Center for Environmental Excellence by AASHTO
Stormwater Management Community of Practice (CoP)

STATE-OF-THE-PRACTICE REPORT:
Source Control

May 2011

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DISCLAIMER

This State-of-the-Practice Report summarizes the discussions of Stormwater Management Community of Practice members who spoke as individual members of the community and did not necessarily represent their agency's views or positions. In addition, the contents of the report do not necessarily represent the views or positions of AASHTO or the Center for Environmental Excellence.

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EXECUTIVE SUMMARY

The control of the sources of pollutants in highway stormwater runoff is a requirement of most Department of Transportation (DOT) National Pollutant Discharge Elimination System (NPDES) permits. DOTs operate source control programs targeted for specific constituents such as trash and total suspended solids from erosion. Compared to treatment control methods, source control of constituents in highway runoff offers the benefits of improved water quality at a lower life-cycle cost. The limitations of treatment control approaches are well documented: Stormwater quality is highly variable, runoff quantities are large, pollutant concentrations are generally small and pollutant sources are variable and diffuse, making treatment control (with the possible exception of infiltration) only modestly effective. Many constituents of concern in stormwater are in a dissolved form, making them difficult to remove using conventional treatment processes such as sedimentation and filtration.

Potential pollutants in highway runoff include metals, nutrients, trash, total suspended solids, salts and deicers, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), pesticides and herbicides. Depending on receiving water conditions and other uses within the watershed, waterbodies may be impaired for one or more of these constituents, and the DOT may be identified as causing or contributing to the impairment.

Considerable research has been completed characterizing the quality of highway runoff, but relatively little investigation has been conducted to determine the sources of constituents of concern, and most importantly, the relative load of the identified sources of the constituents of concern. The lack of information for constituent sources and loads makes it difficult for the DOT to implement a source control program.

DOTs do not have direct control over all of the sources of potential pollutants in their right-of-way. Pollutant sources include those from outside of the right-of-way (such as aerial deposition, and from stormwater runoff discharging to the highway right-of-way from adjacent land), mobile sources within the right of way (vehicles) and fixed sources within the right of way (highway materials, appurtenances, slopes, maintenance practices). DOTs can influence pollutant sources from outside of the right-of-way and the mobile sources within the right-of-way through public education and behavior modification. More direct control of these sources must be accomplished by eliminating the commercial use of the pollutant.

The current state-of-practice for DOT source control includes public education (anti-litter campaigns) and with quasi-source control through litter collection (sweeping, DOT litter pickup and adopt-a-highway programs). Suspended solids are controlled through slope repair and erosion control within the right-of-way and through sweeping. Nutrients and pesticides application is controlled with the use of integrated pest and vegetation management systems that emphasize mechanical or non-chemical pest and vegetation control. Traction control in snow and ice requires the use of salt, de-icers and sand; the application of these materials is controlled closely.

A more comprehensive or true source control approach is being implemented for some constituents. Copper has been identified as a pollutant impairing receiving waters in many states. The problem is particularly acute for some receiving waters in Washington, Oregon and

California, where the combination of urban areas near freshwater streams with sensitive fish species has resulted in copper Total Maximum Daily Load (TMDL) listings, or in the case of Washington, limits on dissolved copper and zinc in highway runoff through Endangered Species Act (ESA) Section 7 consultations. Washington and California state legislatures have recently passed state legislation banning or greatly reducing the amount of copper in automobile brake pads. Research indicates that up to half of copper in stormwater in urban areas is from this source. Control of the source of copper on highways has exceptional benefit for the DOT. In California, it is estimated that all copper TMDL stakeholders in the state will save between 30 and 50 billion dollars using source control, compared to a treatment control approach.

DOTs are interested in applying the cost and performance advantages of source control to other constituents of concern in highway runoff. The CoP has identified copper, zinc, lead, nutrients and salt (and deicers) as potential candidates for true source control approaches. More research is needed to identify the source of loads in highway runoff of these constituents to design an effective source control program or support enabling legislation. Four research problem statements are included as a part of this report as the first step in the source control implementation process.

INTRODUCTION

The Center for Environmental Excellence by AASHTO has established a Stormwater Management Community of Practice (CoP). The purpose of the Stormwater Management CoP is to create a forum where State Department of Transportation (DOT) practitioners can engage in facilitated discussions on emerging issues, research data needs, and innovative stormwater quality compliance solutions. The CoP has two primary goals, the first of which is to extend each state DOT's network and contacts, enabling them to share experiences and engage in technology transfer. The second goal is to develop a State-of-the-Practice Report (this document) on a selected focus topic. The Stormwater Management CoP consists of representatives from 16 state DOTs, the Federal Highway Administration (FHWA), and the Federal Transit Administration (FTA). The Stormwater Management CoP members agreed that source control of constituents of concern in the highway environment should be the top priority for this phase of the CoP.

Source control is one of the most effective ways to control pollution of water resources. Source control focuses on limiting the contact between the source(s) of a pollutant of concern and stormwater or non-stormwater runoff. True source control eliminates the source of the pollutant from use through either product substitution or green chemistry. According to the United States Environmental Protection Agency (U.S. EPA),

> "Green chemistry, also known as sustainable chemistry, is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry applies across the life cycle of a chemical product, including its design, manufacture, and use."

BACKGROUND

Source Control

DOTs have limited control of some of the constituents found in stormwater runoff from highways. Wet and dry deposition plays an important role in highway stormwater quality, as does the traveling public. The constituents in highway runoff that may affect receiving waters (based on national highway runoff water quality data) include:

- Total/Dissolved Lead (Pb)
- Total/Dissolved Copper (Cu)
- Total/Dissolved Zinc (Zn)
- Total Mercury (Hg)
- Total/Dissolved Cadmium (Cd)
- Total Nickel (Ni)
- Total/Dissolved Chromium (Cr)
- Ammonia Nitrogen (NH_3-N)
- Nitrate Nitrogen (NO_3-N)
- Total/Dissolved Phosphorus (P)
- Gross Solids
- Total Suspended Solids (TSS)
- Chloride (Cl)
- Total Dissolved Solids (TDS)

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- Total Iron (Fe)
- Total Aluminum (Al)
- Nitrite Nitrogen (NO_2-N)
- Oil and Grease (Petroleum Products)
- Turbidity
- Polychlorinated Biphenyls (PCBs)
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Herbicides and Pesticides

Receiving water standards developed by states can require treatment facilities on highways that reduce pollutant concentrations to the parts per billion (ppb) level or lower. It is often difficult to meet these standards using conventional Best Management Practices (BMPs). Improving the effectiveness of BMPs for highways has received significant research attention, but only modest results. It is difficult to treat stormwater at the edge of pavement or the end of the pipe due to the required space, the dissolved nature of many constituents, and the requirement to move runoff from the pavement quickly. In addition, it is difficult for BMPs to operate passively and with a minimum of maintenance.

The objective of this document is to identify some of the sources of stormwater pollutants in DOT runoff to determine which of these pollutants might be better reduced or eliminated through source controls rather than through treatment controls. Source controls might include eliminating the use of certain materials by DOTs in the construction, operation, and maintenance of highways and ancillary facilities. Product substitution may be used to replace current materials identified as the source of stormwater pollutants with less polluting alternatives. DOTs may wish to consider promoting regulatory actions by the state to require the elimination of sources of pollutants in vehicles, fuels, and lubricants that are difficult or prohibitively expensive to manage with structural treatment controls.

Potential sources of pollutants on highways are shown in Figure 1. Many factors affect the type and amounts of these pollutants, including traffic volume and type, local land use, and weather patterns. Roadway maintenance practices, such as sanding and deicing, or the use of herbicides on highway right-of-ways, may also act as sources of pollutants. Other possible, but infrequent, sources of pollutants include spills of recreational vehicle wastes, agricultural or chemical products, and oil and gas losses from accidents. These losses are related to traffic volume and may often go unnoticed, but could result in a large pollutant load locally (Asplund et al., 1980).

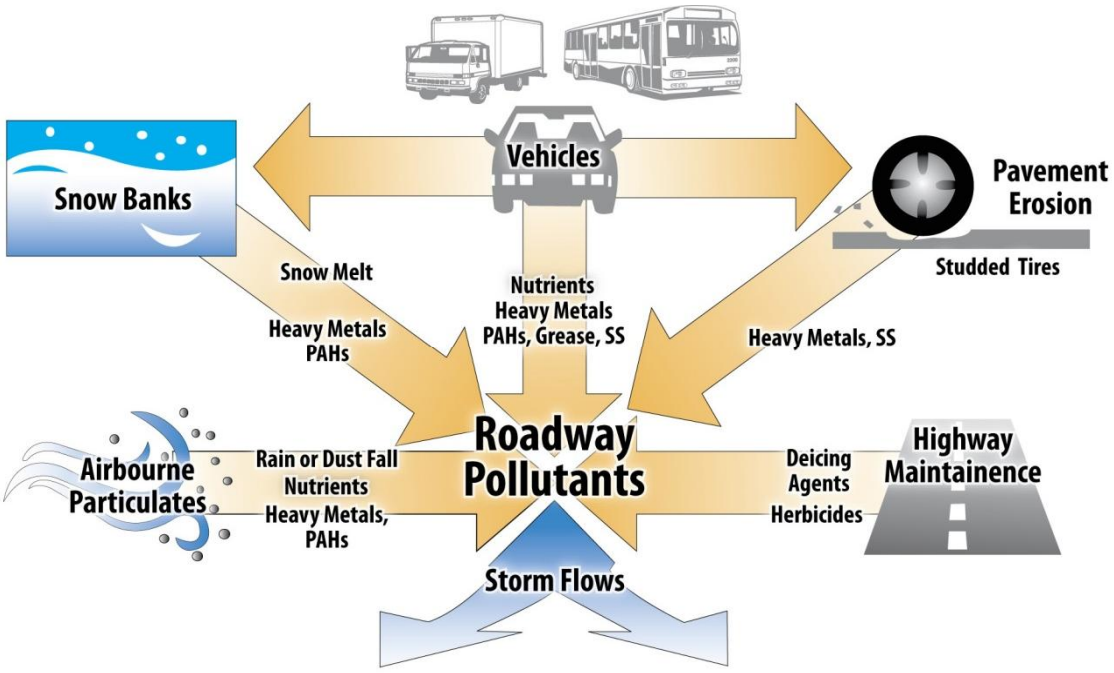

Figure 1 – Sources of Pollutants in Highway Runoff (Caltrans, 2003)

Highway materials and construction activities have influenced their surrounding environments; however, the majority of studies on highway runoff have focused on highways in operational settings. The impact of runoff due to the highway materials themselves is often not investigated. Recent references in this area are National Cooperative Highway Research Program (NCHRP) Report 443, "Environmental Impact of Construction and Repair Materials on Surface and Ground Waters," and NCHRP Report 448, "Environmental Impact of Construction and Repair Materials on Surface and Ground Waters Summary of Methodology, Laboratory Results, and Model Development."

One of the primary barriers limiting further application of targeted source control programs is the lack of understanding of the relative load of constituents of concern for which each of the identified sources is responsible. Unlike most pavement surfaces, highway pavements are a high-energy, turbulent environment. On-highway processes that affect deposited material are poorly understood; these processes include effects from re-suspension and evaporation. This poor understanding, in turn, has prevented accurate determinations of ambient atmospheric-deposition contributions to highway runoff loads in mass-balance calculations. Other stationary sources, such as guard/guide rails, fencing, storm drain conduit and roadside signs may contribute zinc, aluminum, copper or arsenic. The relative loading of each of these sources must be determined to prioritize source control programs.

DISCUSSION

DOTs must emphasize source control as one of the most effective measures available to improve the quality of stormwater runoff. The elimination of a constituent of concern is by far superior in both effectiveness and cost to end of pipe treatment. An obvious example is the elimination of lead in gasoline in the 1970s. Had the EPA not taken this step, DOTs would most certainly be struggling with lead exceedances and lead TMDLs today.

DOT stormwater programs are unique compared to those for traditional MS4s. DOTs primarily operate facilities (highways, rail, and airports) that focus on providing a platform to allow for the efficient movement of people and goods. Municipalities have authority over the people who are using transportation infrastructure in the municipality and have the authority to control how those people conduct themselves through use and enforcement of regulation and ordinance. By comparison, DOT facilities are passive and uniform, diffuse (covering a wide geographic area), and include safety as a primary objective. DOTs cannot regulate the users of their facilities but can influence their activities (behavior) through public education and outreach. DOTs also cannot control aerial deposition of pollutants, and pollutants deposited from vehicles. Unregulated uses adjacent to highways can deposit pollutants in the right-of-way via aerial and stormwater mediums.

DOTs can control the use of materials (conduit, pavement, appurtenances) in the right-of-way, and maintenance practices and materials (pavement repair, deicing). Traffic operations can also potentially reduce pollutant generation such as reducing speed limits and chain requirements (or studded tires) to delay or reduce the use of traction aides.

Metals are one of the most pervasive and problematic pollutants for DOTs. Dissolved metals at various concentrations are known to cause sensory deficiencies that affect the ability of fish to detect and avoid predators; as well as to be acutely toxic to aquatic life, and the toxicity can vary based on the hardness of the receiving water. The Community of Practice members identified zinc, copper and lead as the most urgent concern as pollutants in highway stormwater runoff. Sources of these metals in the highway environment are:

Zinc: Tires, Galvanized metal (highway guard/guide rails, signs, posts, roofs of maintenance facilities, etc.), motor oil, diesel fuel, brake pads, miscellaneous plated parts in vehicles, portland cement concrete (PCC), various asphalt concrete formulations, ammoniacal-copper-zinc-arsenate (ACZA), copper-chromated-zinc (CCZ)

Copper: Brake pads, diesel fuel, shingle-asphalt, PCC with plasticizer, ACZA, CCZ, atmospheric deposition (from exhaust emissions and windblown dust)

Lead: Tire weights, brakes, tires, diesel fuel, gasoline, used motor oil, paint, methyl methacrylate, residual contamination from soils contaminated by leaded gasoline exhaust

The Community of Practice also identified nutrients, nitrogen and phosphorus as constituents of concern in highway runoff that may be best addressed through source control. Sources of nutrients in the highway environment are:

Nitrogen: Atmospheric deposition, use of fertilizer within the right-of-way, vegetation within the right-of-way, discharge to the right-of-way from adjacent land uses

Phosphorus: Soil, fertilizer, atmospheric deposition (wet and dry), road sanding; crumb rubber asphalt, discharge to the right-of-way from adjacent land uses

Finally, the Community of Practice identified salt as a constituent of concern in highway runoff. Salt is commonly used as a deicer and is critical to maintain highway safety in areas of the country that receive snowfall. There has been substantial research into alternative products to salt and as additives to enhance the effectiveness of salt (to reduce the application), but salt remains the primary choice for deicing nationally.

STATE OF THE PRACTICE

Nationally, DOTs have implemented source control programs to control constituents of concern in highway runoff. DOT source control programs are highly effective in improving runoff water quality, but are limited by the lack of regulatory authority the DOT has on the users of their facilities. The current state-of-practice for source control programs at the member DOTs is as follows.

California Department of Transportation

Caltrans has an active public education program to help eliminate litter, and zinc from roadways. The "Don't Trash California" and "Adopt-A-Highway" campaigns have successfully been used to reduce litter deposited on roadways. Caltrans is investigating the use of Open Graded Friction Course (OGFC) as a method of source control, since it reduces splash on the undercarriage of cars, thereby reducing the amount of abraded metals that wash off onto the pavement surface.

Soil can also contain nutrients and metals in addition to total suspended solids. Caltrans uses design pollution prevention BMPs to reduce soil erosion: the preservation of existing vegetation, concentrated flow conveyances, slope/surface protection, peak flow attenuation devices, soil modification, energy dissipation, lateral slope drains, channel linings, flared culvert end sections, benching, terracing, slope rounding, and grade reductions.

Caltrans also participated in the Brake Pad Partnership (BPP) with a coalition of non-governmental organizations and vehicle manufacturers. The objective of the BPP was to reduce the amount of copper used in vehicle brake pads. Studies have shown that up to half of all copper in stormwater runoff in urban areas may be from automobile brake pads. The California BPP was successful in getting SB 346 signed into law in September of 2010, which will largely eliminate copper from vehicle brake pads in California by 2032.

Colorado Department of Transportation

CDOT reduces total suspended solids (TSS) by sweeping and recovering traction sand within 48 hours after application in the Denver Metro Area to help meet EPA PM_{10} (particles less than 10 micrometers in diameter, a fine particle designation for air quality) standards at specified locations and on Interstate 70 in Grand Junction. CDOT has also implemented standards for the application of deicers. CDOT uses no lead paint in the right-of-way. CDOT uses glass reflective beads that are recycled and have lower arsenic and lead standards than required. CDOT policies require native vegetation for landscape, and the maintenance practice is to mow 10 to 15 feet on the right-of-way to control weeds but allow the rest of the right-of-way to remain native. CDOT also has an "Adopt-A-Highway" program with public groups picking up the trash on the roadway with acknowledgement signage. CDOT has quality requirements on liquid deicers, in addition to application standards.

Delaware Department of Transportation

DelDOT has a public education program to reduce highway litter from the traveling public. DelDOT also has a program to sweep for litter and TSS reduction. In addition, salt usage is monitored, and no sand is applied to roads in the upstate region.

Florida Department of Transportation

FDOT has essentially eliminated periodic fertilization of turf for maintenance purposes. FDOT participates in street sweeping programs for litter and programs to control pet waste. The state has implemented a public education campaign targeting "personal pollution" that includes encouraging "Florida-friendly" yards and reducing nutrients used around the home. FDOT has a statewide "Adopt a Highway" litter control program.

Illinois Department of Transportation

The Illinois DOT has implemented a public education campaign targeting litter and pet waste controls at highway rest areas.

Michigan Department of Transportation

The Michigan DOT has implemented an anti-litter public education campaign, a street sweeping program, including tracking of sweeping activities, and catch basin cleanout programs. The DOT only uses fertilizer when needed based on site soil testing. MDOT also minimizes application of salt used for deicing.

New York State Department of Transportation

New York State DOT has a street sweeping and drainage system cleanout program. The DOT participates in the CleanSweepNY program (http://www.cleansweepny.org), whereby it uses its maintenance stations as public collection centers for household hazardous waste. It also has "Adopt-A-Highway" and "CLEAN (Create a Long Island Environmentally Aesthetic and Neat) Week" programs to remove roadside litter and debris. They have removed lead from specifications for paint used in the right-of-way.

The DOT has an Integrated Vegetation Management Program that addresses fertilizer use, herbicide application, and mowing practices. This program includes the use of "No-mow" grasses to reduce mowing and herbicide applications.

The DOT has purchased advanced vehicles for the application of salt that work in tandem with pavement temperature monitors to ensure the proper quantity and use. The salt application vehicles ensure a metered quantity of salt is applied to the roadway. NYSDOT will be required to implement wildlife management measures (based on permit requirements) to reduce the Canada geese population at mitigation sites to improve receiving water sanitary quality.

The DOT also has Spill Prevention, Control, and Countermeasures (SPCC) Plans at its maintenance facilities to prevent the discharge of oil and other compounds into water bodies.

New Hampshire Department of Transportation

NHDOT has a public behavior modification campaign, notifying the public that the DOT is applying less salt, increasing the need to drive more carefully as a result. The program also tries to reduce private applications of salt by providing indemnification for slip falls if private applicators follow the management plan (reduce liability). The DOT has largely eliminated sand

applications to reduce phosphorus and TSS loads to receiving waters. Sand is only used for very low temperatures (less than ten percent of the time). NHDOT also uses temperature sensors in the road to ensure that salt is applied only when it is effective (above ten degrees Fahrenheit). The DOT has a trash-sweeping program.

NHDOT also has a source control program focused on nutrients. During construction, fertilizer and herbicide use is restricted. Low phosphorus fertilizer is used when specified. In the near future, the DOT will be reviewing soil amendments and stabilizers to reduce sediments from right-of-way.

North Carolina Department of Transportation

NCDOT industrial facilities each have facility pollution prevention plans (FPPPs) in place. The DOT uses a targeted employee training program for source control. The DOT requires that all third parties verify that state stormwater requirements have been met before connecting to the DOT storm drain. In addition, the DOT maintains a litter control program, and sweeping program.

OGFC research is ongoing similar to investigations in California and Texas for source control of materials from vehicles. The DOT has also instituted a highly erodible soils project, with the target of eliminating problematic erosion areas within the right-of-way. The DOT also has education programs for pathogens and illicit discharges. Fertilizer is only applied during plant establishment periods.

The North Carolina DOT is transitioning to brine application prior to storm events with a high probability of snowfall. This approach reduces quantity of salt required to maintain acceptable conditions on the roadways.

Finally, the DOT in partnership with North Carolina State University (NCSU) operates an Integrated Roadside Vegetation Management (IRVM) system. The IRVM is a decision-making and quality management process for maintaining roadside vegetation that integrates cultural, biological, mechanical, and chemical pest control methods to economically manage roadsides for safety plus environmental and visual quality.

Oregon Department of Transportation

ODOT has an integrated vegetation management program (IVMP) targeted to minimize the amount of herbicides used in the right-of-way. The DOT design guidance specifies the use of native vegetation. Fertilizer is generally used only during planting. Special controls on fertilizer composition are in the standard specifications for the west (wet) and east (dry) sides of the state, as well as for plantings within 50 feet of open water. The DOT has restrictions on placement of fuel storage facilities at construction sites.

For winter traction aides, ODOT uses sand (gravel) and non-sodium chloride (NaCl) deicers. The deicers are tested for quality to make sure there are no contaminants in the chemicals. To some extent, deicers are used to reduce the amount of sanding material used to minimize sediment and turbidity impacts to streams. The DOT has an “Adopt-a-Highway” program for litter removal. State programs are in place that are helpful to the DOT, such as mandatory bottle deposits, reducing trash in the right-of-way.

Texas Department of Transportation

The "Don't Mess with Texas" public education campaign and Adopt-A-Highway program for litter reduction has been very successful. The DOT develops and distributes materials that have an educational message intended to raise public awareness of storm water issues (brochures, inlet stencils, rain gauges, rub-on tattoos for kids, coloring books, wildflower seed packets, lesson plans for teachers, etc.).

The DOT is currently researching the benefits of permeable friction course (PFC) overlays, which reduce pollutants washed from undercarriage of vehicles. DOT maintenance facilities are regularly inspected. No lead is used in paint on the right-of-way. Slow release nitrogen fertilizer is applied only during initial vegetation establishment and in two phases to minimize release to the environment. When salt is applied, it is typically swept up after the weather event. Certification is required for pesticide (herbicide) application personnel. The DOT primarily uses post-emergent herbicides, and has an environmental evaluation program for herbicides. The dispensing equipment in herbicide and de-icing trucks is calibrated to ensure proper application rates.

Virginia Department of Transportation

The Virginia DOT has a public education campaign targeting litter through the "Adopt-A-Highway" program for litter clean up on roadways and DOGIPOT pet stations at highway rest areas/welcome centers for pet waste control. The DOT tracks stormwater management facility cleanouts. The DOT has a comprehensive public awareness campaign which promotes storm drain stenciling, develops and makes available for broadcasting public service announcements, installs watershed signs, operates a Stormwater Web page and actively participates in local activities aimed at increasing public awareness of water quality and stormwater issues. The DOT in conjunction with Virginia Tech is developing a nutrient management program that will establish fertilizer application rates linked to soil test results. The DOT also has Spill Prevention, Control, and Countermeasures (SPCC) Plans at its maintenance facilities to prevent the discharge of oil and other compounds into water bodies.

Washington State Department of Transportation

The Washington State DOT is supporting source control of heavy metals through the product manufacture process. Washington adopted a brake pad bill (SSB 6557) in June 2010 that sets out a timeline to work with manufactures to eliminate copper from vehicle brake pads in Washington. They have established a litter control program using volunteer groups and the Ecology Youth Corps (a state program). The DOT has a roadside management program for reduction in use of herbicides and fertilizers. Street sweeping is used to clean shoulders up-gradient of catch basins, and they are proposing use of high efficiency sweepers as a BMP in those areas where conventional water quality BMPs cannot be used, such as on floating bridges, and at ferry terminal holding lots.

Wisconsin Department of Transportation

The Wisconsin DOT uses various combinations of salt and sand and deicers, depending on receiving water sensitivity and roadway (temperature) conditions. The DOT has a requirement for a comprehensive street sweeping in the spring season to remove material from the roadway following snowmelt. The DOT does not apply fertilizer, and is currently sponsoring a research

project with the University of Wisconsin to develop a seeding policy that does not require fertilizer or herbicide application. The DOT has an "Adopt-A-Highway" program for litter.

OPPORTUNITIES FOR SOURCE CONTROL FOR DOTs

The most immediate opportunities for source control of constituents may be provided for those constituents that are present in the right-of-way with a source that is significant compared to that from vehicles and atmospheric deposition. It will be important to quantify the load from the various constituent sources both within the right-of way and external to the right of way to determine the appropriate source control strategy that will provide the most return on investment.

Metals

Copper, lead and zinc each have various sources within the right-of-way. The dissolved form of these metals is responsible for sub-lethal effects and toxicity to aquatic life in receiving waters; however, receiving water chemistry makes both dissolved and particulate forms of metals important since metals can move in and out of solution, depending on the environment. It is recommended that source control studies be conducted to identify the source of these metals in the environment, so that the highest priority (largest source) for each can be targeted with an effective source control program.

Copper

Copper is present in vehicle brake pads and in treated lumber (lumber treated with CCA or ACZA). Other sources may include exhaust emissions and PCC concrete that uses plasticizers. Two states (California and Washington) have passed legislation to reduce the copper content in vehicle brake pads.

The use of CCA and ACZA treated lumber is being phased out. EPA has classified CCA as a restricted use product, for use only by certified pesticide applicators. As of December 31, 2003, the pressure treated wood industry discontinued the use of CCA as the primary wood preservative used for most residential and general consumer construction. Products alternatives, such as borates may be specified as substitutes to CCA and ACZA.

It is unknown at this time whether the copper present in PCC plasticizer is a significant source for highway runoff. Further study is needed to determine if the copper in the plasticizer can become mobile following pavement abrasion, and if the load from this source is significant compared to other sources, the most significant of which is believed to be wet and dry deposition.

Lead

Lead is present in tire weights, brakes, diesel fuel, gasoline and paint. Many lead sources have been reduced or eliminated through true source control programs due to the problem of lead poisoning in humans. Some lead problems are due to legacy use of lead in gasoline that has contaminated soils adjacent to highways.

The most obvious source control options for lead within the right-of-way would appear to be lead tire weights. The European Commission banned the use of lead wheel weights in 2005 (Directive 2002/525/EC), and now most European wheels are balanced with zinc wheel

weights—another potential issue. Many states in the U.S. are acting on this issue to reduce or eliminate the use of lead wheel weights:

- California: Starting Jan. 1, 2010, California law prohibits the manufacture, sale, or installation of wheel weights that contain more than 0.1 percent lead.
- The State of Washington recently enacted legislation stating that a person who replaces or balances wheels on or after Jan. 1, 2011, must replace the weights with weights of alternative materials (House Bill 1033 [2009]).
- Maine enacted a ban on lead and mercury wheel-weight installation, effective January 1, 2010 (Legislative Document 986 [2009]).
- In Vermont, tires on state vehicles may not have lead wheel weights as of January 1, 2010, and any vehicle offered for sale in Vermont may not have lead wheel weights as of September 1, 2011.
- Minnesota is voluntarily phasing out the use of lead wheel weights in some state vehicle fleets.

Zinc

Zinc is one of the most widely used metals in the highway right of way. Zinc is used as a coating for most steel to reduce rust. Zinc coatings are sacrificial, meaning that zinc is lost as the coating ages, and may be discharged in dissolved form from the highway right-of-way. Tires also have a significant amount of zinc (about 1.5 lbs per tire) that may be responsible for a significant portion of zinc in highway runoff.

For the near-term, it would appear that DOTs should investigate the benefits of alternatives to zinc coated appurtenances. To the extent that zinc coated materials are used in areas that are directly connected via impervious surfaces to storm drain systems, or to storm drain systems constructed with zinc coated materials, they may be responsible for a measurable portion of the zinc load in highway stormwater discharge.

Nutrients

The use of fertilizers for plant establishment and plant maintenance is common, since highway construction can expose soils that are not well suited to sustain plant life. The use of non-native plant materials may also increase the need for fertilizer.

The significance of loading of nitrogen and phosphorus from applied fertilizers versus atmospheric deposition and (in the case of phosphorus) road sanding is unknown. Further research is needed to quantify the load contribution of various nutrient sources within the right-of-way.

DOTs should develop programs that emphasize xeriscape, the use of native plants, preservation of topsoil when implementing new and redevelopment projects. The use of reclaimed water may also be a viable option. Reclaimed water typically has enough nitrogen and phosphorus to support healthy plant growth without the use of supplemental fertilizer. Reclaimed water also reduces potable water demand and is part of a sustainable landscape management approach.

Salt and Traction Aides

The effects of sanding and deicing during the winter months have been shown in several studies to increase loadings of suspended and dissolved solids to receiving waters. Warrington (1998) cites results from studies in Ontario in which about 45 percent of applied road salt enters runoff. The accumulation of pollutants in snow banks after roadways have been plowed is also a concern. As snow banks begin to melt, the runoff with significant levels of pollutants can be transported to receiving waters. Glenn and Sansalone (2002) determined that winter maintenance practices generate significant levels of inorganic and organic constituents, many of which become particle bound in the snow banks with increasing residence time.

Work completed by Fischel (2001) for the Colorado Department of Transportation examined the effects of two common groups of deicers, chloride-based and acetate-based, on receiving waters. For each of the chloride-based deicers studied, higher salinity in the soil near the roadways was observed. Calcium, magnesium, and sodium ions are also suspected of contributing to the mobilization of trace metals to surface waters. All were found to create relatively low levels of toxicity to fish and aquatic invertebrates but were thought to have adverse effects on terrestrial vegetation. Results from the study of acetate-based deicers show that the breakdown of acetate ions may cause oxygen depletion in roadside soils and receiving waters. The deicers with potassium or sodium were found to have relatively high toxic effects on aquatic life, while those with magnesium were found to be relatively non-toxic. The deicers with sodium are also thought to have negative effects on the nearby terrestrial vegetation.

A number of other chemicals that act as abrasives, corrosion inhibitors, and anti-caking agents are also commonly added to road salts. Corrosion inhibitors are added to help prevent or reduce the formation of rust on vehicles and highway structures (e.g., guardrails and signs) due to the deicing agents. Fischel (2001) found that many of these proprietary inhibitors cause oxygen depletion in receiving waters.

Sanding materials are also frequently applied alone or with road salt to help increase traction during winter ice conditions. A study of runoff quality in the State of Washington (Asplund et al., 1980) found that a major fraction of solids loadings could be traced to sand used during these conditions. Fischel (2001) found that sanding materials added to deicing agents prior to application resulted in increased turbidity in receiving waters.

Warrington (1998) provides some methods for reducing the pollution from conventional road salt and deicing practices. These include:

- Reducing salt use by strictly following application guidelines
- Replacing some salt with sand (or vice versa) or by removing snow
- Pre-wetting the salt or sand/salt mixture
- Using advanced equipment such as special plows or remote monitors
- Using automated deicer sprays or infrared pavement temperature monitors
- Using anti-icing techniques and materials

DOTs should consider the above source control methods for road salt applications. Further research is needed into alternative methods to maintaining safe conditions on roadways with reduced salt application.

SUGGESTED RESEARCH AND DATA NEEDS

The CoP has developed research and data needs specifically focused on the control of sources of constituents in highway runoff discussed above. Details of selected research topics are contained in Appendix A.

ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations are used in this report:

AASHTO	American Association of Highway and Transportation Officials
ACZA	Ammoniacal-Copper-Zinc-Arsenate
BMP	Best Management Practice
BPP	Brake Pad Partnership
Caltrans	California Department of Transportation
CCA	Chromated-Copper-Arsenate
CCZ	Copper-Chromated-Zinc
CDOT	Colorado Department of Transportation
CoP	Community of Practice
DelDOT	Delaware Department of Transportation
DOT	Department of Transportation
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FHWA	Federal Highway Administration
FLDOT	Florida Department of Transportation
FPPP	Facility Pollution Prevention Plan
FTA	Federal Transit Administration
ILDOT	Illinois Department of Transportation
IVPM	Integrated Vegetation and Pest Management
MEP	Maximum Extent Practicable
MIDOT	Michigan Department of Transportation
MS4	Municipal Separate Storm Sewer System
NCDOT	North Carolina Department of Transportation
NCHRP	National Cooperative Highway Research Program
NCSU	North Carolina State University
NHDOT	New Hampshire Department of Transportation
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NYSDOT	New York State Department of Transportation
ODOT	Oregon Department of Transportation
OGFC	Open Graded Friction Course
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyls
PFC	Permeable Friction Course
PM	Particulate Matter
SB	Senate Bill
SPCC	Spill Prevention, Control and Countermeasures
SSB	State Senate Bill
TMDL	Total Maximum Daily Load
TRB	Transportation Research Board
TSS	Total Suspended Solids
TXDOT	Texas Department of Transportation
WISDOT	Wisconsin Department of Transportation
WSDOT	Washington State Department of Transportation

RESOURCES

Center for Environmental Excellence by AASHTO, http://environment.transportation.org

Practitioner's Handbooks Webinar: 13. Developing and Implementing a Stormwater Management Program in a Transportation Agency, available at http://environment.transportation.org/center/products_programs/webinar_handbook_13.aspx
Description: Assists transportation agencies in developing and/or implementing a storm water management program that satisfies the requirements of the Clean Water Act

NCHRP Report 448: Environmental Impact of Construction and Repair Materials on Surface and Ground Waters Summary of Methodology, Laboratory Results, and Model Development (2001). This report summarizes the research conducted in NCHRP Project 25-09 to develop a new testing technology to realistically estimate how conventional, recycled, or waste highway construction and repair materials may affect surface and ground waters in environments surrounding highway rights-of-way. The methodology involves simple, standard aquatic toxicity screening tests that may lead to more detailed laboratory evaluation tests, and a computer model that uses the test results in computing the concentrations and loads of mobile toxicants at the highway site boundary.

NCHRP Report 443: Environmental Impact of Construction and Repair Materials on Surface and Ground Waters – publication from NCHRP Project 25-09, which looked at the Environmental Impact of Construction and Repair materials on Surface and Ground Waters. The research team identified potentially mobile constituents from highway construction and repair materials and whether they were conventional, recycled or waste products and measured their impact on surface and ground waters. The research excluded constituents originating from construction processes, vehicle operation, maintenance operation and atmospheric depositions. The study focused on the leachates from pavements and other construction and repair materials. It did not address contaminants deposited on pavements from external sources, such as from vehicles or atmospheric fallout.

Oregon Department of Transportation Research Section, "Copper Speciation in Highway Stormwater Runoff as Related to Bioavailability and Toxicity to ESA-Listed Salmon." (April 2011). The overall objective of this study was to develop a fundamental framework for estimating the likely impact of copper in highway stormwater runoff that discharges to surface receiving waters inhabited by ESA-listed fish species in the State of Oregon. This guidance will allow ODOT to predict when, where, and to what extent copper toxicity is likely to be a problem and will inform NMFS in their assessment of the risks associated with transportation projects. Measurement of copper speciation and the concentrations of other constituents that influence copper toxicity are keys to this analysis and therefore were the focus of this work.

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APPENDIX A:

Selected Research Statements

A. Research Title:

Contribution of Zinc from Highway Fixtures: Targeted Monitoring

B. Research Title:

Contribution of Tire Weights to Lead in Runoff

C. Research Title:

Salt/Deicing Practices Source Control

D. Research Title:

Nutrients (Nitrogen/Phosphorus) Source Control

CoP Research Proposal
Source Investigation and Source Control for Highway Runoff

Contribution of Zinc from Highway Fixtures: Targeted Monitoring

Scope

Zinc is an important targeted constituent for Departments of Transportation (DOTs). The average concentration in highway runoff exceeds water quality objectives. A number of receiving waters in the United States are listed as impaired for zinc and Total Maximum Daily Loads (TMDLs) have been adopted or being developed. These TMDLs currently require DOTs to construct and operate structural Best Management Practices (BMPs) at substantial costs to treat the storm water at the end-of-pipe. A potentially more cost-effective approach for managing zinc in storm water would be to remove the sources from the highway environment. Unfortunately, little is known about the relative magnitude of the various sources. This project is designed to fill part of that knowledge gap. The work will include an analysis of the potential reduction in lifespan of highway infrastructure and the associated costs if zinc use is curtailed.

Purpose and Benefits

This study could include a Laboratory Preliminary Evaluation, during which manual grab samples will be collected from runoff leaving individual galvanized fixtures (portions of guardrails, signs, signposts, building roofs, etc.) during the dry season by spraying deionized water on the fixture and collecting the runoff. The purpose is to determine if the quantity of zinc leaching from fixtures is likely to be significant source of pollution in highway stormwater runoff. Detailed observations will be made of the fixture locations, fixture surface area exposed to stormwater, and the flow path for the runoff they create, so that estimates can be made of the proportion of this runoff that reaches the catchment monitoring location. The objective of this monitoring will be to determine the contribution of zinc from individual components in the watershed that is discharged from various sources. For some cases, it is likely that zinc from appurtenances is not mobilized beyond the immediate area due to adsorption to sediments.

Product: Estimates of quality and quantity for runoff from individual fixtures.
A simple model, perhaps in spreadsheet form, will be developed to estimate the total mass of zinc derived from individual sources during the events monitored. The objective is to determine the relative contribution from each of these individual sources and then to make a mass balance comparison with the load observed at the catchment outlet to assess their contribution of zinc relative to all other unquantified sources (tires, rainfall, dry atmospheric deposition, etc.)

A statistical analysis also will be performed to determine whether coating galvanized fixtures with an inert substance reduces the concentration of zinc in runoff.

Product: Mass balance to determine relative and overall contribution of zinc in runoff.

Urgency

Metals are a target constituent for DOTs and must control them in their discharge, to the maximum extent practicable (MEP). This research will assist DOTs in prioritizing the sources of zinc in their runoff, and allow them to fashion effective mitigation programs (BMPs). This work is particularly urgent in that metals TMDLs are becoming common across the country and this research will be an important component for use in the TMDL implementation process as well as for the traditional elements of the DOT stormwater program.

CoP Research Proposal
Source Investigation and Source Control for Highway Runoff

Contribution of Tire Weights to Lead in Runoff

Scope

Lead tire weights used to balance wheels may be a substantial source of lead in the highway environment. These weights are sometimes released from wheels and then abraded by traffic, releasing lead into the environment. Lead wheel weights are used worldwide to balance vehicle tires. An estimated 64 million kg/year (70,000 tons/year) of lead is used worldwide in the manufacture of wheel weights. Automobile and light truck wheel weights vary in size and weight, ranging between 5-150 millimeters (0.2-6 inches) in length and 7-113 grams (0.25-4 ounces) in weight. A typical vehicle contains between 200 and 250 grams of lead in wheel weights. Excluding the vehicle's lead-acid battery, wheel weights are the number-one ongoing automotive use of lead.

Material collected during street sweeping operations will be analyzed. An attempt will be made to extract both whole and abraded wheel weights from the other material collected using density separation. This would provide a good measure of the amount of lead lost from wheels on a curb mile basis. These lead weights could be placed in a water solution with a pH similar to that observed in rainfall to determine the rate of leaching. The weights could also be tumbled to simulate abrasion and then retested to determine if broken surfaces increase the rate of leaching.

Product: Information on the amount of lead retained in the highway environment.

Purpose and Benefits

The U.S. EPA has declined to regulate the use of lead in wheel weights based on the limited data available (U.S. EPA, 2005). They indicated that additional information related to environmental impacts in the highway environment was needed. The purpose of this research is to provide this information:

- Whether abrasion of lead wheel balancing weights occurs on the road, and, if so, the extent of the abrasion and the mass of lead lost from the abrasion;
- The contribution of lead from wheel balancing weights to the overall levels of lead near roadways;
- The quantity of lead from lead wheel balancing weights deposited on highways that subsequently enters various environmental pathways; and
- The percentage of deposited lead that enters each pathway (to determine which pathways are of concern).

The work will include collection and evaluation of the amount of lead contributed to highway runoff by lead tire weights. This evaluation includes the contribution of both in-place weights and weights lost during use.

Urgency

Metals are a target constituent for DOTs and must be controlled in their discharge, to the MEP. This research will assist DOTs in prioritizing the sources of lead in their runoff, and allow them to fashion effective mitigation programs (BMPs). This work is particularly urgent in that metals TMDLs are becoming common across the country, and this research will be an important component for use in the TMDL implementation process, as well as for the traditional elements of the DOT stormwater program.

CoP Research Proposal
Source Investigation and Source Control for Highway Runoff

Salt/Deicing Practices Source Control

Scope

The objective of this study is to determine the optimum timing and application rates of various deicing materials. A variety of standard tests can be conducted to determine the effectiveness of various chemicals, including:

- Ice Melting
- Ice Undercutting
- Ice Penetration
- Controlled Site Testing

The following five chemicals have been used extensively for liquid anti-icing treatments: sodium chloride (NaCl), magnesium chloride (MgCl2), calcium chloride (CaCl2), calcium magnesium acetate (CMA), and potassium acetate (KAc). Each has its own set of pros and cons, dependent upon application location and cost sensitivity. There are other chemicals that are becoming more common, as well as a number of additives to "fix" one or another property of the parent chemical.

Study shall include fiscal component based on optimal application processes. The range of temperature for chemicals for optimal performance should also be evaluated. Additionally, the environmental concerns shall be detailed also based on optimal application processes. BMPs to mitigate possible environmental concerns could be incorporated into the analysis including financial aspects.

Purpose and Benefits

The benefit of the study is to determine the optimal practice for roadway winter practices/ice control. Receiving waters in areas of the United States are impaired for salts/chlorides, either 303(d) listed or enforced through Total Maximum Daily Loads. DOTs are named stakeholders for certain Salts TMDLs.

This research is intended to provide a common ground between the highway and regulatory communities targeting environmentally responsible deicing practices that employs feasible and economically prudent strategies for the safe operation of the roadway.

Urgency

To highway agencies, deicing operations are an essential element to maintaining the safety of the traveling public. Given the expectations of the public and the scarcity of public highway funding, we need to optimize deicing practices with a balance of fiscal, environmental and safety concerns.

CoP Research Proposal
Source Investigation and Source Control for Highway Runoff

Nutrient (Nitrogen/Phosphorus) Management and Source Control

Scope

EPA has reported recently that the amount of nitrogen and phosphorus pollution entering our waters has escalated dramatically over the last 50 years, and that this trend will continue with U.S. population growth (EPA 2011). In addition, EPA has developed numeric nutrient criteria in Florida and has suggested numeric requirements be incorporated into NPDES Permits for TMDLs (EPA 2010). EPA has also begun dialogue to work in partnership with states to address phosphorus and nitrogen pollution using a framework for state nutrient reductions (EPA 2011). EPA acknowledges that nutrient pollution has the potential to become one of the costliest and most challenging environmental problems.

Many state DOTs have spent millions of dollars and are planning to spend billions of dollars collectively to comply with nutrient related regulations over the next several decades. DOTs have invested considerable research dollars in how to best control nutrient sourcing in the highway environment and have engaged in regulation development to better represent DOT contribution to nutrient loading. While significant progress has been made in understanding nitrogen and phosphorus cycling and nutrient management approaches in the highway environment, there is a need to document what has been learned, and develop equitable approaches to nutrient management in the linear environment on a watershed scale.

Therefore, it is recommended that additional nutrient research be performed to facilitate effective nutrient management and provide tools for DOTs:

- Quantify and develop concepts of nutrient sourcing in the highway environment. This would include providing a clear definition of nutrient sources and discuss variations in load due to geographic location.
- Develop and identify a summary of nutrient contributing mechanisms in the highway environment and identify loading rates, cost of removal, and comparison to other nutrient sources in the watershed.
- Develop a nutrient adaptive management framework for DOTs to implement that could be included in NPDES permits and address the EPA's current framework for nutrient management.

Purpose and Benefits

This research is intended to provide a common ground between the highway and regulatory communities, targeting environmentally responsible nutrient management that employs feasible, economically prudent strategies for the highway environment. To increase the probability of success, the regulatory community, highway drainage community, and the environmental water chemistry community should participate in both the development and review of the research results, with members of these communities included in the research team and review panel.

To highway agencies, nutrients are an essential element to maintaining the roadway turf and landscaping, an essential part of erosion control and pollution abatement. Thus, our focus must be to manage, not just eliminate nutrients. Given the limitations of a public, linear facility, and the scarcity of public highway funding, we need highway specific, cost effective treatment methods to satisfy our need to remove excess nutrients. These tools are expected to include both source controls and nutrient removal methodology.

Urgency

Nutrient management for DOTs has taken on a high priority with the proliferation of nutrient TMDLs in many states. There are few viable methods for nutrient reduction in highway runoff and a concise accounting of the sources as well as a framework for reduction is needed.