Environmental Performance Measures for State DOTs

NCHRP Report 809
Webinar Agenda

1. introduction
2. environmental focus areas
3. measure design
4. proof of concept pilot results
5. conclusions
“you can achieve incredible progress if you set a clear goal and find a measure that will drive progress toward that goal ... this may seem basic, but it is amazing how often it is not done, and how hard it is to get right”

Bill Gates, 2013
Performance Process

1. adopt meaningful goals
2. measure progress
3. make course adjustments if needed
Many DOTs use performance measures...

TRENDS IN NATIONAL BRIDGE CONDITIONS

Percent of deck that are structurally deficient (all bridges)

National Goal: 10%

Percent of bridges rated good, fair, and poor (all bridges)

- **GOOD**: 2014 - 45%, 2004 - 46%
- **FAIR**: 2014 - 48%, 2004 - 44%
- **POOR**: 2014 - 7%, 2004 - 9%
Use of environmental measures by DOTs — a work in progress?
Spur dialogue about a suite of core national environmental performance measures to help DOTs make progress toward shared environmental goals.
environmental focus areas
air quality
More areas in nonattainment with tightening of ozone standard
Vehicle emissions are concern in urban areas as contributor of ozone precursors and articulates.

Air pollution trigger for health problems like asthma, reduced lung capacity, susceptibility to respiratory illness.

But, DOTs have limited impact on vehicle emissions versus travel volumes & Federal emissions standards.
energy & climate
“In 2015, cars, motorcycles, trucks, and buses drove more than 3 trillion miles in our country—farther than driving to the Sun and back 16,000 times.”

(National Academies)
Share of total U.S. energy used for transportation, 2015

- Transportation: 28%
- Other: 72%

Source: U.S. Energy Information Administration, Monthly Energy Review, Table 2.1, preliminary data, April 2016
Total U.S. Greenhouse Gas Emissions by Sector (USEPA, 2014)

- **Electricity**: 30%
- **Transportation**: 26%
- **Industry**: 21%
- **Commercial & Residential**: 12%
- **Agriculture**: 9%
Total U.S. Transportation Sector GHGs Over Time (USEPA, 2014)
materials
recycling
total U.S. raw materials consumption (USGS, 2006)
Supplies of aggregates shrinking due to land use changes & population growth, which restrict mining opportunities.

Aggregate extraction causes damage to environment and transport from source to job sites is energy intensive.
stormwater
**Quantity - erosion and siltation:** excessive erosion during and after construction can contribute sediment and silt to runoff waters, which deteriorates water quality and can lead to ecological problems.

**Quality - anthropogenic contamination:** dissolved or suspended anthropogenic contaminants including metals, nutrients, organic compounds, bacteria or suspended solids.
ecosystems & wildlife
Diversity/abundance in wildlife and integrity of habitats are key to healthy ecosystems.

At risk resources include wetlands and streams, wildlife movement corridors, and threatened and endangered species.

Natural habitats vary widely between states.
core measures
Selection Criteria

1. Measure can be applied consistently by all or most states?

2. Can measure be reported easily with existing data or data that is easy to generate?

3. Measure data quality is credible and defensible?
More Selection Criteria

1. Issue of meaningful significance?
2. Measure links to desired environmental outcome?
3. State DOTs have influence over results?
4. Data are valuable to decision-makers?
5. Meaningful and clear to general public?
identified 190 measures

distilled down to 6 measures
air quality
Measures Rejected

- Direct measures of air quality (e.g. # of nonattainment days, etc.)
- Emissions control strategy-related measures
- Change in metropolitan motor vehicle emissions, relative to base year
Preferred Air Quality Measure

Change in statewide motor vehicle emissions for nitrogen oxides, volatile organic compounds, and fine particulate matter

Selection justification –

- Contribution of vehicle emissions to air quality problems is a significant environmental issue
- Vehicle emissions directly influence air quality
- State DOTs have influence over vehicle emissions
- Vehicle emissions are easily calculated
Measure Methodology

1. Run MOVES model at national scale
2. Apply statewide VMT by road type
3. Apply other state-specific inputs, if available

Alternatively, use county-level MOVES analysis (e.g., NEI approach)
energy & climate
Measures Rejected

- GHG emissions measures
- Per capita CO2 emissions from on-road transportation
- Per capita transportation energy use
- Measures of VMT
- State DOT fleet fuel carbon intensity or average fuel economy
Preferred Energy & Climate Measures

Measure 1 - state DOT fleet alternative fuel use as a percent of total fuel use by volume

Selection justification -

• Alternative fuel use has direct impact on GHGs
• States control fleets
• Easily measured
• Easily understood by state DOTs, decision-makers, and public
• Supports emerging markets for new fuels
Measure Methodology

1. Collect state DOT fuel use by type
2. For biofuel blends, calculate volume of biofuel vs. conventional fuel (gasoline or diesel)
3. Convert all fuels to a gallon-equivalent basis
4. Divide alternative fuel volume by total fuel volume
Preferred Energy & Climate Measures

Measure 2: statewide on-road gasoline consumption per capita

Selection justification –

• Consumption of gasoline directly linked to GHG emissions
• State DOTs have influence over gasoline consumption
• All states can estimate gasoline consumption and estimates are comparable across states
• Gasoline provides a reliable and easy to understand indicator of transportation energy consumed
Measure Methodology

1. Collect state highway gasoline use data (*Highway Statistics* table MF-27)
2. Collect state population data
3. Divide
materials recycling
Measures Rejected

- % by mass of all recycled materials used
- % of DOT projects that have a waste diversion or recycling plan
- Measures aimed at increasing infrastructure life
Preferred Materials Recycling Measure

Annual percent by mass of all roadway pavement materials used by state DOT that is composed of reclaimed asphalt pavement (RAP)

Selection Justification -

• Pavement materials consumed in large quantities
• RAP-related data accessible
• Largest category of recycled material among state DOTs
• Only recycled material used consistently across states
• Promotes construction cost savings
• Decreases landfill waste
• Promotes energy conservation
• Reduced use of virgin materials conserves natural resources
Measure Methodology

1. Collect data on RAP use per year in tons
2. Collect data on total asphalt use per year in tons
3. Divide RAP use by total asphalt use
Measures Rejected

- Direct water quality measurement
- Number of NPDES permit violations
- Compliance with TMDL implementation plans
- Number of BMPs incorporated annually
Preferred Stormwater Measure

Percent of state DOT-owned impervious surface for which stormwater treatment is provided

Selection justification -

• Structural stormwater treatments affect water quantity and quality
• All state DOTs build and maintain structural stormwater treatment facilities
• Location of structural BMPs can be tracked
Measure Methodology

1. Calculate state DOT owned impervious area:
   • detailed road inventory method
   • imagery analysis method

2. Locate structural BMPs

3. Delineate BMP drainage areas

4. Estimate the impervious area treated by each BMP

5. Calculate the % of the state DOT owned impervious area that is treated by all BMPs
ecosystems
& wildlife
Measures Rejected

- Programmatic agreement/conservation policy-related measures
- Investment level on training, outreach, habitat surveys, invasive species management, etc.
- Number of threatened and endangered species takings
- Proportion of new ROW from greenfields versus redevelopment
- Proportion of ROW managed as natural area/replanted with native vegetation
Wetlands Measure - Rejected

Percent of wetland and stream mitigation that achieves regulatory approval on, or ahead of schedule based on the permitted monitoring period.
Preferred Measure: Ecosystems Self Assessment Tool

Self-administered assessment composed of 41 questions that evaluate performance across all aspects of state DOT programs relevant to wildlife and ecosystems, including policy, planning, operations, and project implementation.

Selection Justification –

- ESAT addresses states’ ability to protect wildlife and ecosystems
- State DOTs have influence over ESAT performance results
### Measure Methodology

**Example ESAT Question**

<table>
<thead>
<tr>
<th>Question</th>
<th>Wildlife collision hazard sites are prioritized for mitigation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scoring Values</td>
<td>0 points</td>
</tr>
<tr>
<td>None</td>
<td>1-25% of state highway network</td>
</tr>
</tbody>
</table>

**Example of Best Practice**
- Oregon DOT "wildlife collision hot spots map"

**DOT Planning Level**
- Statewide Data/Strategy

**DOT Function Area**
- Wildlife Movement Planning

**Ecological Focus Areas**

<table>
<thead>
<tr>
<th>General</th>
<th>Wetlands</th>
<th>Aquatic, Streams</th>
<th>Wildlife movement/corridors</th>
<th>Invasive Species</th>
<th>T&amp;E/ Sensitive Species</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
**Measure Methodology**

**Ecosystems Self Assessment Tool (ESAT)**
Submit agency responses to each question in cells shaded yellow.

### Assessment Questions and Scoring

<table>
<thead>
<tr>
<th>Question ID</th>
<th>Question</th>
<th>0 Points</th>
<th>1 Point</th>
<th>2 Points</th>
<th>3 Points</th>
<th>Examples of Best Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Construction guidance and manuals include specific biological resource conservation/mitigation practices?</td>
<td>None</td>
<td>1 practice</td>
<td>2 practices</td>
<td>3 or more practices</td>
<td>Ohio DOT, &quot;Construction Administration Manual of Procedures&quot; 2013: contains criteria for screening borrow and waste sites for environmental resources</td>
</tr>
<tr>
<td>02</td>
<td>Operations and maintenance guidance and manuals include specific biological resource conservation/mitigation practices?</td>
<td>None</td>
<td>1 practice</td>
<td>2 practices</td>
<td>3 or more practices</td>
<td>Ohio DOT, Highway Operations Environmental Checklist</td>
</tr>
<tr>
<td>03</td>
<td>Manuals and guidance include specific practices for minimizing impacts to biological resources from stormwater runoff?</td>
<td>None</td>
<td>1 practice</td>
<td>2 practices</td>
<td>3 or more practices</td>
<td>NY DOT Highway Design Manual, Chapter 8 – Highway Drainage discusses specific site considerations for the protection of fish and wildlife resources</td>
</tr>
<tr>
<td>04</td>
<td>Percent of environmental staff and construction contractors receiving biological resource conservation/mitigation training?</td>
<td>None</td>
<td>1-33%</td>
<td>34-66%</td>
<td>Greater than 66%</td>
<td>Illinois DOT INVEST v1.0: Construction environmental training requirements</td>
</tr>
<tr>
<td>05</td>
<td>Programmatic guidance and planning documents from state wildlife agencies (e.g., Wildlife Action Plans) are used in DOT projects and planning decisions?</td>
<td>Not utilized, or not available</td>
<td>Somewhat</td>
<td>Modestly</td>
<td>Extensively</td>
<td>Texas DOT uses Species of Greatest Conservation Need, which are part of the State Wildlife Action Plan, and species listed on county lists as triggers for coordination with Texas Parks and Wildlife Department</td>
</tr>
<tr>
<td>06</td>
<td>Culvert designs that mitigate impacts to aquatic species are used during new construction or retrofits?</td>
<td>Rarely or never</td>
<td>As required on a project-specific basis</td>
<td>Frequently (i.e., more than half of projects)</td>
<td>Routinely (i.e., nearly all projects)</td>
<td>State laws in Oregon and Washington require culvert designs that allow for passage of all native and migratory fish and access to historic habitat</td>
</tr>
<tr>
<td>07</td>
<td>Inspections occur before and during construction to determine compliance with biological resource commitments?</td>
<td>Rarely or never</td>
<td>As required on a project-specific basis</td>
<td>Frequently (i.e., more than half of projects)</td>
<td>Routinely (i.e., nearly all projects)</td>
<td>Caltrans Environmental Commitments Record System</td>
</tr>
<tr>
<td>08</td>
<td>Work periods are set to minimize disruption to fish and wildlife?</td>
<td>Rarely or never</td>
<td>As required on a project-specific basis</td>
<td>Frequently (i.e., more than half of projects)</td>
<td>Routinely (i.e., nearly all projects)</td>
<td>Nebraska DOT (GAO-04-563): Nebraska DOT is working with the state resource agency to identify preferred times for construction in order to reduce impacts on the breeding of certain species</td>
</tr>
<tr>
<td>09</td>
<td>Number of Memoranda of Agreement (MOAs) with state or federal resource agencies to improve biological resource impact analyses, mitigation, conservation actions?</td>
<td>None</td>
<td>MOA in place with one or more agencies</td>
<td>Routinely coordinate with one agency in accordance with MOA</td>
<td>Routinely coordinate with multiple agencies in accordance with MOAs (directly or indirectly)</td>
<td>Illinois DOT uses Illinois National Heritage Program staff to perform ecological surveys</td>
</tr>
<tr>
<td>10</td>
<td>Extent of asset management/data sharing related to biological resources?</td>
<td>None</td>
<td>Agreement in place with one or more agencies</td>
<td>Data sharing system implemented with one agency</td>
<td>Data sharing system implemented with multiple agencies</td>
<td>Illinois DOT has a data license agreement with the Illinois Department of Natural Resources for the Illinois Natural Heritage Database</td>
</tr>
<tr>
<td>11</td>
<td>A system exists for planners, maintenance crews, and construction crews to communicate regarding environmental sensitivities? (e.g., Restricted activity zone mapping, Standardized Data Sheets)</td>
<td>No</td>
<td>As required on a project-specific basis</td>
<td>Frequently (i.e., more than half of projects)</td>
<td>Routinely (i.e., nearly all projects)</td>
<td>Texas DOT uses Environmental Permits, Issues, and Commitments (EPIC) Sheet used for communicating environmental constraints including permits and/or ESA consultation commitments</td>
</tr>
</tbody>
</table>

### DOT Responses

<table>
<thead>
<tr>
<th>Response (Select One from Menu)</th>
<th>Sources, Documentation, and Notes</th>
<th>Score Received</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>None</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>2 practices</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>1-33%</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Extensively</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Rarely or never</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>As required on a project-specific basis</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Rarely or never</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>3 or more agencies</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Data sharing system implemented with multiple agencies</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Routinely (i.e., nearly all projects)</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>
proof of concept
measure pilot results
1. Measure can be applied consistently by all or most states?

2. Can measure be reported easily with existing data or data that is easy to generate?

3. Measure data quality is credible and defensible?
### Summary of Participating Pilot States

<table>
<thead>
<tr>
<th>Comprehensive Statewide Data Obtained</th>
<th>Experimental Data Obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air</strong></td>
<td><strong>Stormwater</strong></td>
</tr>
<tr>
<td>Energy/Climate Change</td>
<td>% of roads receiving</td>
</tr>
<tr>
<td>Recycling</td>
<td>treatment</td>
</tr>
<tr>
<td><strong>Statewide vehicle emissions</strong></td>
<td><strong>Wildlife/Ecosystems</strong></td>
</tr>
<tr>
<td>Gasoline Consumption per capita</td>
<td>Ecosystems Self-Assessment</td>
</tr>
<tr>
<td>(16 states)</td>
<td>Tool</td>
</tr>
<tr>
<td>(All states)</td>
<td>(4 states)</td>
</tr>
<tr>
<td>DOT Fleet Fuels Use</td>
<td>Ecosystems</td>
</tr>
<tr>
<td>(15 states)</td>
<td>(6 states)</td>
</tr>
<tr>
<td>RAP as % of Total Pavement</td>
<td></td>
</tr>
</tbody>
</table>
air quality
Change in statewide motor vehicle emissions of fine particulate matter (PM2.5)
Change in statewide motor vehicle emissions of nitrogen oxides (NOx)
Change in statewide motor vehicle emissions of volatile organic compounds (VOCs)
Conclusions & Concerns

- Use of nationally accepted MOVES data supports comparative measurement/credibility
- Use of MOVES drives ease of calculation
- Measure data is not sensitive to state DOTs’ congestion relief efforts
energy & climate
State DOT fleet alternative fuel use as a percent of total fuel use by volume

CA, 3.5%
IA, 1.9%
MD, 3.5%
MN, 12.8%
MO, 5.2%
NC, 10.2%
PA, 2.9%
WA, 8.7%
WY, 0.2%
Conclusions & Concerns

- Standardized fuel records/state control of fleets enables fair comparisons
- Some external factors influence state DOTs’ alternative fuel use
- Data on alternative fuels readily available at most state DOTs
- More data and analysis may be needed to capture use of electric vehicles
Gasoline consumption per capita (2011)
Conclusions & Concerns

- Gasoline sales data are easily obtained for all states
- Gasoline sales data is robust
- State DOTs have limited control over gasoline consumption
- Economic growth not a strong predictor of growth in gasoline consumption, but level of urbanization is
RAP as a Percent of Asphalt Laid Annually

- NJ, 14.3%
- FL, 19.4%
- IL, 15.5%
- CO, 15.7%
- DE, 21.7%
- MO, 16.7%
- UT, 18.1%
- NC, 21.8%
- ND, 15.2%
- NJ, 14.3%
- SD, 7.9%
Conclusions & Concerns

- RAP is used by most/all state DOTs
- Limits on RAP content may affect performance results, but states are increasing RAP limits
- Records of necessary data exist, but may require additional effort to compile
## Percent of state DOT-owned impervious surface for which stormwater treatment is provided

<table>
<thead>
<tr>
<th>State</th>
<th>State highway system impervious area</th>
<th>Treated highway area (By SHA BMPs)</th>
<th>Percent of DOT-owned impervious surface for which treatment is provided:*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maryland (Statewide) Results:</strong></td>
<td>32,259 acres</td>
<td>9,025 acres</td>
<td>28.0%</td>
</tr>
<tr>
<td><strong>Delaware (Newcastle County Only)</strong></td>
<td>4,077 acres</td>
<td>899 acres</td>
<td>22.0%</td>
</tr>
<tr>
<td></td>
<td>399 acres</td>
<td></td>
<td>9.8%</td>
</tr>
<tr>
<td><strong>Ohio (Cuyahoga County Only)</strong></td>
<td>4,184 acres</td>
<td>49.9 acres</td>
<td>1.2%</td>
</tr>
<tr>
<td><strong>North Carolina (Statewide Primary Roads)</strong></td>
<td>94,730 acres</td>
<td>4,644 acres</td>
<td>4.9%</td>
</tr>
</tbody>
</table>

*Does not account for surface passively treated or that does not require treatment.
Conclusions & Concerns

Most states today have limited access to BMP data.

Phased approach for measure implementation is viable:
- phase 1: BMP inventory-based measure
- phase 2: impervious surface-based measure
- phase 3: complete implementation

GIS tools are key to stormwater data accessibility.
Conclusions & Concerns

- Scores from pilot testing well distributed, suggesting ESAT captures range of performance.
- ESAT evaluates some practices not regularly tracked by DOTs.
- Many questions are subjective and qualitative:
  - limited ability to verify
  - state-to-state comparisons challenging
conclusions
<table>
<thead>
<tr>
<th>Measure</th>
<th>Supports Consistent Application from State to State?</th>
<th>DOTs Can Report Measure Easily with Existing Data or Data that is Easy to Generate?</th>
<th>Data Quality is Credible and Defensible?</th>
<th>Implementation Readiness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in statewide motor vehicle emissions for NOx, VOC, and PM$_{2.5}$ fleet alternative fuel use</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>Ready for use by many DOTs today</td>
</tr>
<tr>
<td>Statewide on-road gasoline consumption</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Ready for use by many DOTs today</td>
</tr>
<tr>
<td>Annual percent by mass of all asphalt pavement materials composed of RAP impervious surface for which water treatment is provided</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>Ready for use by many DOTs today</td>
</tr>
<tr>
<td>Ecosystems Self-Assessment Tool</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>Suitable for use by DOTs in longer term</td>
</tr>
</tbody>
</table>

**Key**

● Measure is fully consistent with criteria

○ Measure is mostly consistent with criteria

● Measure is somewhat consistent with criteria

● Measure lacks consistency with criteria
Next Steps?

- State DOT environmental performance measures workshop?
- Full-scale or partial data collection?
- Explore trends target setting?
- Comparative performance reporting website?