

**AN ASSESSMENT OF ROAD MAINTENANCE ACTIVITIES
IN FREDERICK COUNTY AND THEIR EFFECT
ON STORMWATER RUNOFF QUALITY**

PREPARED FOR:

**DIVISION OF PUBLIC WORKS
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MARYLAND**

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I. INTRODUCTION

This report has been prepared by Versar, Inc. under a contract supporting Frederick County's ("County") National Pollutant Discharge Elimination System (NPDES) Municipal Storm Sewer Permit activities. The County's NPDES permit (Permit No. MD0068397) requires that an assessment of road maintenance activities and their impact on stormwater runoff be performed and submitted to the Maryland Department of Environment (MDE).

This report is organized into nine sections. Section II describes the objectives and scope of the project. Section III discusses the general environmental impacts of road maintenance activities and the pollutants that are contained in highway stormwater runoff. Section IV describes the County road network system in terms of road miles, management districts and other pertinent information, and describes the County's current road maintenance program. Section V presents recommendations and alternative practices that could be implemented by the County in its road maintenance program. A cost-benefit analysis is presented in Section VI, followed by a proposed schedule for implementing alternatives in Section VII. Report conclusions are presented in Section VIII. References are provided in Section IX.

II. PURPOSE OF REPORT

The purpose of this report is to develop an assessment of the road maintenance activities currently followed by the County and the environmental impacts that such activities have on stormwater runoff. This assessment is required by the County's NPDES permit. It includes the following:

- Evaluation of street sweeping, litter control, deicing procedures, and herbicide application, and their effects on stormwater discharges;
- Analysis of alternative practices for reducing pollutants associated with road maintenance activities;
- Cost analysis summarizing cost savings or overages; and
- A schedule to incorporate alternative practices in road maintenance procedures.

III. IMPACTS OF ROAD MAINTENANCE ACTIVITIES ON STORMWATER RUNOFF

Roadway systems are a large part of the infrastructure of both urban and rural areas across the country. They require regular repairs and maintenance due to traffic use and climatic conditions. Roads, highways, and bridges are also a source of significant contributions of pollutants to our nation's waters. Contaminants from vehicles and activities associated with road construction and maintenance are washed from roads and roadsides when rain falls or snow melts. A large amount of this runoff pollution is carried directly to water bodies.

Runoff pollution is that associated with rainwater or melting snow that washes off roads, bridges, parking lots, rooftops, and other impermeable surfaces. As it flows over these surfaces, the water picks up dirt and dust, rubber and metal deposits from tire wear, antifreeze and engine oil that has dripped onto the pavement, pesticides and fertilizers, and discarded cups, plastic bags, cigarette butts, pet waste, and other litter. These contaminants are carried into lakes, rivers, streams, and ultimately to coastal ecosystems, such as the Chesapeake Bay.

The level of pollutants found in road and bridge runoff is variable and is determined by a number of factors in addition to traffic volume and climate. Other factors affecting pollutant levels include road surfacing material, surrounding land use, bridge or roadway design, the presence of roadside vegetation, roadside application of pesticides and fertilizers, wear and tear due to traffic, maintenance practices, and the frequency of accidents and spills that can introduce hazardous chemicals. In colder climates, the amount of deicer applied to melt ice and snow can also influence the level of certain pollutants in road runoff and its impacts on local water quality. Table 1 illustrates the contaminants that are typically present in runoff pollution from roads, highways, and bridges. Components of road runoff and their effects on aquatic systems are described below.

A. SEDIMENT

Sediment is produced when soil particles are eroded from the land and transported to surface waters. Natural erosion usually occurs gradually because vegetation protects the ground. When land is cleared or disturbed to build a road or bridge, however, the rate of erosion

TABLE 1
TYPICAL HIGHWAY RUNOFF CONSTITUENTS
AND THEIR PRIMARY SOURCES

Constituent	Primary Sources	Environmental Impacts
Particulates, Sediment	Pavement wear, vehicles, atmosphere, maintenance	In excess, this does not allow significant sunlight to penetrate into the water column, which halts photosynthesis and can result in a drastic change in the food chain.
Nitrogen, Phosphorus	Atmosphere, roadside fertilizer application	In excess, either of these two nutrients can cause an increase in both plant and animal life, which results in a depletion of oxygen in the waterway, otherwise known as cultural eutrophication.
Lead	Tire wear (lead oxide filler material, lubricating oil and grease, bearing wear)	Acute exposure to lead can result in delays in normal physical and mental development in young children and increases in blood pressure in adults. Chronic exposure to lead has been linked to cerebrovascular and kidney disease. Lead has the potential to cause cancer if exposure is over a lifetime. Lead does not appear to bioaccumulate significantly in fish, but does in some shellfish.
Zinc	Tire wear (filler material), motor oil (stabilizing additive), grease, galvanized highway structures (guard rails, bridges, sign posts, etc.)	In large doses, zinc causes stomach cramps and nausea. Ingesting high levels of zinc for several months may lead to anemia or damage to the pancreas.
Iron	Auto body rust, steel highway structures (guard rails, bridges, etc.), moving engine parts	For humans, iron in the water is more of a taste nuisance than a health hazard. The current aquatic life standard is 1.0 mg/L based on toxic effects.
Copper	Metal plating, bearing and bushing wear, moving engine parts, brake lining wear, fungicides and insecticides	Exposure to more than 1.3 ppm over short periods of time can cause stomach and intestinal distress, liver and kidney damage, and anemia in humans. Concentrations as low as 5-10 ppb could cause reduced growth or photosynthesis in algae or teratogenic effects in fish or amphibians.

Cadmium	Tire wear, roadside insecticide application	Exposure to more than 5 ppb over short periods of time can cause nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock, and renal failure. Effects from a lifetime of exposure over 5 ppb are kidney, liver, bone, and blood damage. High acute toxicity to aquatic life. Bioaccumulates in living tissues.
Chromium	Metal plating, moving engine parts, brake lining wear	Exposure to more than 0.1 ppm for a short period of time can result in skin irritation or ulceration. Effects from a lifetime of exposure over 0.1 ppm are damage to the liver, kidney, circulatory, and nerve tissues; and skin irritation. High potential for bioaccumulation in aquatic life.
Nickel	Diesel fuel and gasoline, lubricating oil, metal plating, brake lining wear, asphalt paving	Long-term exposure can cause decreased body weight, heart and liver damage, and skin irritation. Nickel can accumulate in aquatic life, but its presence is not magnified along food chains.
Manganese	Moving engine parts	In humans, very large doses of ingested manganese can cause some diseases and liver damage. Permanganates have been reported to kill fish in 8 to 18 hours at concentrations of 2.2 to 4.1 mg/L.
Cyanide	Anti-cake compound used to keep deicing salt granular	Exposure to more than 0.2 ppm for short periods of time can result in rapid breathing, tremors, and other neurological effects. Effects from a lifetime of exposure over 0.2 ppm are weight loss, thyroid effects, and nerve damage. Because cyanides rapidly evaporate and are broken down by microbes they are not likely to accumulate in aquatic life.
Chlorides of Sodium, Calcium	Deicing salts	Corrosive compound. Toxic to vegetation and aquatic life.
Petroleum	Spills, leaks, or blow-by of motor lubricants, antifreeze and hydraulic fluids, asphalt surface leachate	Toxic to vegetation and aquatic life.

Source: U.S. EPA, 1993

increases. The vegetation is removed and the soil is left exposed, to be quickly washed away by wind or the next rain, if not properly controlled. Erosion around bridge structures, road pavements, and drainage ditches can damage and weaken these structures.

Soil particles carried by surface water runoff settle out of the water in lakes, streams, or bays and are deposited onto aquatic plants, rocks, and the bottom. This sediment prevents sunlight from reaching aquatic plants, clogs fish gills, chokes other organisms, can smother fish spawning and nursery areas, and can interfere with navigation.

Other pollutants such as heavy metals and pesticides adhere to sediment and are transported with it by wind and water. These pollutants degrade water quality and can harm aquatic life by interfering with photosynthesis, respiration, growth, and reproduction.

B. OILS AND GREASE

Aquatic impacts can result when oils and grease are leaked onto road surfaces from car and truck engines, spilled at fueling stations, or discarded directly onto pavement or into storm sewers instead of being taken to recycling stations. Rain and snowmelt can transport these pollutants directly to surface waters.

In Frederick County, residents are encouraged to take used motor oil to one of the County's nine collection sites. Information about these locations is publicized on the County's web site.

C. HEAVY METALS

Heavy metals come from some "natural" sources such as minerals in rocks, vegetation, sand, and salt. The contribution of these sources depends on the geology of the area. Significant amounts also come from car and truck exhaust, worn tires and engine parts, brake linings, weathered paint, and rust. Heavy metals are toxic to aquatic life and can potentially contaminate ground water.

D. DEBRIS

Grass and shrub clippings, pet waste, agricultural waste from farm animals, food containers, and other household wastes and litter can lead to unsightly and polluted waters. Pet

waste from urban areas and agricultural waste from rural areas can add nutrients that are transported downstream to rivers and estuaries, contributing to over enrichment and oxygen depletion associated with eutrophication. Both agricultural and pet waste contribute harmful bacteria (such as *Escherichia coli* and Fecal Streptococci) and other pathogens (such as *Giardia* and *Cryptosporidium*) to aquatic systems.

E. ROAD SALTS

In the snow belt, road salt can be a major pollutant in both urban and rural areas. Snow runoff containing salt can produce high sodium and chloride concentrations in streams, ponds, lakes, and bays. Unnaturally high salinity can harm freshwater fish and other biota. The presence of free chloride ion promotes acidity in waters and can cause fish kills and changes to water chemistry. Salt spray kicked up by vehicles can also “burn” or otherwise stress roadside vegetation.

F. HERBICIDES

Herbicides can be transported from treated roadsides to the aquatic environment through spray drift, volatilization, overland runoff, or by infiltration to subsurface groundwater. Herbicides may volatilize before or after they contact foliage. The most direct route to adjacent waters, however, is through surface runoff. Because many of these herbicides are water-soluble, they are quickly transported from highway ditches to local waterways. In excessive quantities in rivers, streams, lakes, and bays, herbicides can be disruptive to the aquatic ecosystem and biota. The small streams that often parallel or cross roadways are particularly susceptible because their dilution capacity is small.

As Table 1 demonstrates, there are numerous pathways for pollutant deposition on roadways and bridges that can influence the water quality of stormwater runoff. Routine performance of general maintenance activities such as street sweeping, vegetation maintenance, and cleaning of runoff control structures can help alleviate the impacts of these pollutants. Modifications in roadway resurfacing practices and application techniques for salt and other deicers can also help reduce pollutant loads to stormwater runoff and protect the quality of receiving waters.

IV. COUNTY'S EXISTING ROAD MAINTENANCE AND REPAIR PROGRAM

This section describes Frederick County's existing road maintenance programs and practices. Maintenance of most County roads is conducted by the County's Department of Highways and Transportation (DOHT).

Frederick County, located in northcentral Maryland and encompassing approximately 664 square miles (424,960 acres), is divided into six districts for the purpose of administration and maintenance. Appendix A contains a map of the County displaying the six districts. There are a total of 1,240 road miles, 80 of which are urban, curbed roads. The County's roads are spread over five watersheds as shown in Table 2. Towns within the County are responsible for maintenance of their roads.

A. STREET SWEEPING

Generally, sweeping occurs once a year on the 80 miles of curbed roads, primarily located in the Spring Ridge and Urbana areas. In addition, sweeping is also performed before routine maintenance activities. In the past, the County Department of Highways and Transportation has borrowed a sweeper from the County's Reich's Ford Landfill, which is a simple brush and vacuum type sweeper. However, according to the County officials, the sweeper has not been very efficient in removing dirt and debris from the streets due to the fact that the water supply and the vacuum do not work well. This results in dust being spread around rather than removed. The County is currently looking at options for street sweeping such as acquiring contractors and/or rental equipment.

The material removed from the streets through sweeping is taken to the landfill for disposal. The County does not maintain records of the amount of dirt and debris collected from sweeping.

TABLE 2	
FREDERICK COUNTY ROAD SYSTEM BY WATERSHED	
Watershed	Road Miles
Upper Monocacy	393
Double Pipe Creek	74
Catoctin Creek	258
Lower Monocacy	473
Potomac	42
COUNTYWIDE TOTAL	1240

Source: DOHT, Frederick County. Breakdown by unpaved roads in each watershed is currently not available.

B. LITTER CONTROL

Litter is picked up when someone reports it and when manpower is available. Roadkills are picked up when detected or when reported. Deer is the most common animal species killed on County roads. Table 3 provides the number of deer carcasses removed from the roads in 2000-2001. A new trash collection program called the “The Big Sweep” was implemented and targets County roads, dump sites, and key locations within the County’s watersheds. The Big Sweep trash collection was held on March 23, 2002 and resulted in 525 volunteers participating to collect 13.04 tons of litter, 237 bags of recyclables, and 443 tires. The County is in the process of implementing an Adopt-A-Highway program and a Watershed clean-up program under which businesses would be encouraged to adopt a stretch of a roadway or watershed and be responsible for its general upkeep and appearance.

C. DEICING

Nationwide, sodium chloride and calcium chloride are the two most common anti-icers that prevent water from bonding to the road surface and forming ice. Once applied, the chloride ion in these chemicals bonds with the hydrogen of water to form an acid that can have adverse effects on aquatic life and water chemistry. Also, the acid characteristics of the slurry formed after application has a potential to corrode vehicles. To improve traction, the salts are typically mixed with sand or fly-ash for application.

The County gets a fair amount of snow, sleet, and freezing rain during a typical winter season and maintains a fleet of snow plows and spreader trucks to ensure that streets and roads are clear and safe for use. To that end, the County uses a mix of cinders (obtained from Pepco) and sodium chloride for deicing and traction control on snowbound roads. The number of deicing events varies between 10 and 20 times per season, depending on the amount on snowfall. Table 4 presents the amount of deicing material (mix of cinders and salt) used by event during the 2000-2001 season. The County performs calibrated spreading at the rate of 400 lbs per mile. Open-section roads are applied with cinder and salt mixture whereas closed-section roads are applied with pure salt. Open-section roads are defined as a road without a curb, while a closed-section road is curbed on both sides. Closed-section roads are generally present in commercial and urban residential areas. The reason that only salt is applied to closed-section roads is because cinder on curbed roads gets tracked into homes and businesses, thereby posing cleanup problems.

TABLE 3 DEER ROADKILL REMOVAL IN FY2001	
Road District	Number Removed
1	94
2	55
3	27
4	10
5	28
6	58
TOTAL	272

Source: DOHT, Frederick County

TABLE 4
DEICING CHEMICAL USAGE, WINTER 2000-2001

Week Ending	Loads of Mixture Used	Tons Used Over 1,208 Road Miles
11/24/00	4	36
12/15/00	129	1,161
12/22/00	41.5	373.5
12/29/00	304.5	2,740.5
01/05/01	183	1,647
01/12/01	220	1,980
01/19/01	333	2,997
01/26/01	7	63
02/02/01	120.5	1,084.5
02/09/01	121	1,089
02/23/01	284	2,556
03/05/01	118	1,062

Source: DOHT, Frederick County

Note: In most cases, the County uses a 60/40 mixture of sodium chloride and cinders for deicing and traction control during winter weather. In FY '01, the County spent approximately \$283,300 on salt purchases and approximately \$56,000 on cinder purchases. Another \$82,000 was spent on snow removal contractors. In addition, approximately 100 hours of overtime were authorized per County crew person for snow removal activities.

Salt for deicing activities is stored at six locations in the County as described below:

- Three 3,300-ton each salt domes are located at Urbana, Johnsville, and Thurmont. At each location, there are separate covered piles of pure salt and cinders.
- Approximately 8,000 to 10,000 tons are stored at Frederick under tarpaulin coverage. Here too, there are two piles, one for pure salt and one for cinders.
- At Wolfsville, 300 tons of salt and cinder mixture is stored in a rented building.
- At Jefferson, approximately 300 tons are stored in a barn.

To augment its own capacity, the County plans to build a 5000-ton facility in Myersville and is exploring the purchase of other property for a 3,500-ton storage facility. None of the current storage locations have individual NPDES permits. Both Jefferson and Myersville have equipment and vehicle storage.

The amount of deicing material used varies from season to season as can be expected. On as needed basis, the County also uses material from other sources such as Carroll County and the State storage dome at Point of Rocks. When using this option, the County replenishes the material used from these other sources.

The Department of Highways and Transportation has, within the last four years, researched and integrated salt-reduction procedures into its winter road maintenance programs. Following protocols recommended in the University of Wisconsin's manual, *Managing Snow and Ice Operations (1995)*, the Department has implemented measures such as use of salt/cinder mixtures, calibration of spreading rates, and spot salting. Staff training is conducted in 'Snow College'.

The County is planning to take additional steps to minimize adverse environmental impacts from deicing activities. One step will be to replace sodium chloride with the more environmentally-friendly liquid magnesium chloride. Also, as funds become available, the County is proposing to acquire additional new spreader trucks with more efficient calibration mechanisms that are managed directly from the cab. Two such trucks have already been purchased at a cost of \$90,000 each.

D. HERBICIDE APPLICATION

Most weeds found along a roadside are invasive species that have been carried there by migrating birds or vehicles. Frequently, these invasive species have out competed natural

vegetation in the disturbed ecosystem into which they are introduced. Many jurisdictions attempt to eliminate or reduce the extent of these invasive species.

The County applies herbicides to keep vegetation off the areas along guard rails on the roadside. Application is through spraying and is typically performed twice every year, once each in spring and summer, by certified applicators. Currently, the County has 14 certified applicators, one of whom is a senior applicator with years of experience. Table 5 presents the herbicide application data during 2001. According to officials, the amount of herbicides used annually has remained fairly constant in recent years. The County uses two different chemicals as herbicides—Razor and Pendulum. Razor is manufactured by Riverdale Chemical Company of Illinois and contains glyphosate as the active ingredient. Pendulum is manufactured by BASF Chemicals and contains 37.4% pendamethalin as the active ingredient.

Glyphosate is a broad-spectrum, non-selective, non-residual, post-emergence systemic herbicide used for control of annual and perennial plants including grasses, sedges, broad-leaved weeds, and woody plants. The chemical is taken up through the leaf surface, where it is then absorbed into the plant cells and translocated into meristematic tissues. Glyphosate's primary action is the inhibition of the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). This prevents the production of chorismate, which is required for the biosynthesis of essential aromatic acids that are used by plants in protein synthesis. Glyphosate is strongly adsorbed to most soils even those with lower organic and clay content, remains in the upper soil layers, and has a low propensity for leaching. Glyphosate's primary route of decomposition in the environment is through microbial degradation in soil. In soil, the average half-life is 60 days. Glyphosate enters aquatic systems through accidental spraying, spray drift, or surface runoff. For aquatic systems, sediment appears to be the major sink. It dissipates rapidly from the water column as a result of sediment adsorption and microbial degradation. The more suspended sediment there is the faster the rate of microbial degradation. In most bodies of water the half-life is a few days. Glyphosate does not bioconcentrate or bioaccumulate.

Pendamethalin is a selective preemergence herbicide used for the control of broadleaves and grasses. This chemical may be taken up by both root and foliage, while foliar absorption is the most effective. The mode of action is unknown, but related to cell elongation and division. Pendamethalin is strongly adsorbed to most clay soils and organic matter and moves very little. Insignificant levels of volatilization and photodecomposition may occur. Pendamethalin is applied by spraying. It is strongly adsorbed by most soils and is basically insoluble in water, thus it will not leach appreciably in most soils. An increase in organic matter and clay results in an increase in soil binding capacity. It does not degrade microbially unless anaerobic conditions are

TABLE 5. HERBICIDE USAGE IN 2001

Date	District	Pesticide Used	Strength	Amount Used	Road Names
5/02/01	3	Razor EPA #228-366	2½ gal-200 gal (1.25%)	120 gals	Grindstone, Canada Hill, Clark, Mt. Tabor, Monument, Milt Summers, Dalgren, Old Hagerstown, Station, James Street, Palmer, Pete Wiles, Brethren Ch. Hollow, Old Harmony, Valley View, Michel, Echo Lake
5/03/01	3	Razor	2½ gal-200 gal (1.25%)	80 gals	Hollow, Haw Bottom, Fishers Hollow, Brittle, Harmony, Coxey Brown, Crow Park, Highland School, Church Hill, Easterday, Harp Hill, Meeting House, Woodland Way, Pleasant Walk, Black Rock, Garfield, Brandenburg Hollow, Stot Hamyer, Pleasant Valley, Hays Road
5/04/01	5	Razor	2½ gal-200 gal (1.25%)	110 gals	Baker Valley, Flint Hill, Monarchy Bottom, Parks Mill, Mt. Ephrom, Lily Ponds, Ed Sears, Greenfield Road, Thurston, Dixon, Sugar Loaf Mountain
5/06/01	6	Razor	2½ gal-200 gal	110 gals	Daysville Road, Hoffman, Seacrest, Berry Vunecal, Linganore Road, ½ Plan Hedon Road, Rt. 144 from Bar Hollows Road to Mt. Airy, back to 75, from Boyers Mill to 70 Overpass, Meadow Road, Quinn Road, one way
5/07/01	5	Razor	2½ gal-200 gal (1.25%)	90 gals	Fire Tower, Big Woods, Prices Distillery, Ball Road, Reights Field, Reals Mills Road, Musettes, Ijamsville, Bartonsville Road, Kella La, Old Baltimore Pike, Pine Cliff Park, Raysmith, Baldwin Road, ½ Bar Hollows Road
5/09/01	5	Razor	2½ gal-200 gal (1.25%)	100 gals	Winsor, Browningville, Mill Bottom, Bill Moxley, Baldwin, Bartholows, Old Bar Hollows, Lynn Bord, Urbana Yard Fence
5/10/01	4	Razor	2½ gal-200 gal (1.25%)	95 gals	Carpenter, Ederone, Catholic Church, Horine, Mt. Lane, Mt. Philip, Mt. Zion, Old Swimin Pole, South Mountain Road, St. Marks, Virtsia, Arshermen, Gene Hemp, Cemetery Cr., Gapland, Pemie Woods
5/11/01	4	Razor	2½ gal-200 gal (1.25%)	100 gals	Gapland, Arnoldstown, Arnold, Cherry Lane, Store Road, Teen Barnes, Poole, South Clifton, Roy Shaner, Bennies Hill, Bidle Road, Quebec School, Pemie Woods, Boliver Road, Old Middletown, Holter, Figeville, Culler Road, Mt. Zion, ½ Elmer Derr

TABLE 5. HERBICIDE USAGE IN 2001

Date	District	Pesticide Used	Strength	Amount Used	Road Names
5/12/01	4	Razor	2½ gal-200 gal (1.25%)	30 gals	Ballenger Creek Pike, Crestwood Blvd, Pleasant Valley, New Design
5/15/01	4	Razor	2½ gal-200 gal (1.25%)	160 gals	Doubs, Fry, Elmer Deer, Lander, Mountville, Timberly Drive, Capstone, Penn Road, Bassford
5/16/01	6	Razor	2½ gal-200 gal (1.25%)	120 gals	Biggs Ford Road, Dublin, Devil Biss Bridge, Glade, Links Road, Gravel Hill, Links Bridge, Old Frederick, Shyrode Mill, Lewistown Road, Hessons Bridge, Angelborger, Spahrs, Quarry Road, Utica, Road, Ramsburg Road, Lenhart Road
5/17/01	6	Razor	2½ gal-200 gal (1.25%)	40 gals	Biggs Ford, Dublin, Dwellbliss Bridge
6/5/01	6	Razor	2½ gal-200 gal (1.25%)	190 gals	Legore Bridge, Lewistown, Crom, Gashouse Pike, Boyers Mill, McKegg, Old Annapolis, Lorie Court, Water Street, Staulfer, Kelly Road, Linganor, ½ 144 to Bartholows Road
6/12/01	6	Razor	2½ gal-200 gal	60 gals	Putman, Kemp Lane, Arburn, Morrisville Road, Baugher Road, Bethel Road, Mountaindale Road, Hamburg Road, Masser Road, Opossantown, Sundays, Ford, Yellow Springs, Indian Springs, Rokey Springs, Dist. 2 Good Intent Road, Simpson Mill
6/13/01	2	Razor	2½ gal-200 gal	100 gals	Kemar, Renner, Warner, Kemar Road ½, Simppsons Mill ½, Handboard Road, Bunker Hill, Nickleson Road, Haughes Church, Detor, Legore Road, Clyde Young, Oak Hill, Stiner Smith
6/19/01	2, 6	Razor	2½ gal-200 gal	200 gals	Quinn, Meadow, Yeagerstow, Glissons Mill, Kimmel, Timmons, Morrisville, Mapleville Road, Dolly, Hyde, Woodsville, Bottom Fordice Drive, Old Annapolis Road, Amy Terr, East Side Drive, Buffalo, Petty Coard, Harrisville, Sherly Binn, Chelsby Ave., Unionville Road, Boxwood Court, Sam's Creek, Leighroph, Bessie Clemson, Fountain School, Coppermore, Beverdam, Repp, Molassas

TABLE 5. HERBICIDE USAGE IN 2001

Date	District	Pesticide Used	Strength	Amount Used	Road Names
6/20/01	4	Razor	2½ gal-200 gal	40 gals	Crestwood Blvd.
6/21/01	1	Razor	2½ gal-200 gal	60 gals	Moser Road, Lamens, Hessons Bridge, Blacks Mill, Tongs Mill, Stevens, Old Frederick, Appolds, Apples Church, Graceham, Old Mill Road, Four Points, Keysville ½, Sixes, Sixes Bridge, Grimes
6/25/01	1	Razor	2½ gal-200 gal	110 gals	Creamy Road, Simmons, Four Points, Keysville Road, Annandale Road, Ballenger School, Bull Frog, Harney, Old Emitsburg, Shoemaker Road, Hornets Nest, Four Points, Bridge Road, Franklinville, Black Road, Grotto Road, Roddy Creek Road, Smith Road, Catocton Hollow, Eylers Valley Plant, Foxville, Deerfield, Raven Rock,, Bucklantz Road, Old Sahlsville, Sunshine Trail. Coppermine at 550
7/20/01	3	Razor, Pendulum	2½ gal-200 gal; 3 gal-200 gal	50 gals	Coxey Brown, Fishers Hollow, Echo Lake, Grindstone WN, ½ Harmony, Haw Bottom, Hollow, James Street, Milt Summers, Monument, Mt. Taber, Old Hagerstown, Old Harmony, Palmer Pete Wiles, Shookstown, Station, Walren, Ridge Road
7/23/01	3	Razor, Pendulum	2½ gal-200 gal; 3 gal-200 gal	20 gals	Brandenburg Hollow, Brethren Church, Forrest School, Foxville, Deerfield, Highland School, Pleasant Valley, Overlook School, Stoffle Myer
7/24/01	3	Razor, Pendulum	2½ gal-200 gal; 3 gal-200 gal	60 gals	Black Rock, Harp Hill, Woodlyn, Meeting House, Canada Hill, Church Hill, East and West

Source: DOHT, Frederick County

present and minimal losses can result from photodecomposition and volatilization. In soil the average half-life is 40 days. Pendamethalin can enter aquatic systems through accidental spraying, spray drift, or surface runoff. It is stable to hydrolysis, but may be degraded by sunlight. It is usually removed from the water column by binding to suspended sediment and organic matter. Once precipitated to sediment, it is rapidly degraded under anaerobic conditions. Pendamethalin is highly toxic to fish and can bioconcentrate and bioaccumulate.

As a policy, the County does not apply pesticides within 50 feet of streams or other waterways. With implementation of this “no-spray” buffer, the risk of Pendulum reaching surface waters is thus minimal, as this product does not move laterally through soils very well.

E. ROAD REPAIRS AND MAINTENANCE

1. Dust Control

Once a year, the County applies a pre-mixed solution of calcium chloride for suppression of dust during shoulder stabilization activities on unpaved roads. Calcium chloride works to control dust by retaining moisture for prolonged periods. Alternatives to using calcium chloride for dust suppression are brine or magnesium chloride. Brine is produced from oil and gas wells or from brine treatment plants and wells. In 2001, calcium chloride was applied in June and July during stabilization activities. Table 6 presents usage data for July 2001. During this application, approximately 65 road miles were subjected to 60,000 gallons of calcium chloride solution. Thus, approximately 923 gallons were applied per mile. In June 2001, approximately 27,000 gallons of calcium chloride solution were used. The amount of calcium chloride used for this purpose is in annual decline given that the County periodically converts a portion of its gravel roads to paved sections.

2. Road Striping

The County performs annual striping on 149 miles of roads. As funds allow, additional striping is performed one district at a time. Two districts may be completed in a single year. During the 2001 calendar year, approximately 297 miles have been striped as of the writing of this report. Table 7 shows the breakdown of roads that were striped during 2001.

The County uses a paint manufactured by Sherwin Williams with trade names of TM2256 and TM2257. They are fast-drying, waterborne traffic paints and meet all specification and performance requirements of the Maryland and Pennsylvania Departments of Transportation. The paints have a low concentration of volatile organic compounds (100 g/L)

TABLE 6. CALCIUM CHLORIDE USAGE FOR DUST CONTROL, JULY 2001

District	Mileage	Gallons of Solution Used	Gallons/Mile
1	12.19	11,000	902.38
2	9.30	9,000	967.74
3	15.84	15,000	946.97
4	7.43	7,500	1009.42
5	17.50	15,000	857.14
6	2.62	2,500	954.20

Source: DOHT, Frederick County

TABLE 7
ROAD STRIPING IN FY2001

District	Center Lane Miles	Edge Miles	Total Striped Miles
1	14.6	15.14	29.74
2	30.98	27.27	58.25
3	96.27	84.85	181.12
4	61.03	85.73	146.76
5	21.46	25.2	46.66
6	59.96	57.42	117.38
TOTALS	284.3	295.61	579.91

Source: DOHT, Frederick County

and good resistance to early washout as long as no water or other soluble solvents are added, which would adversely affect drying time.

3. Road Repairs

Frederick County's Pavement Management Program (PMP), initiated in FY'01, manages road repairs in several phases. The phases are:

- Routine Maintenance;
- Preventative Maintenance;
- Overlay; and
- Recycling/Rehabilitation.

The foundation of the Department of Highways and Transportation's new Pavement Management Program (PMP) is Road Surface Management Software (RSMS). RSMS was successfully implemented in FY'01 and FY'02, including the completion of pavement distress surveys for approximately 823 miles of asphalt-surfaced roads in FY'01 and approximately 363 miles of tar-and-chip/gravel-surfaced roads (and 56 facility parking lots/access roads) in FY'02. The PMP program goal is to use the County-wide pavement distress ratings and the RSMS program results as a planning tool to optimize the use of limited County funding and preserve the serviceability of the County roadway infrastructure, as a whole.

The Overlay FY'03 contract is an integral part of the implementation of this methodology in Frederick County. The overlay process consists of limited patching and other repairs to the existing surface, where needed, which serves as the base for subsequent placement of bituminous asphalt concrete leveling and resurfacing courses.

The County performs routine road repairs throughout the year. These typically include:

- Re-chipping of the road, which involves replacement of the polymer asphalt;
- Pavement patching and repair;
- Repair of culverts to include new wall sets and head walls;
- Bridge rehabilitation and repair;
- Pipe repair and replacement;
- Rip-rap replacement; and,
- Conversion of gravel roads.

These activities are generally performed on an as-needed basis and are subject to the availability of funds. Re-chipping, for example, is typically performed at the rate of 50 road miles per year. Prior to performing any road repairs, the County obtains proper authorization from the Maryland Department of the Environment and from the U.S. Army Corps of Engineers, Baltimore District.

The types of stormwater runoff precautions the County uses during road repair activities include filter cloth, matting, rip rap, silt fence, and sand bags. These are all used to intercept excess sediment while allowing water to percolate through. Pumps are used for dewatering.

Conversion of gravel roads is an ongoing process. In the past 15 years, the length of gravel roads has been reduced from 300 miles to 68 miles. During the past year, 7.68 miles of gravel roads have been converted as shown in Table 8. Conversion of an additional 5 miles is planned in the next two years. The County balances the conversion of gravel roads against the desire of some communities to preserve the rustic nature of such roads. Where such sentiment prevails, the gravel surfaces are preserved. In some cases, gravel roads can prove to be beneficial due to the fact that they are more pervious than paved roads, although gravel roads may increase the amount of sediment that is carried in the stormwater runoff.

In 2001, Frederick County conducted a study to test various binder materials for use on gravel roads. Binder materials hold the aggregate together and maintain the integrity of the road surface. However, materials vary in their ability to bind the aggregates effectively and also in their longevity. The County tested Calcium Chloride from Calcium Chloride Sales, Inc.; Ultrabond by JMG Enterprises; and, TopSeal by DiCarat Association. All three chemicals were tested or used on three stretches of gravel roads. Two of the chemicals used, CaCl and Topseal, resulted in potholes after three months. Study results show Ultrabond to be the most effective binder material thus far, though the study is ongoing and other materials may be tested.

TABLE 8. CONVERSION OF UNPAVED ROADS IN FY2001

District	Road	Mileage
1	Irishtown	0.62
3	Crow Rock	0.45
3	Tower	1.05
3	Coxey Brown	1.15
5	Cook Brothers	1.56
2	Ward Kline	0.85
2	Harp	2.0

Source: DOHT, Frederick County

V. RECOMMENDATIONS FOR ALTERNATIVE PROCEDURES OR IMPROVEMENTS IN EXISTING COUNTY PROCEDURES

This section presents recommendations for additional and alternative procedures that Frederick County can implement to minimize the level of pollutants in road runoff. In large measure, these are best management practices (BMPs) that County personnel could incorporate in their maintenance activity schedule. Many of these practices (as well as others) are already being implemented by County personnel, as documented in the County Division of Public Works (DPW) memorandum, Highway Operations' Policy and Procedures, dated July 20, 2000. Because this report is meant to be a reference document for recommended practices, suites of applicable BMPs for various road maintenance activities are listed below, including ones that County personnel already implement. For example, the County follows erosion and sedimentation control measures in accordance with currently accepted practices, such as the use of filter cloth, matting, silt fence, sand bags, and dewatering pumps. The BMPs and recommendations presented below were developed based on experience with non-point source pollution and from researching documents produced by U.S. Environmental Protection Agency and others related to road runoff. The recommendations are discussed by activity.

A. STREET SWEEPING

Street sweeping is one of the most cost-effective BMPs in an urban environment for minimizing runoff pollution from paved surfaces, primarily because it reduces pollutant levels at the source. Hydrocarbons, pesticides, animal waste, antifreeze, and heavy metals, as well as silt and sand, reside on the roadways (inside minute cracks and adhering to aggregate) waiting for a good rain that will carry them to a surface water body. If these pollutants can be captured effectively right off the roadway, it reduces the need for other, more expensive BMPs.

Equipment. Advances in street sweeping technology today make it possible to pick up enough of these non-point source pollutants to help municipalities substantially reduce stormwater pollution. It is up to a municipality to pick the right kind of sweeper for its needs. Frederick County DOHT does not own street sweeping equipment and borrows a vacuum-type sweeper from the County's landfill when needed. The County's long-term plans include the purchase of a street sweeper. The most basic and the oldest kind is the *mechanical broom sweeper* that is designed to pick and collect larger size road debris such as stones, detached mufflers, roadkills, and large litter. The mechanical sweeper does not help in preventing toxic

pollutants from running off into streams and rivers. Studies have shown that they may actually make the water quality worse by removing the surface dirt to which the pollutant particles may have adhered and thus been prevented from going directly into the runoff. The mechanical action of the broom also breaks down the pollutants into smaller sizes, making it easier for them to be transported by flowing water. Approximately 90% of the street sweepers currently in use in the country are mechanical.

Regenerative sweepers came into existence approximately 25 years ago out of necessity. They were invented to help a road builder clean debris out of cracks and crevices of the road surface prior to bonding a new layer of asphalt on top of the old one. A regenerative sweeper blows a stream of air at the surface causing the fine particles to rise up and be caught through a vacuum system. A *vacuum sweeper*, in contrast, simply creates a vacuum at the road surface, sucking up the particles into the collection system. The force of a vacuum sweeper, however, cannot always reach into the tiny cracks, where a positive air force of the regenerative sweeper would be more effective¹.

Recommended Practices. Regardless of the type of sweeper being used, it is recommended that the County's street sweeping runs follow practices that maximize pollutant pickup:

- Ensure that street sweeping techniques collect pollutants rather than putting them into drains.
- Monitor cleaning areas to determine 'hot spots' for pollutants, and identify these areas to ensure they receive adequate attention. Examples of hot spots are high-traffic, downtown streets and streets located in light industry or workshop type areas.

¹ More recently, a new type of street sweeper has been introduced by Schwarze Industries of Huntsville, Alabama, a major supplier of road sweeping equipment. Their E-Series sweepers, *EV-1 and EV-2*, are small micron surface cleaners, that pick up and contain debris, and filter exhausted air, to 2.5 microns -- 1/28th the width of a human hair. The manufacturer claims that because the EVs use no water and offer secure containment, they can be used for handling hazardous or toxic material cleanup. The machines can pick up and allow recycling or proper disposal of a wide variety of material, including lead, copper, coal dust, gypsum, raw material powders and many more. When outfitted with an optional 'sock-and-auger' secure offloading system, the EV-series machines can pick up 2.5 micron material, keep it dry, and also keep it securely contained throughout the off-loading process.

Independent tests conducted on the EV-1 model have shown that the sweeper picks up considerably more pollutants and debris (up to 4 times more than a mechanical sweeper), and can result in a 30-40% reduction in pollutant loadings from streets even with limited use. The EV-1 is the most expensive kind, costing between \$240,000 and \$300,000. In contrast, a basic mechanical sweeper costs only about \$60,000. However, the EV-1 is cheaper to maintain in the long run and is a high-efficiency sweeper.

(This information is presented for comparison purposes and is not meant to be an endorsement of a specific product.)

- Coordinate street cleaning with other maintenance programs such as grass cutting and tree pruning. This ensures that the debris and waste will be collected upon generation.
- Arrange street cleaning to be in off-peak periods, as cleaning is easier with less vehicles on the road.
- Identify when ‘one-time’ cleaning is required, e.g., special events or road work.

It is also recommended that the County keep track of the amount of material collected during each sweeping run. Depending on the sweeping schedule and route, this data could be recorded by street or area swept. Keeping these data would enable the County to evaluate its sweeping practices and determine their efficiency in reducing pollutant loads.

B. LITTER CONTROL

Litter control programs can serve as important and effective measures to keep trash, waste oil, and other materials from reaching stream channels. In addition to the County’s current Big Sweep program and its efforts to establish an Adopt-a-Highway program and Watershed clean-up program, further educational efforts should be made to reduce litter at its source. Particularly in rapidly developing communities, the County should develop targeted educational programs or materials that educate citizens on the connection between roadside litter and its transport to local streams. This educational effort should include additional information about the harmful effects of improper disposal of oil and other hazardous materials. The County should continue to support oil recycling and hazardous waste drop-off programs.

C. DEICING

Deicing or snow and ice removal, consists of plowing snow from bridges, roadways, and shoulders, together with the application of chemicals to prevent water from bonding to the road surface and to create traction for vehicles.

Chemicals. Frederick County currently uses sodium chloride for deicing. Cinders (fly-ash) is used for traction control. The County already plans to augment its road deicing efforts with liquid magnesium chloride. It is also recommended that the County explore the feasibility of using alternative salts or additives such as calcium magnesium acetate (CMA) and potassium acetate (Kac), if not cost-prohibitive. According to the Federal Highway Administration (FHA), these two deicing chemicals are most benign to the environment because they form weak, biodegradable acids when applied. CMA is considerably more expensive than sodium chloride. However, both CMA and Kac result in less corrosion to infrastructure and damage to roadside

vegetation. In addition, the ability to use less material may offset the higher cost. It has also been demonstrated that adding brine to a salt-cinder mixture will significantly increase the rate at which ice and snow are melted. Salt treated with brine sticks to roads better because of the added moisture, which can result in a reduction of the overall amount of salt used.

Recommended Practices. The following practices are recommended for snow and ice removal:

- Ensure that the equipment is calibrated to optimum levels according to manufacturers instructions.
- Place barriers in site-specific locations, i.e., along streams or direct drainages to route deicing material away from water bodies.
- Reduce plowing speed in sensitive areas to prevent exposure to deicing material.
- Identify and create facilities to capture deicing materials, where practical using booms or other similar barrier materials.
- Ensure that the quantity of cinders applied is optimized relative to the amount of deicing material.
- Use alternative but equally effective products such as brine, calcium magnesium acetate, or potassium acetate when not cost-prohibitive.

The County should continue to integrate proper instruction on snow and ice removal BMPs into its training programs. In addition, guidelines for appropriate storage of road salts and other materials are given in Section E below.

D. HERBICIDE APPLICATION

Increasingly, states and municipalities are looking into alternative ways of spraying herbicides for vegetation control along guardrails and understructures. Residue from broad-based herbicide application has the potential to run off into adjacent streams and rivers and cause adverse effects to aquatic life. In fact, one of the two herbicides used by Frederick County, Pendulum, is known to be toxic to aquatic life. Care should be taken to ensure that Pendulum is not applied near surface waters.

Better Targeting. Several states have focused their efforts on better targeting of weeds and noxious vegetation, so that herbicide application can be minimized. Districts within the California Department of Transportation have mounted special sensors onto their equipment. These sensors, manufactured by a company in Ukiah, California, pinpoint the location of an undesirable plant and then target and spray the weed with herbicide. Each sensor views a 12-

inch wide area. When it finds weeds, it signals a spray nozzle to deliver a precise amount of herbicide directly at the weed and not the bare ground. According to the company, a side-mounted strip of sensors at the rear of a vehicle lets the unit target and spray roadside weeds at 10 miles per hour. Using the sensors cuts herbicide amounts and costs by 50 to 80% compared to broadcast or manual spot spraying.

At North Carolina State University, two researchers have come up with an herbicide applicator that can be attached to weed mowers. The unit applies a film of chemical to the weed stem as the plant is cut by the mower. The researchers claim that 70 to 90% of the herbicide is absorbed into the plant to prevent future growth. By contrast, in other methods, 80 to 90% of the sprayed chemical misses its mark and is wasted. The applicator is designed for use on rotary roadside weed cutters. A reservoir mounted on the cutter's deck holds the premixed chemical solution. A pump regulates the adjustable flow of chemical through the spindle shaft and out along the blade to an opening on the cutting edge.

A cheaper option, at least in the short term, is to train crews to identify undesired and inappropriate vegetation and perform selective spraying (foliar or basal) with the objective of encouraging growth in slow-growing, strong plant communities while destroying fast-growing, colonizer species. However, this option could be labor intensive and training costs could also be significant in a high turnover organization.

It is recommended that Frederick County explore these and other options to reduce the amount of herbicide applied along highways.

Recommended Practices. The County already has a policy in place banning herbicide spraying within 50 feet of a stream. It is recommended that the County incorporate better targeting equipment as old equipment is replaced. In addition, the following practices are also recommended for herbicide application:

- Ensure that the “no-spray” buffer extends to wetlands, to eliminate spray activities on structures located over any streams or adjacent to wetlands.
- Use only those chemicals approved for use near aquatic resources, or as directed by regulators.

E. ROAD REPAIRS AND MAINTENANCE

These are recommended BMPs for activities associated with road repairs and maintenance discussed by activity.

1. Storing Materials

Stockpiles of materials used in road construction and maintenance activities, such as sand and gravel, can contribute to stormwater pollution if rain or other water passes through or over them. Many other materials—petroleum products, sealants and paints, etc.—have the potential to adversely affect stormwater if they are not correctly stored on site.

Frederick County stores salt and cinders in large quantities for use in deicing activities. These storages are either domed or covered with a tarpaulin. While the potential for these materials to get into the runoff appears to be minimized, it is, nonetheless, recommended that Frederick County convert its tarpaulin-covered storage to a permanent structure.

In addition, the following general material storage practices are recommended to minimize the potential for stormwater pollution:

- Inspect stockpiles regularly to ensure 100% coverage at all times.
- Locate stockpiles away from waterways, roads, slopes steeper than 10%, and areas of concentrated water flow.
- Prevent runoff from washing through storage areas by locating stockpiles high on the site or diverting runoff around the site or the stockpile areas.
- Place sediment controls down gradient from stockpiles and provide weatherproof covering.
- Stabilize topsoil that is to be stockpiled for extended periods.
- Store potentially harmful chemicals in safe, secure, on-site storage facilities and in accordance with current regulations.
- Conduct training seminars for proper handling and application.

2. Asphalt Laying

Asphaltic concrete is commonly used as a surface on main roads and pavements that need a smooth finish. When used as pavement it is generally heated and mixed with aggregate off-site before being transported in a heated state to the site. The material is then deposited in layers using special machinery and compacted before curing into a solid mass. This has the potential to affect stormwater if runoff occurs before curing (because of the creosol and PAHs in the asphalt) or if compacting is inadequate.

The following material storage practices are recommended to minimize the potential for stormwater pollution from asphalt laying operations:

- Select sealing materials appropriate for site conditions, i.e., traffic volume, temperature, gradient, shade, humidity, etc.
- Time the laying so as not to coincide with rainfall during or immediately after sealing.
- Install sand bags next to stormwater inlets that receive drainage from the site.
- Sweep up loose metal from gutters immediately following the laying and routinely as required.
- Remove all waste and debris from the site.

3. Pavement Patching and Repair

Faults in the pavement, e.g. potholes and breaking edges, may be a source of sediments that can wash out during rain. Pavement patching principally involves patching a spot with a new surface, or replacing the sub-grade before resurfacing. Repairing pavements can contaminate stormwater with sediments if waste is not properly disposed of, compacting is inadequate, or runoff occurs before curing.

Sometimes reshaping and stabilization is needed, requiring the mixing of cement and lime before moistening, compacting, and replacing the surface. This lime and cement can wash off and enter waterways.

To minimize stormwater pollution from pavement repair activities:

- Monitor roads for potholes and fix them promptly.
- Do a pavement investigation to identify exactly how much work is needed and how best to do it. After the investigation, replace and compact soil into any auger holes and test pits, and seal them the same day.
- When stabilizing, mix materials during periods of calm, dry weather, and seal as soon as possible after dressing.
- Fill and compact soil, gravel, and asphalt in layers.
- Reuse spoil in repairs; otherwise sweep it up.
- Eliminate 'edge break' by fully sealing road shoulders.
- Dispose of used soil samples and excess spoil at a suitable fill site.

4. Road Striping/Line Marking

Striping is done on new as well as existing roads. Generally it involves applying either paint or thermoplastic material to the road surface by machine or by hand. Thermoplastics are organic materials that melt when heated. They are melt processable, or they are formed when they are in a melted or viscous phase. Line marking can have an impact on stormwater if the site is not cleaned properly or marking is done in the rain.

Line removal generally involves techniques such as grinding and sandblasting, resulting in residue that can be washed or blown into nearby waters.

To minimize stormwater pollution during striping activities, implement the following practices:

- Use water-based paints or thermoplastics rather than solvent-based ones.
- Avoid using materials while the pavement is wet, during humid conditions, or if rain is likely
- Avoid applying thermoplastics at low temperatures, i.e. below 13°C.
- When possible, use portable drip trays under equipment to catch spills
- Use a skirt around the blaster to minimize the spraying of material away from the work site
- Coordinate street-sweeping with line removal, so that waste material is picked up before it can be transported by rain, wind, and traffic.

5. Saw Cutting

Saw cutting of concrete, asphalt, and brickwork is periodically done as part of pavement repair, concreting, bricklaying, and sidewalk repair or placement. The grinding process produces a fine particle residue that combines with the cooling water to produce a slurry that typically ends up in the stormwater system.

The following practices are recommended to minimize the impact of saw cutting on stormwater pollution:

For small jobs (a typical County job is saw cutting a 3'x3' sized piece of pavement)

- Use as little cooling water as possible; switch the water off when the saw is not in use
- Prevent cooling water from flowing across exposed soil or other pollutants

- Where a stormwater inlet is next to the work area, that drain should be blocked completely and controls put in place between the worksite and the next stormwater inlet

For large jobs, the following additional measures may be taken

- Confine waste water to an infiltration trench or collect it for disposal off-site
- Use sand bags to slow the flow of water and allow sediments to settle; for larger jobs a sandbag dam may be needed
- Where sandbags are used, ensure there is enough capacity for materials to settle before treatment, disposal, or reuse
- At the end of a job, collect sediment and liquid from behind sandbags and within the gutter and dispose of it where the material will not wash into waters.

6. Maintenance of Unpaved Roads

Frederick County has approximately 68 miles of unpaved roads that carry local traffic between rural lands and communities, and provide connecting links between paved collector roads. Disturbances to unpaved roadway surfaces and ditches, and poor road surface drainage can result in deterioration of the road surface. This deterioration is evident in the resulting erosion, which accounts for a large percentage of unpaved road maintenance costs and can increase sedimentation within watercourses, streams, and rivers. Maintaining unpaved roads involves grading, patching, and re-sheeting of dirt or gravel. Each of these activities can affect the stormwater system through erosion and flow of sediments. Unpaved road shoulders (e.g., gravel shoulders) are also a source of sediments.

Erosion of unpaved roadways occurs when soil particles are loosened and carried away from the roadway base, ditch, or road bank by water, wind, traffic, or other transport means. Exposed soils, high runoff velocities and volumes, sandy or silty soil types, and poor compaction increase the potential for erosion. Loosened soil particles are carried from the road bed and into the roadway drainage system. Some of these particles settle out satisfactorily in the road ditches, but most often they settle out where they diminish the carrying capacity of the ditch, and in turn cause roadway flooding, which subsequently leads to more roadway erosion. Much of the eroded soil, however, ultimately ends up in streams and rivers, where it diminishes channel capacity, causes more frequent and severe flooding, degrades aquatic and riparian habitat, and otherwise adversely shocks water quality and aquatic habitat.

Reducing the potential for erosion is the key to minimizing the impact on unsealed roads on the environment. Proper, timely, and selective surface maintenance (which includes water disposal) prevents and minimizes erosion problems, thereby lengthening the life of the road

surface, which in turn lessens the frequency and cost of maintenance. This will also decrease the amount of sediment carried into surface waters. Below are practices that should be employed in the maintenance of unpaved roads to minimize erosion and runoff pollution. These elements should be part of a training program for Foremen and Highway Equipment Operations personnel.

1. Do not disturb roadway sections that *do not* need maintenance while repairing, blading, or grading those sections that do.
2. Avoid grading when the road is extremely dry.
3. When routine maintenance is being performed, limit the amount of disturbed areas to that which can be re-established to the desired final shape by the end of the work day.
4. To minimize opportunity for degradation of the roadway, it is best not to blade, grade, or drag if rain or freezing temperatures are likely within the 48 hour forecast.
5. As much as possible, avoid non-essential or non-emergency work near streams or stream crossings during the “wet” months of the year. Save this work for drier seasons.
6. It is best to limit roadway blading to times when there is enough moisture content to allow for immediate re-compaction. Often, an optimum time for this is soon after a rain while the surface materials are still moist but not too wet.
7. Proper crowning and compacting of the road surface quickens the removal of runoff, thus protecting the road surface from degradation. Crown roads 3/4 to 1 inch for each foot of road width, measured from the center of the roadway to the outside edge, to ensure good drainage.
8. Periodically blade the road surface against traffic flow to prevent aggregate from drifting onto ends of bridges, culverts, intersections, and railroad crossings. This is commonly referred to as “back dragging”.
9. Repair potholes, depressions, and soft spots periodically, using accepted and effective practices.

10. Consider small raised dirt or grassed dikes along roadsides that will direct runoff to acceptable culverts.

Recently, methods traditionally employed to maintain unpaved roads have been re-evaluated in Pennsylvania and, as a result, an Environmentally Sensitive Maintenance of Dirt and Gravel Roads program has been implemented statewide to foster the control of non-point source pollution (sediment and dust) originating along unimproved roads, thereby reducing their impact on streams and wetlands. The Center for Dirt and Gravel Road Studies at Penn State University has developed numerous techniques to improve both road and environmental conditions. These techniques include design and maintenance approaches (e.g., turnouts, water bars, broad based dips, grade breaks, ditches, culverts, stream crossings, road stabilization, and dust control), development of a driving surface aggregate specification, vegetation management approaches (e.g., selective removal of vegetation to discourage colonizing species, bank stabilization, shading/daylighting to prevent ice and dust), implementation of a training program for municipal road managers, and other materials to support this program. Since Frederick County's climatic, geologic, topographic, and road use conditions are similar to those in Pennsylvania, many of the techniques and information developed for the Pennsylvania program would be applicable and advantageous to use on the County's unpaved roads. Additional information on this program, including training opportunities open to out-of-state personnel, is found in Appendix C. Another good reference is the Gravel Roads Maintenance and Design Manual developed by the South Dakota Local Transportation Assistance Program (Skorseth and Selim 2002).

The County is currently testing different binder materials (such as Calcium Chloride, Ultrabond, and Topseal) for the stabilization of gravel roads. The results of this study should be evaluated and incorporated as applicable to reduce the potential nonpoint runoff of sediment and gravel to surface waters.

VI. COST-BENEFIT ANALYSIS

Many of the recommended BMPs in the report can be instituted at nominal cost, as part of the County's regular road maintenance programs. Several specific recommendations as outlined below, however, may incur additional costs. This section presents a largely qualitative analysis of the costs and benefits of implementing some of the additional measures

recommended in this report. A tentative schedule for implementing these measures is presented in Section VII.

1. **Purchase of Sophisticated Sweeping Equipment:** The County has long-term plans to purchase, subject to the availability of funds, a sophisticated street sweeper system. Table 9 presents a comparison of the various types of equipment available from Schwarze Industries. Appendix B includes manufacturer's brochures. While the EV-series sweepers are certainly better cleaners of roadways, their price is a deterrent for most municipalities. The A-series regenerative sweepers are the next best choice, and are, indeed, becoming more popular. These data are provided for informational purposes only and are not meant to be an endorsement of a specific product.
2. **Use of Alternative Deicing Chemicals:** Frederick County currently uses rock salt (sodium chloride) as the deicing agent mixed with cinders for traction control. Sodium chloride is an effective ice-melter and is inexpensive. It is, however, not very environmentally friendly; specifically it is highly detrimental to vegetation and aquatic life. It is also a corrosive compound that damages vehicles. Upon drying, it leaves a white residue, which gets washed away into the runoff.

Two alternatives to rock salt are magnesium chloride and calcium magnesium acetate (CMA). Both are less toxic than rock salt, with CMA being the most environmentally friendly of all. It is, however, the most expensive as well. Table 10 presents a cost and benefit summary of these chemicals.

Frederick County has decided to augment with magnesium chloride in its liquid form. As the table shows, it is approximately twice as expensive as rock salt. However, it is less corrosive and toxic to the environment. In terms of effectiveness, it works well at temperatures down to 5 F; by comparison rock salt loses much of its effectiveness at temperatures below freezing. Given CMA's extremely high costs, magnesium chloride is an appropriate choice for the County.

3. **Use of Alternative Herbicide Application Methods:** The report recommends better targeting methods to achieve more efficient use of herbicides. Techniques such as infrared sensing and application while mowing are still in their infancy and do not have reliable cost versus benefit data available. A qualitative assessment, however, would suggest that use of better weed-targeting methods, such as the California method described earlier in this report, would certainly reduce the amount of herbicide used, while applying it more effectively. Besides better targeting equipment, enhanced employee training in identifying undesirable vegetation for targeted removal would be a

TABLE 9
COST AND BENEFITS OF AVAILABLE SWEEPING EQUIPMENT

Model No.	Type	Key Features	Budgetary Price	Anticipated Effectiveness
M5000	Mechanical Power Sweeper	Basic broom type with 2 gutter brushes and 1 main broom. Debris Hopper is 5 CY. Uses water for dust suppression.	\$130,000	Less effective
A4000	Regenerative Air Power Sweeper	Can pick up PM-10 fines. Quieter operation. Debris Hopper is 4.3 CY.	\$85,000	Less effective
A7000	Regenerative Air Power Sweeper	Same design and operation as the A4000, except this is bigger in size (brooms, hopper, water capacity).	\$120,000	Moderately effective
EV-1, EV-2	Particulate Management System	High-end, sophisticated cleaner. Picks up PM-2.5. Waterless cleaning. EV-1 is bigger in size than EV-2.	\$225,000 to \$280,000	Both highly effective

Source: Atlantic Machinery, Inc., Silver Spring, MD (Authorized dealers for Schwarze Industries)

TABLE 10
COST-BENEFIT SUMMARY OF SELECTED DEICING CHEMICALS

Chemical	Benefits	Harmful Effects	Approximate Cost
Sodium Chloride	Inexpensive. Provides adequate ice melting capabilities in most instances.	Very corrosive. Toxic to vegetation and aquatic life. Leaves a white residue upon drying. Loses effectiveness quickly below 32° F.	\$3.25 per 50 lb bag
Magnesium Chloride	Less corrosive, safer around vegetation and on concrete. Deicing effectiveness down to 5F. Easy application because of liquid state.	Still has a measure of corrosivity and toxicity.	\$7.25 per 50 lb bag
Calcium Magnesium Acetate (CMA)	Very low corrosion effects. Low toxicity, biodegradable. Safe for concrete.	None.	\$45.35 per 50 lb bag
Potassium Acetate (KAC)	Biodegradable, low toxicity. deicing effectiveness down to -20° F and below. Safe for concrete.	Slightly corrosive unless mixed with a corrosion inhibitor.	

Source: Peters Chemical Company, New Jersey

low-cost alternative that, while not providing maximum benefit, would certainly reduce herbicide usage from present levels.

4. **Evaluate Alternative Herbicides:** Frederick County currently uses Pendamethalin as its selective preemergence herbicides for control of broadleaved weeds and grasses. Pendamethalin is effective and rather inexpensive. It is, however, an environmentally unfriendly chemical to aquatic life. Pendamethalin is highly toxic to fish and aquatic invertebrates. If alternatives are desired, the County should review its use of Pendamethalin and identify the amount, cost, and expected effectiveness of alternative treatments.

VII. PROPOSED IMPLEMENTATION SCHEDULE

This section proposes an implementation schedule for the specific recommendations identified in this assessment. Elements listed below are detailed in the previous sections.

Overall: Conduct an in-house review of all Recommendations for Alternative Procedures or Improvements in Existing County Procedures (see Section V) to implement changes to existing programs. Incorporate recommendations into staff training programs.

- **Schedule:** Conduct in-house review within 12 months of approval of report
- **Schedule:** Incorporate recommendations into staff training programs (ongoing)

A. Street Sweeping

1. Purchase/Lease more effective street sweeping equipment
 - **Schedule:** Investigate funding within 12 months of approval of report, purchase/lease within 48 months
2. Develop regular sweeping schedule for all closed section and selected open section roads, including identification of high use areas where higher frequency sweeping is desirable. Track amount of material collected and compile data annually by watershed to estimate effectiveness in reducing pollutants.
 - **Schedule:** Develop and implement sweeping schedule within 48 months

Litter Control

1. Continue to develop Adopt-a-Highway program; continue County support of community litter clean-up efforts such as the Big Sweep.
 - **Schedule:** ongoing
2. Develop educational program and distribute information on litter, oil recycling, and other steps citizens can take to reduce sources of litter
 - **Schedule:** Initiate program within 24 months

Deicing

1. Augment sodium chloride with magnesium chloride or other less damaging deicing agent
 - **Schedule:** Initiate conversion within 24 months
2. Acquire new computerized calibration equipment
 - **Schedule:** Ongoing, as equipment is replaced

Herbicide Application

1. Investigate alternative herbicide application methods and equipment; evaluate feasibility for use in Frederick County
 - **Schedule:** Within 24 months
2. Investigate alternative pesticides and herbicides to reduce potential harm to aquatic systems
 - **Schedule:** Within 12 months

Road Maintenance and Repairs

1. Assess need for further pollution prevention measures at county storage or equipment maintenance facilities (e.g., salt storage)
 - **Schedule:** Within 24 months
2. For unpaved roads, implement findings of comparative study of the effectiveness of binder materials
 - **Schedule:** Within 24 months of final evaluation

3. Develop and distribute guidelines for crews

- **Schedule:** Within 24 months

VIII. CONCLUSIONS

This report presents a baseline assessment of road maintenance practices currently employed by Frederick County and their potential adverse impacts on stormwater runoff. The report finds that while the County already implements a number of measures to reduce pollutants in runoff, additional measures can be taken to minimize pollution. These measures are discussed in the Recommendations for Alternative Procedures or Improvements in Existing County Procedures (Section V). A qualitative cost-benefit analysis of selected recommendations has also been presented, along with a proposed schedule for implementation.

In the future, the County's annual NPDES reports will document the measures taken to reduce pollutants in stormwater runoff from the County's roads. At a minimum, the County anticipates reporting on

- a. Cleaning inlets;
- b. Reducing the use of pesticides, herbicides, fertilizers, and other pollutants associated with roadside vegetative management practices; and
- c. Increasing the effectiveness of winter weather deicing materials through improved application, more efficient chemicals, and reduced toxicity of deicing chemicals.

Future reporting on storm drain inlet maintenance should be made easier by the recent efforts the County has initiated to map storm drains in its GIS system. It is expected that the improvements to data and software capabilities will facilitate better management of storm drain maintenance, emergency spill response, and watershed assessment efforts.

IX. REFERENCES

- Meetings, telephone conferences with the Office of Highway Operations, Frederick County.
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- Recommended Practices Manual: A Guideline for Maintenance and Service of Unpaved Roads, Choctawhatchee, Pea and Yellow Rivers Watershed Management Authority, State of Alabama, February 2000.
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- Routine Road Maintenance, Water Quality and Habitat Guide, Best Management Practices, Oregon Department of Transportation, July 1999.
- Stormwater Management for Road Construction and Maintenance, New South Wales Environmental Protection Agency, Australia.
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APPENDIX A

FREDERICK COUNTY ROAD SYSTEM & HIGHWAY DISTRICT BOUNDARIES

APPENDIX B

ROAD SWEEPING EQUIPMENT BROCHURES

APPENDIX C

**INFORMATION FROM PENNSYLVANIA'S
DIRT AND GRAVEL ROADS MAINTENANCE PROGRAM**

OVERVIEW OF PENNSYLVANIA'S DIRT AND GRAVEL ROADS MAINTENANCE PROGRAM

Sediment and dust generated from roads, particularly unpaved ones, are a major source of non-point pollution affecting streams, wetlands, and water quality in the Chesapeake Bay watershed and across the country. Pennsylvania has approximately 25,000 miles of unpaved roads, and the State Conservation Commission has developed a Dirt and Gravel Road Pollution Prevention Program to provide training, technical support, and funding to municipalities to help mitigate this non-point source pollution. Since 1997, the program has apportioned approximately \$14 million to County Conservation Districts who administer the program at the local level. The goal of the program is to (1) help road managers recognize the connection between road maintenance and the environment, (2) identify erosion, sediment, and dust pollution associated with dirt and gravel roads, (3) arm local maintenance staff with knowledge on the basic principals of nature and natural systems as applied to road maintenance and a healthy environment so that they can make on the ground decisions when standards do not fit local situations, and (4) convey information on road maintenance materials and techniques that can be effectively applied in both daily and special use situations to improve unpaved roads and also protect the environment.

Training and technical support is provided by the Center for Dirt and Gravel Road Studies at Penn State University, which offers a two-day course for road managers and maintenance staff on "Environmentally Sensitive Maintenance of Dirt and Gravel Roads." Courses, which are held in various counties across the state, cost approximately \$20 per person, which covers course materials, lunches, and snacks, and are open to out-of-state road personnel.

Techniques promoted by the program cover a wide range of road design and maintenance practices geared towards providing a more stable driving surface that will also resist erosional forces. Erosion of road materials not only causes road conditions to deteriorate, but also results in the deposition of road materials into adjacent streams and wetlands, where they are harmful to the plants and animals in these sensitive habitats. The training provides a toolbox approach, consisting of a variety of tools that may be used individually, or in conjunction with each other to address site-specific conditions. Tools in the toolbox include methods to reduce and disperse concentrated flows of water that can lead to erosion (e.g., turnouts, water bars, broad based dips, grade breaks), design and maintenance approaches to stabilize ditches and culverts to prevent sediment transport and minimize sediment deposition into streams at stream crossings, and effective approaches for road stabilization and dust control that minimize or avoid the use of potentially harmful chemicals. An Aggregates Handbook has also been developed that contains specifications for purchasing and placement of driving surface aggregate, as well as procedures for testing the quality of the delivered material. Rather than applying aggregate specifications developed for base course material in paved roads to the driving surface of unpaved roads, these specifications have been developed specifically for unpaved roads and are designed to minimize wear and erosion of the driving surface. Additional tools compiled for this program include innovative approaches for vegetation management designed to reduce long-term maintenance costs (e.g., selective removal of vegetation to discourage fast-growing colonizing species, bank stabilization, shading/day lighting to prevent ice and dust).

Selected examples of reference materials developed by the Center for Dirt and Gravel Road Studies as part of this program have been included in this Appendix, including technical information on driving surface aggregates, grade breaks, and French mattresses.

For additional information on this program, including training course schedules and additional technical information, contact:

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