for project mitigation and TMDL compliance for wetlands, streams, and forests.

## Assessments

Florida DOT's Maintenance Rating Program has been in effect since the 1980s, and FDOT was one of the first DOTs to invest in mapping of culvert and drainage infrastructure locations. FDOT ensures that condition assessments are conducted for roadsides, ditches, stormwater facilities, culverts, inlets, and cross-drains. With the new MS4 permit, FDOT is now trying to quantify debris removal and, by extension, prevention of nitrogen pollution. FDOT evaluates the performance outcomes of its asset maintenance contracts by undertaking quality-assurance reviews of roadways and reviewing required data pursuant to Maintenance Rating Program Handbook. Disincentives are included in maintenance contracts as needed to ensure performance.

In New York, GreenLITES (Leadership In Transportation and Environmental Sustainability) Operations was launched into its pilot year on Earth Day 2009 and tracks Transportation Maintenance, Fleet Administration, Traffic, Safety & Mobility, and Modal Safety and Security activities for environmental stewardship and compliance activity. NYSDOT developed the GreenLITES certification program to help integrate sustainability principles into transportation using the building industry's LEED system as a model <https://www.dot.ny.gov/programs/greenlites>. The GreenLITES Maintenance/Operations Plan Spreadsheet, containing over 100 items, is tied to the Maintenance and Operations Plan (MOP – Budget development system) and the ongoing March 2010 Regional Pilot Program.

## Other Observations

Transportation agencies have reported a number of ongoing benefits from implementation of EMS in recent years, including:<sup>vii</sup>

- More effective management at all levels
- Increased environmental awareness
- Employee training
- Nonconformity/corrective action tool
- Cost savings
- Environmental compliance and continuous improvement – ability to apply process to every operation

- Recognizes the strength of employee involvement
- Facilitates “good housekeeping,” well-maintained, clean, and well-organized facilities
- Simplifies documentation
- Opportunities to integrate with other management systems
- Positive public relations

## **Institutionalization of Environmental and Sustainability Concerns in Case Study States**

### **Structure/Staffing/Ethic**

Some maintenance personnel have an inherent understanding of how their work activities affect the natural environment (e.g., water quality, habitat, air quality). Most states began with comprehensive environmental stewardship at maintenance facilities and in the highway rights-of-way, primarily because of state and federal environmental regulations. The need for environmental permits in design and subsequent violations of those permits during construction or maintenance of newly constructed projects made the state DOTs focus on necessary compliance and the need to be better stewards over time. Some states, at their own initiative, moved well beyond a compliance orientation and began environmental-enhancement programs. A few states are significantly engaged in assuring that their maintenance efforts are “sustainable” from environmental, economic, and social perspectives.

### **Training/Communications**

Some states have developed comprehensive staffing plans by putting environmental staff in their district/region maintenance units. Others supported their maintenance programs by having main office staff support the district or region maintenance staff on an as-needed basis. Those states with environmental staff in the regions or districts seemed to be able to respond more quickly and to develop environmentally sound solutions to problems as they arose in day-to-day operations. Some states developed comprehensive policy and written guidance systems and provide focused training programs on key environmental issues important to their particular states. Some states implemented system-wide inventories and environmental management systems.

### **Quality Assurance/Metrics**

Most states began to assess and measure certain, often limited, environmental parameters important to their daily operations, to their state budgeting processes, or important to their governor and other state officials to meet statewide environmental and transportation goals. Written performance measures and quarterly or annual public reporting allowed a few states to develop improved transparency with the public.

## Summary Assessment

The Case Study DOTs are systematically institutionalizing environmental concerns in these areas: Structure/Staffing/Ethic; Training/Communications; and Quality Assurance/Metrics. The following is intended to convey the degree to which DOTs are incorporating environmental compliance, stewardship (going beyond compliance to enhance the environmental), and sustainability (purposeful systematic contribution to their state’s Triple Bottom Line of environment, social, economic well being) into their institutional framework.

States have developed different approaches and levels of progress because of conditions unique to each state, including but not limited to: different environmental resources; varying state regulatory programs; DOT organizational structures and staffing patterns; state and regional environmental goals; department and state budgetary constraints; and executive leadership actions and emphases. In general, most of the case-study states have achieved a high degree of “penetration” on an environmental ethic, have effective training programs focused on compliance, and have an appreciation for, but limited applications in, sustainability. The tables, charts, and text presented elsewhere in this report document how DOTs are institutionalizing environmental concerns in these three areas: Structure/Staffing/Ethic; Training/Communications; and Quality Assurance/Metrics; but these categories alone can only convey a snapshot of current efforts in each of these topic areas.

The following chart is intended to convey a sense of the degree to which DOTs are incorporating environmental compliance, stewardship (going beyond compliance to enhance the environmental), and sustainability (purposeful systematic contribution to their state’s Triple Bottom Line of environment, social, economic well being) into their institutional frameworks.

Figure 3.1 is based on the information obtained throughout this study, but its focus is on the case-study states where, in addition to survey information, data, impressions, and intentions offered by DOT interviewees provide a more complete picture of the dynamics at work.

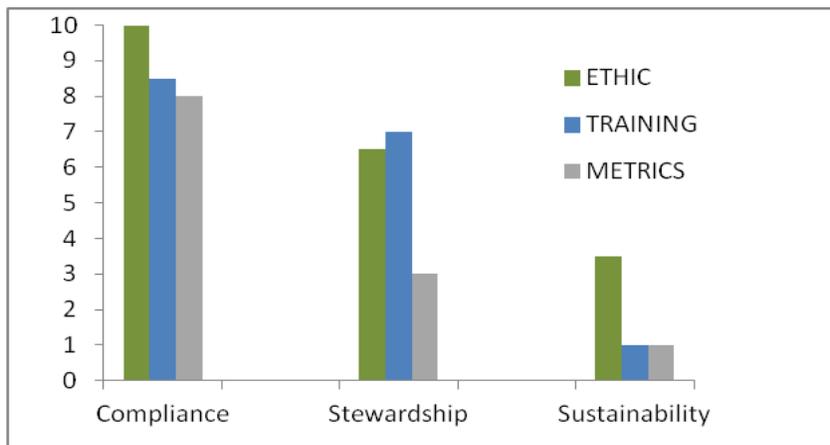


Figure 3.1 – Integrated Snapshot of Maintenance/Environment Institutionalization.

In characterizing these efforts, the following conventions were employed to characterize each topic area, i.e., Structure/Staffing/Ethic; Training/Communications; and Quality Assurance/Metrics.

<b>Institutional level</b>	Full development - 1 point	Emerging - 0.5 points	Total / 10 Case-Study States
<b>COMPLIANCE - focus on</b>			
Facility Housekeeping			
IVM/Pesticides/Invasives			
Stormwater/Drainage			
<b>STEWARDSHIP – above plus</b>			
Broad Environmental			
Erosion & Sediment			
Recycling			
Snow and Ice Control			
Spills/HazMat			
Stream Restoration			
Wildlife/Fish Passage			
Wetlands			
Habitat			
<b>SUSTAINABILITY –above plus</b>			
Social			
Economic			

And, while DOT programs are ever-evolving due to budget, leadership, and technology changes, the basic patterns are clear and constant with interview data, i.e. States have, by necessity, focused on compliance despite a natural inclination toward stewardship, and are just beginning to institutionalize sustainability across a broader range of concerns.

## **SECTION 5. CONCLUSIONS**

With the interstate era behind us and the full realization of the environmental movement into the larger issues of sustainability still before us, the contributions of a DOT to a sustainable society fall increasingly to maintenance and operations.

### **Research Objectives**

The objectives of the study were to examine how state DOTs are incorporating environmental requirements, stewardship, and sustainability into highway maintenance programs.

### **Research Approach**

Three general methods were employed to achieve the research objectives:

1. A targeted review of the literature to assess state DOT policies, procedures, and practices;
2. A survey of state DOTs to assemble information on how maintenance and environmental stewardship policies, procedures, and practices have been institutionalized; and
3. A detailed case studies of 10 states to illustrate a range of practices.

### **Key Findings**

#### **Structure, Staffing, and Stewardship**

Highway agencies were organized as capital-project production organizations, and now they're making a transition, devoting ever more attention to maintenance and operations as systems age and budgetary realities drive a new focus. They are continuing to improve environmental performance with a focus on compliance.

While every state is different, and there's no "right path" to institutionalization of environmental sensitivity, stewardship, and sustainability of maintenance and operations activities; the DOTs profiled in this report, and many of their peers, have shown that good and effective routes are being charted, and DOT maintenance organizations continue to evolve

toward effective and efficient management frameworks capable of maximizing their contribution to a sustainable society. Among these frameworks, asset-management tools that focus on environmental costs and benefits of improvements to pavements, roadsides, drainage, lighting, signing, and other facilities have been found to be effective. The NYSDOT GreenLITES program, for example, has been quite successful in its integration of environmental and sustainability concerns into “the mainstream” of departmental work.

Similarly, a systematic approach to staffing seems most effective. States that have embedded environmental support staff in maintenance have found this to be well worth the investment. Adjunct environmental support from outside maintenance tends to produce varying results.

## Training and Communications

Most State DOTs are incorporating environmental requirements, stewardship, and sustainability into highway maintenance programs, and that progress has naturally tended to focus on statutory compliance in the areas of policy, training, and metrics. An appreciation for environmental stewardship is well engrained, and training in the essentials of stormwater management, hazardous materials, and vegetation management has progressed steadily.

Twenty-four of 27 (89%) of the responding DOTs provide environmental training specifically for maintenance and operation personnel. The same number and percent say that maintenance and operations (M&O) staff understand the potential environmental impacts and/or ecological value of their work activities. Leading examples include Colorado DOT’s annual weeklong Maintenance Academy, Maryland’s mandatory environmental ethics training, New York State’s GreenLITES budgeting/messaging/communications program, and California’s Frequent “Best Management – Tailgate Sessions.”

Environmental training for maintenance staff is best done systematically in-house and includes manuals or other internal guidance documents. It is also essential that environmental guidance materials are readily available in maintenance shops and trucks, where most needed. Additional environmental training could be offered in such areas as wetlands, water quality, waste management, species concerns, local agency permits, and cultural resources.

Many state DOT maintenance and environmental leaders indicated the importance of speaking to practicality, costs, and the reasons behind environmental considerations in fostering good performance. These lessons are best imparted by peers or environmental specialists who are familiar with the day-to-day realities of maintenance and operations. Most DOTs choose to deliver training and technical support in this manner. Active involvement of environmental staff with maintenance also seems to be foster good relationships with external environmental agencies.

## Quality Assurance/Metrics

Comprehensive facility audits are well established and valuable, as are follow-up systems for resolving environmental violations. However, proactive systems for managing environmental assets are only beginning to emerge.

Two-thirds (18 of 27) of responding DOTs said they conduct internal audits of maintenance programs or activities to conform with environmental policies and guidance. If audits were performed, results were shared with maintenance and operations managers as well as staff to improve future performance.

Nearly three-quarters (20) of respondents reported that they participate in external audits performed by regulatory agencies. Stormwater, erosion and sedimentation control, and spill prevention were the most common audit areas. Over 80% said internal policies, guidance documents, or training materials are modified to address the cause and prevention of the deficiencies.

Broad spectrum environmental quality-assurance systems tied to annual inspections, budgeting, and performance are only beginning to develop. The Maryland performance management system and NYSDOT's GREENLITES program could serve as models for others.

## Institutionalization of an Environmental Ethic

While compliance systems are relatively well developed and policy level approaches to an environmental ethic are well represented; , the development of training and metrics in support of such an ethic is still developing. This stands to reason in that intentions are first reflected in policy followed by training and later tracked in metrics. Judging from the literature, surveys, and interviews conducted in this effort; most DOT's seem to feel that when it comes to maintenance and operations, regulatory compliance is a given, environmental stewardship (enhancement of the environment beyond compliance, as practicable) is desirable, and sustainability in support of a broader range of economic and social concerns may warrant further development.

## Suggestions for Further Work

Given the importance of maintenance and operations in transportation in support of a sustainable society and, in particular, the environmental footprint of the existing highway system, DOTs should have ready access to the tools and benchmarking needed to enhance performance. While this study has provided links to current best practices and has benchmarked the state of development, the industry as a whole lacks consensus on what DOT Maintenance Organizations should be doing on environmental and sustainability concerns, as well as the mechanisms needed for the effective development and delivery of training and other tools.

Accordingly, the research team suggests that the AASHTO Highway Subcommittee on Maintenance and the Standing Committee on Environment use this report as background for a discussion on how to advance environmental concerns in maintenance. Ideally, the Center for Environmental Excellence might convene a workshop to explore the development of benchmarking tools and the establishment of a clearinghouse for the continuing exchange of best practices and materials.

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