Washington State
Department of Transportation

Stormwater Management Plan

National Pollutant Discharge Elimination System
for large and medium municipal separate storm sewer discharges

40 CFR 122.26(d)2.iv

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3.0 Stormwater Management Plan

40 CFR 122.26(d)2.iv

This document has been drafted to record WSDOT's plan to comply with the federal standard for non-point source wastewater discharges "to reduce pollutants in discharges to the *maximum extent practicable*" (MEP, 40 CFR 122.26d.2.iv) and the Washington State standard of "All known, available, and reasonable methods of prevention, control, and treatment." (AKART, WAC 173-201A-020). The WSDOT stormwater management plan (SWMP) has been developed to comply with the National Pollutant Discharge Elimination System (NPDES) application requirements for large and medium municipal separate storm sewer (MS4) discharges for the Cedar-Green, Island-Snohomish, and South Puget water quality management areas of Washington State. The SWMP is in effect over the term of the NPDES permits, through July 5, 2000. WSDOT's Stormwater Management Plan (SWMP), although drafted specifically to comply with NPDES and State of Washington regulations for the areas mentioned above, will be implemented throughout the Western Washington.

WSDOT must balance all aspects of the mobility needs of the people and products of Washington. This continuous process begins with the development of goals and policies through the Statewide Multimodal Transportation Policy Plan. In the planning process, the Transportation Commission and WSDOT develops and reviews service objectives that define the types and levels of service for state-owned and state-interest transportation systems.

The State Transportation Policy Plan has identified Environmental Protection and Energy Conservation as an area of policy focus. This focus strives to integrate into the planning, construction, operation and maintenance of the transportation system measures to protect, restore and enhance the environment.

The Environmental Protection and Energy Conservation focus establishes goals to:

- Design new and improve existing transportation systems that avoid the disruption and degradation of the natural environment and heritage resources, and are aesthetically pleasing and energy efficient.
- Conserve scarce and valuble natural resources.
- Reduce pollutants from the transportation system.

These goals direct WSDOT to integrate measurers that protect, restore and enhance the environment in the planning, construction and maintenance of a balanced multimodal transportation system. The Washington State Commission has developed the State Highway Plan as one element of a Statewide Multimodal Transportation plan. The Highway System Plan specifically defines the "service objectives" attempt to solve the identified transportation needs.

Potential revenues over twenty years may not be enough to fund fiscally constrained levels of service objective needs (refer to δ3.2.3.2 of this document). Therefore, priorities are established to further limit service objectives to a financially realistic level. Washington's Transportation Plan proposes strategies and actions over twenty years within this financially realistic level. Finally, a two-year budget and a six year program are proposed to advance the most important projects contained within the twenty-year plan. These projects are chosen through the priority programming process.

While total needs reflect what anyone could ever want, service objectives represent cost-effective desirable outcomes that we can collectively agree are necessary over twenty years to protect the state's interest in the transportation system. Therefore, service objective needs are targeted to address our most pressing problems but not all transportation needs.

The service objectives include: maintenance, transportation system management, preservation, mobility, safety economic initiatives and environmental retrofits. The priority of stormwater management integrates into many of WSDOT's service objectives.

3.1 Planning Processes Used to Develop the WSDOT Stormwater Management Plan

40 CFR 122.26(d) 2.iv.A.2
WSDOE Expectations Document S7.B.1

3.1.1Q2000 Work Team Process

Striving to assure the greatest contact with all the transportation system customers WSDOT has implemented a program of effectiveness as the primary planning tool to address the service objectives. WSDOT Managers utilize Q2000 to establish the customer-supplier relationship of requirements integral to the problem solving process. Tools are given to all WSDOT staff that enable staff to succeed through: customer focus, total involvement, measurement, systematic support and continuous improvement in delivering quality to its identified customers.

WSDOT will continue to work to incorporate the Q2000 process into watershed planning and water quality service objectives in its transportation project scoping process.

3.1.2 Watershed Planning

WAC 400-12 - Local Planning and Management of Non-point Source Pollution

WSDOT has been actively involved in a number of watershed programs statewide, including plans developed under Washington State's Non-point Action planning process under WAC 400-12., *Local Planning and Management of Non-Point Source Pollution.*

WAC 400-12 requires watershed action plans in the Puget Sound Basin to include eight elements, one of these being a *statement of concurrence* from agencies responsible for implementing the specific watershed action plan recommendations. WSDOT's staff participates in many phases of action plan development including identification of non-point source problems, draft plan development, and adoption of the final action plans. During the development of watershed action plans, impacts from each identified non-point source within the watershed, including highway runoff, are prioritized. WSDOT has been and will continue to prioritize stormwater improvement needs on a continuing basis throughout Washington State using a weighted decision matrix known as a condition index. Condition indexing is a set of rules that defines the physical state of a given problem in terms of a numerical value. Condition indexing has been used for prioritizing BMP retrofit sites (detailed in δ3.2.3.6) and will be used to estimate the benefit/cost ratio of stormwater enhancements in roadway construction projects (detailed in δ3.2.3.4).

The prioritized list of BMP retrofit sites is the primary tool in planning highway runoff improvement efforts. This list, required by the Puget Sound Highway Runoff Program (Chapter 173-270 WAC) and NPDES regulations, is currently available to various state, local, and tribal governments. To date, highway runoff sites throughout WRIAs 8-12, 27, 28, and Spokane County have been inventoried ranked and prioritized for state highways with an average daily traffic (ADT) count greater than 20,000 vehicles per day. Crews will continue screening outfalls in remaining WRIAs of Puget Sound. These include WRIAs 13-17 and 1, 3, 5, and 7.

WSDOT has responded, commented and written letters of concurrence on the following list of developed Watershed Action Plans (plans in Puget Sound NPDES MS4 areas highlighted in **bold**):

Table 1 – WSDOT's Watershed Action Plan Involvement Under WAC 400-12

Watershed / Basin Action Plan	County	WRIA
Budd Inlet - Deschutes River	Thurston	13
Cedar River Basin	**King**	**8**
Drayton Harbor	Whatcom	1
Dyes Inlet - Clear Creek	Kitsap	15
East Lake Sammamish Basin	**King**	**8**
Eld Inlet	Thurston	13
Green / Duwamish	**King**	**9**
Henderson Inlet	Thurston	13
Issaquah Creek Basin	**King**	**8**
Kamm Creek	Whatcom	1
Longfellow Creek	**King**	**8**
Lower Hood Canal	Mason	15
Lower Puyallup	**Pierce**	**10**
Nookachamps	Skagit	3
North Creek Watershed	**Snohomish**	**7**
Oakland Bay Watershed	Mason	14
Padilla Bay	Skagit	3
Pipers Creek	**King**	**8**
Port Angeles	Clallam	18
Port Townsend / Hood Canal	Jefferson	17
Quilceda - Allen	**Snohomish**	**7**
Quilcene / Dabob Bay	Jefferson	17
Samish Bay	Skagit	3
Sinclair Inlet Watershed	Kitsap	15
Sequim Bay	Clallam	17
Silver Creek	Whatcom	1
Stilliguamish	**Snohomish**	**5**
Swamp Creek Watershed	**Snohomish**	**7**
Totten and Little Skookum Inlets	Mason	14

WSDOT has provided technical and administrative support on the *Swamp Creek Plan* and the *North Creek Plan*. WSDOT will work on a continuing basis with the *Quilceda/Allen Watershed Committee* to develop recommendations for transportation-related problems in that watershed. These types of planning documents are influential in choosing appropriate permanent highway runoff BMPs and temporary erosion and control measures for new construction.

WSDOT has been an active participant on several interagency forums that address statewide watershed-based policy issues, including:

- Interagency Partnership on the Environment & Transportation (IPET)
- State of Washington Cooperative Sediment Management Program
- Monthly U.S. Army Corps of Engineers Preapplicaton Meetings
- American Public Works Association Stormwater Managers Meetings
- University of Washington Research Consortium on Urban Non-Point Source Pollution
- SB 5894 Standing Committee and Research Committee
- Puget Sound Action Team, including participation by Sid Morrison, Secretary of Transportation

- Interagency Wetlands Review Board
- Marine Coordination Board
- Wetland Banking Development Process Oversight Committee
- Governor's Watershed Coordinating Council

WSDOT will continue to participate in the development and implementation of local Watershed Action Plans and to participate in Basin Plans as they are developed throughout the State of Washington.

3.1.3 WSDOT and Washington's Watershed Coordinating Council

3.1.3.1 Goals and Members

The Washington Watershed Coordination Council (the Council) was established by House Bill 2741 and Executive Order 94-04 to improve interagency coordination for state watershed planning and management activities with those of federal agencies, local governments, tribes, businesses and non-government organizations. The Council is comprised of representatives from the Washington departments of Fish and Wildlife, Ecology, Natural Resources, Agriculture, Transportation, Health, and Community, Trade and Economic Development Puget Sound Water Quality Authority, Inter-Agency Committee for Outdoor Recreation; U.S. Forest Service, Northwest Indian Fisheries Commission; Association Cities; Association of Counties; and a 14 member public advisory group comprised of representatives from affected landowners, industry, and environmental organizations. The Council's mission is to facilitate interagency cooperation in order to:

- Achieve healthy watersheds;
- Maximize the utility and benefit of available financial and human resources through improved state program delivery, and;
- Meet current and future environmental, economic, and social needs.

WSDOT is a participating member of the Council, and has taken a leadership role in the development and implementation of the Council's objectives. The WSDOT has identified with the Council several areas where transportation's mitigation and stormwater retrofit projects could benefit from increased coordination with other agency activities in specific watersheds.

The enabling authority for the Council sunsets in July 1997. Various legislative proposals are being considered to refine watershed governance in Washington state. WSDOT, Ecology and EPA will need to revisit the value and function of the SWMP as comprehensive watershed management programs evolve.

3.1.3.2 Watershed Prioritization Processes

WSDOT has presented a proposal to the Council to begin work intensively with other agencies and interested participants to target individual watersheds where enhanced coordination for mitigation activities could have substantial benefits for wetlands and the ecological health of the basin. WSDOT's proposal has been supported by all Council Members, including the EPA's representatives and local jurisdictions within the target watersheds. Thus far the Council has identified the Snohomish, Nooksack, Chehalis, and Yakima watersheds as primary candidates for demonstrating enhanced interagency coordination, and for off-site, out-of-kind mitigation based on allocating mitigation funds for the overall ecological benefit to the watershed.

WSDOT has presented a proposal to the Council to begin to work intensively with other agencies and interested participants in the target watersheds. Promoting enhanced coordination for mitigation activities, including stormwater, could have substantial benefits for the ecological health of the entire basin. The Snohomish Basin was selected for demonstrating WSDOT's ability to incorporate a watershed-based approach into the project development process.

WSDOT commitments for implementation under the SWMP should be subject to re-evaluation when multiple interests in a watershed are considered. Local priorities and values can influence the tradeoffs between investments in achieving beneficial uses. Efficiencies can be gained by concentrating resources in a logical sequence. This approach may best demonstrate cost effectiveness and further the long term strategy of comprehensive watershed protection. Where stormwater is a low priority relative to other unmet needs in the watershed, some stormwater dollars may get redirected. Conversely, where stormwater (quality or quantity) issues are key issues, other mitigation or enhancement dollars could be redirected toward stormwater controls.

3.1.3.3 The Snohomish Watershed Demonstration Project

WSDOT systems (rail, road, air, and water) cross and interconnect all of the watersheds in the state. Planning, construction, and maintenance of transportation systems and maintenance facilities have the potential to significantly impact the environment, unless adequate mitigation is provided. WSDOT typically provides mitigation on a case-by-case basis, with priorities driven by each project's schedule and the regulatory process. This approach facilitates a piece-meal approach to mitigation, often ignoring the top priorities and needs of individual watersheds.

WSDOT has experienced the ecological and economic problems associated with project-by-project mitigation. There is strong support among managers at WSDOT to develop and implement strategies which integrate a watershed approach into the selection, design, and construction of the Department's environmental mitigation projects. Commitments have been made by executive management at the State Watershed Coordination Council meetings to undertake a pilot project in the Snohomish Basin.

The goal of the pilot project is to incorporate a watershed approach into the mitigation planning components of transportation projects within a target watershed. The Snohomish Basin will serve as the first target watershed. The objective of the project is to direct WSDOT's substantial mitigation dollars towards watershed restoration and enhancement projects having the highest priority in the basin. This proposal incorporates other WSDOT initiatives such as wetlands banking, fish passage retrofits, and implementation of SSHB 2031. Our program objectives are supported by the Snohomish Basin Work Group, the US EPA, and the Washington Rivers Council.

Necessary Steps for Implementation:

Policy, planning, and science disciplines must come together to facilitate implementation of these concepts. In order for the WSDOT to establish methodologies for implementing mitigation projects on a watershed basis, two major components must be developed:

I. (a) A decision making framework must be established to provide a foundation for developing communication and partnerships with watershed stakeholders and regulatory agencies. Historically, watershed stakeholders have had limited input into WSDOT's mitigation planning process. A decision making model must be developed to include groups once excluded from the process. Developing partnerships and communication forums would enable the participants to make recommendations for addressing the top priorities of the watershed, rather than limiting WSDOT's consideration to only in-kind, on-site projects. Participation by both governmental and non-governmental groups is desired.

(b) Fundamental changes must occur within WSDOT so that identified watershed priorities can be incorporated into the project development process. As transportation construction projects are scoped, internal work teams must be formed to predict mitigation needs earlier in scoping process for projects having limited on-site and/or in-kind options. Partnerships must be formed with stakeholders to evaluate mitigation alternatives as these problem areas are identified.

(c) Other components of the decision making model include an evaluation of the barriers and opportunities given the current regulatory and jurisdictional limitations within the basin. Questions remain as to whether a watershed approach can realistically be implemented given current regulatory requirements.

(d) A deliberate effort must be made to link long range transportation planning and watershed management. Regional and Metropolitan Transportation Planning Organizations have yet to fully implement the Intermodel Surface Transportation Efficiency Act requirements for environmental analysis for regional transportation plan impacts. WSDOT's Environmental Affairs and the Transportation Planning Offices are coordinating efforts to achieve this goal.

II. (a) A second component of the project is to utilize the best science available to make recommendations for mitigation tradeoffs. There is no widely accepted procedure for determining appropriate tradeoffs. When is a substitution of an off-site and/or out-of-kind proposal the most appropriate course of action? What evaluation process can be utilized to make decisions about preferred options?

(b) Decisions concerning recommendations for addressing priority projects in the basin require a consolidation of technical information, so that all mitigation priorities within the watershed can be considered in the evaluation process. There has been a host of resource management plans completed for a variety of sub-basins within the Snohomish Basin. However, watershed restoration recommendations included in these documents have never been consolidated for the entire basin, and spatially displayed using GIS. WSDOT's proposal to do so was recently funded by the EPA. This information will be combined with the Snohomish Basin Work Group's *Conditions and Issues Report* (now in progress) and with the Department of Ecology's *Puget Sound Watershed-Based Wetland Restoration Project* (funded for May 1997). Linkages would be established by consolidating research results from the three projects, and by establishing partnerships between participants to ensure data are collected, analyzed, and shared in the most efficient manner. The final product represents a comprehensive set of GIS products depicting priority watershed restoration projects within the Snohomish Basin. WSDOT will continue to work with federal, state, local and tribal governments to develop proposals which facilitate implementation of watershed-based mitigation strategies.

3.1.4 Intergovernmental and Co-Permittee Coordination

Expectations Document S7.B.7

3.1.4.1 Forward Mitigation and Retrofit Planning By Watershed Based On WSDOT's 2, 6, and 20 year Preservation and Improvement Project Projections

As WSDOT biennial budgets, six-year capital improvement programs, and twenty year system plans are developed, coordination of improvement and maintenance projects that affect commingled drainage systems, impaired receiving streams, and local watersheds both will be discussed and negotiated with co-permittees. Coordination in the early stages of project development will allow flexibility for improved project delivery. Coordination between permitted municipalities may result in a comprehensive, integrated management plan as opposed to a series of small, fragmented mitigation projects. Early coordination between co-permittees may also result in more effective utilization of funds through shared work and joint project funding. Some of the groundwork for this coordination can be found in local watershed management plans. It is WSDOT's intent to continue this coordination as the permits are issued and the provisions of WSDOT's SWMP is implemented. A future objective for WSDOT will be to link the regional transportation planning objective to local watershed or basin plans. Long-term watershed planning would permit the multiple objectives of addressing local water quality needs, maximizing benefit/cost performance of mitigation dollars, and increase efficiency of WSDOT's project planning for environmental mitigation.

One of the initial steps in putting together the WSDOT budget and capital improvement program is prioritization of all transportation system needs. Existing facilities are included in this listing, along with mobility, safety, modal integration and other transportation-related needs. Once the prioritized needs are established, costs and methods are developed to meet the individual needs. Projects on the prioritized list become "draft" projects. The projects are then evaluated relative to each other for cost/benefit performance. Mobility projects are graded using a 5-tier system, one of which are environmental considerations. Under this system, a project decreases in value as environmental impacts increase. The maximum value is given for minimal environmental impacts.

3.1.4.2 Intergovernmental Agreements Between WSDOT and Other NPDES Permittees

Graded projects then go through a coordination process with local governments to assure compatibility with local and regional issues. Projects and funding amounts are then reviewed and approved by the Transportation Commission and forwarded to the State Legislature. The Legislature and Governor eventually approves the proposed budget, which is dependent upon available funds.

WSDOT will attempt to increase the degree of cooperation between it and the other municipal MS4 permittees in Washington State (the "gang of six") in the future. Project scoping, 2SHB 2031 funding opportunities (described in δ3.2.3.3), SWMP development, and the Snohomish Basin Watershed Project will provide opportunities to inprove intergovernmental cooperation.

3.1.4.3 WSDOT Internal NPDES Task Force

An internal task force has been assembled to provide guidance on development and implementation of the various plans and programs in the NPDES MS4 permit areas. Representatives from many of the functional groups within WSDOT make up the membership. Their participation is valuable as most of the groups within WSDOT are affected by conditions of the NPDES MS4 Permits.

3.2 WSDOT's Statewide Stormwater Needs and Prioritization Systems

40 CFR 122.26(d) 2.iv.B.1

Expectations Document S7.B.2

WSDOT's stormwater needs and prioritization systems can be divided into two main categories, facilities operating programs and facilities capital programs. Facilities operating programs are continuing programs comprised mainly of highway and ferry systems operation and maintenance activities. Federal and State highways are responsible for over 95 percent of the impervious surface maintained by WSDOT. Moreover, WSDOT's ferry terminals are regulated for stormwater runoff through Stormwater Pollution Prevention Plans under the NPDES industrial permitting system. Therefore, state highway maintenance programs are the only facilities operating programs that are relevant to WSDOT's SWMP. Facilities operating programs, excluding the ferry system, are the highway improvement and preservation projects related to new construction.

The emphasis on the facilities capital programs, i.e. road construction projects, at WSDOT and in this document are because of budgetary considerations. If one combines the biennial budgets appropriated for highways in Washington State, capital programs command 85 percent of the total. Additionally, any structural improvements to roadway systems, which include upgrading or retrofitting stormwater facilities, can only be facilitated through capital programs. Based on these facts, building and upgrading structural stormwater controls is the highest priority for WSDOT's stormwater management plan.

3.2.1 Water Quality Issues Associated With Stormwater Runoff From State Highways

Traffic volume has been found to be an important factor in predicting runoff quality, particularly the number of vehicles using a roadway during a storm event. Traffic density and usage has typically been quantified by automotive traffic data. Two measures of traffic volume are most often considered: average daily traffic (ADT) count and vehicles during a storm (VDS). Irish, et.al. (1995) has found strong statistical correlations between VDS and concentrations of lead, copper, BOD_5, and Oil & Grease in highway runoff. There generally has been mixed results in correlating ADT with pollutant concentrations (Barrett, 1993). However Driscoll, et.al. (1993), based on monitoring results from over 900 storm events in 31 states found significant differences between urban (ADT>30,000) and rural (ADT<30,000) highways, particularly for nutrients, metals, particulates, and chemical oxygen demand. Because ADT is relatively easy to quantify for most, if not all roadways, its has been the focus for predicting pollutant concentrations, and is used in many modeling techniques.

In general, the quality of stormwater runoff from roadway systems is a complex function which is dependent on several variables (FHWA, 1996), including:

1. Storm duration and intensity.
2. Traffic characteristics, primarily traffic density of the roadway during the storm event.
3. The number of dry days prior to the storm event. Dry accumulation of debris from vehicles and atmospheric deposition is deposited on the roadway during these periods.
4. Percent pervious and impervious surface(s) within the drainage.
5. Maintenance policies, including sweeping, mowing, pesticides, and deicing.
6. Surrounding land use (residential, commercial, industrial, rural).
7. Ambient air quality in the region.
8. Anti-litter laws and regulations covering vehicle emissions (e.g. lead gasoline).
9. Use of special additives in vehicular operations.
10. Vegetation types on the highway right-of-way, and;
11. Spill risk from vehicular accidents.

Material is also continually removed from highway surfaces by natural and vehicle induced winds that "sweep" the highway surface (Aye, 1979, Asplund, et.al., 1980). Visually, this can be observed on curbed highways by the buildup of litter and debris along the curb and the noticeable lack of such material in traffic lanes. It has been reported that >90% of highway accumulations of litter and debris occur within 0.27 meters (12 inches) of the curb (Northern Virginia Planning District Commission, 1992).

Table 2 - Highway Stormwater Constituents in Highway Stormwater Runoff and Potential Sources

Constituent	Potential Sources
Particulates & Solids (TSS, TDS)	Transport of many other pollutants, including heavy metals & PAHs, are facilitated by sorption to solids. Causes include pavement wear, vehicles, atmospheric dust, maintenance. Many highway BMPs are designed to enhance removal of solids and the associated sorbed pollutants.
Nitrogen, Phosphorus	Particularly problematic in drainages to eutrophic lakes. Sources include , fertilizer application, organic nutrients in roadsides vegetation, atmospheric deposition.
Lead	auto exhaust, tire wear, lubricating oil & grease, bearing wear
Zinc	tire wear, galvanized steel, motor oil, grease
Iron	auto body rust, steel highway structures, moving engine parts
Copper	metal plating, moving engine parts, brake lining wear
Cadmium	lubricants, auto exhaust, tire wear, galvanized steel, insecticides
Chromium	metal plating, moving engine parts, brake lining wear
Nickel	lubricating oil, metal plating, bushing wear, brake lining wear, asphalt paving
Manganese	moving engine parts
Bromide	automobile exhaust
Cyanide	anticake compounds used to keep deicing salts granular
Sodium, Calcium	deicing salts, grease
Chloride	deicing salts
Sulfates	roadway beds, fuel, deicing salts
Pathogenic Bacteria	soil litter, bird droppings, trucks hauling livestock, litter
Oil & Grease, TPH	spills, leaks, antifreeze, hydraulic fluids, asphalt leachate
PCBs	PCB catalyst in synthetic tires
Polynuclear Aromatic Hydrocarbons (PAHs)	Automobile exhaust combustion product. Group of sixteen base/neutral compounds found in very small concentrations in highway runoff, and have been found to mostly sorbed to the solid phase. Background information on PAHs in Washington water bodies, atmospheric deposition, source listings, etc., is minimal.
Pesticides, Herbicides	Applied to roadsides for insect and noxious weed control.
Pathogenic bacteria	litter discarded from vehicles, bird dropping, livestock trucks
Asbestos	clutch and brake lining wear

The Center for Research in Water Resources at the University of Texas at Austin (Irish, et.al., 1995) developed a comprehensive series of nonlinear regression models relating pollutant loading from highway stormwater runoff to variables which may affect these loadings. Data used to generate these models was collected using both natural precipitation events and simulated events using a rainfall simulator which provided a uniform rainfall over a 230 meter (755 ft) length of the MoPac Highway in Austin. Statistical analysis showed no significant differences between runoff quality generated from the simulated and natural precipitation events. A summary of selected water quality constituents and controlling variables derived from regression models are summarized in Table 3.

Table 3 - Variables Affecting Highway Constituent Runoff Loads Within An Individual Drainage System

Constituent (% of variation explained)	*Storm Duration*	*Storm Volume*	*Storm Intensity*	*Vehicles During Storm*	*Antcedent Dry Period*	*Antecedent Traffic Count*	*Previous Storm Duration*	*Previous Storm Volume*	*Previous Storm Intensity*
TSS (92%)		*	*		*				*
Zinc (92%)	*	*				*	*	*	*
Lead (68%)		*	*	*					*
Copper (90%)	*	*		*					
COD (95%)	*	*	*		*	*			
BOD_5 (86%)		*	*	*		*			
Phosphorous (90%)	*	*	*			*			
Nitrates (95%)		*	*			*			
Oil & Grease (94%)		*		*					

From these lists and related studies performed by the City of Seattle (Farris, et.al., 1973), the Federal Highways Administration (FHWA, 1984), the National Urban Runoff Program (EPA, 1978), data from the NPDES Part 2 MS4 application for Portland, Oregon (1993), and studies of highway runoff quality performed by Chui, et.al. (1981), Farris (1973), and the City of Olympia (1995), WSDOT has identified the water quality problems most commonly associated with highway runoff in the Puget Sound area. This section will also include studies of highway runoff quality from the Portland, Oregon area. The Portland characterization study is the most comprehensive and rigorously scientific study available for roadway runoff located west of the Cascades, and included the test results from each of the individual analyses. This allowed WSDOT to assess variability as well as central tendency. The coefficient of variation (CV, defined as the standard deviation divided by the numeric mean of the parameter) are listed with the mean in the tables of highway runoff. However, the Portland transportation runoff data may be atypical in that it was cited on a heavily industrialized corridor in Northwest Portland. At this site (Oregon SR 30) there is heavy industrial truck traffic and four nearby hazardous waste sites that are listed in the CERCLA National Priorities List, which may have some influence on stormwater quality data.

The Pacific Northwest on the west side of the Cascade range has unique precipitation characteristics relative to the rest of the nation, characterized by low intensity, long duration storms (the Western Washington Type 1A hyetograph). For this reason this section will emphasize quantitative data from Western Washington and Oregon. National studies such as FHWA and NURP were used primarily to qualitatively assess pollutants of concern in highway runoff, but not the quantitative data.

3.2.1.1 Highway Constituent Discharge Theory

During dry periods between storm events, debris is continually being accumulated onto the highway surface by vehicles and atmospheric deposition. At the same time, substances are being removed from the roadway surface by natural and vehicle induced winds, volatilization, photodegradation, biodegredation, and chemical decay. The total constituent load, *M*, delivered to a highway stormwater outfall during a precipitation event, is the product of the of the flow-weighted event mean concentration (*EMC*) and the total volume of runoff, *V* (Irish, et. al., 1995). This is expressed:

$$M = EMC * V = \int c(t)Q(t)$$

Where: $c(t)$ = instantaneous constituent concentration

$Q(t)$ = volumetric rate of runoff

V is equal to the net precipitation, P, less any losses, L, such as storage, evaporation, infiltration, etc., expressed by:

$$V = P - L = \int Q(t)dt$$

Generally, L is small and relatively constant for a given drainage, therefore the volume of runoff from a precipitation event is quite predictable. The total mass from a precipitation event is the sum of the mass that has accumulated during the antecedent dry period and the mass introduced during the event minus any decay of pollutant mass during the event. All precipitation events do not result in a net removal of mass from the roadway surface. Many low intensity events produce little or no runoff. However, these low intensity events can produce enough moisture to "wash" the undersides of vehicles traveling during the storm. Therefore, the accumulated mass on the roadway prior to a significant runoff event will not be consistent. The general mass balance for the system is:

Rate of change of mass of the constituent =

the rate of input from rainfall into the system

\+ the rate of input from traffic into the system

\+ the mobilization rate of the accumulated mass within the system

\+ the sum of all rates of output from the system

\+ the rate of production or decay within the system during the event

Expressed mathematically:

$$\frac{d(Vc)}{dt} = W + R - Qc \pm K_1 Vc \qquad (1)$$

Where:

W = mass entering the system = $Q_P c_P + M_v$

Q = runoff flow rate = $Q_P + Q_L$

Q_P = flow provided by the precipitation event or snow melt

c_P = concentration of the constituent in the precipitation or snow melt

M_v = mass input from vehicles during the precipitation event or snow melt

Q_L = loss of flow from infiltration, storage, evaporation, etc.

K_1 = constituent decay rate

R = mobilization rate of accumulated mass on the roadway

$$= f\left(P, \frac{dP}{dt}, VDS\right)$$

At the beginning of precipitation events, some volume will accumulate on pavement surfaces:

$$\frac{dV}{dt} = A\frac{dh}{dt}$$

Where: A = pavement area

h = accumulated precipitation depth

Expanding equation (1):

$$\frac{d(Vc)}{dt} = V\frac{dc}{dt} + c\frac{dV}{dt} = V\frac{dc}{dt} + cA\frac{dh}{dt} \tag{2}$$

Which yields the general equation:

$$cA\frac{dh}{dt} + V\frac{dc}{dt} = W + R - Qc \pm K_1 Vc \tag{3}$$

The decay rate, K_1, can be assumed to be zero, since the time of concentration for the drainage area, which is generally between 2 and 25 minutes, and is generally too short for any chemical transformations to occur. A steady state conditions are established, the mobilization rate, R, can be assumed to be a constant. In order to estimate the mass loading attributable to the debris accumulated during the antecedent dry period, rainfall and *VDS* has no constituent input and $W = 0$. Therefore the concentration of the constituent in the runoff c_f, is given by:

$$c_F = c_0 \exp\left[-\left(\frac{Q}{V} + R\right)t\right] \tag{4}$$

If the constituent input from the rainfall and the *VDS* is assumed to be constant, i.e. with steady state conditions, then:

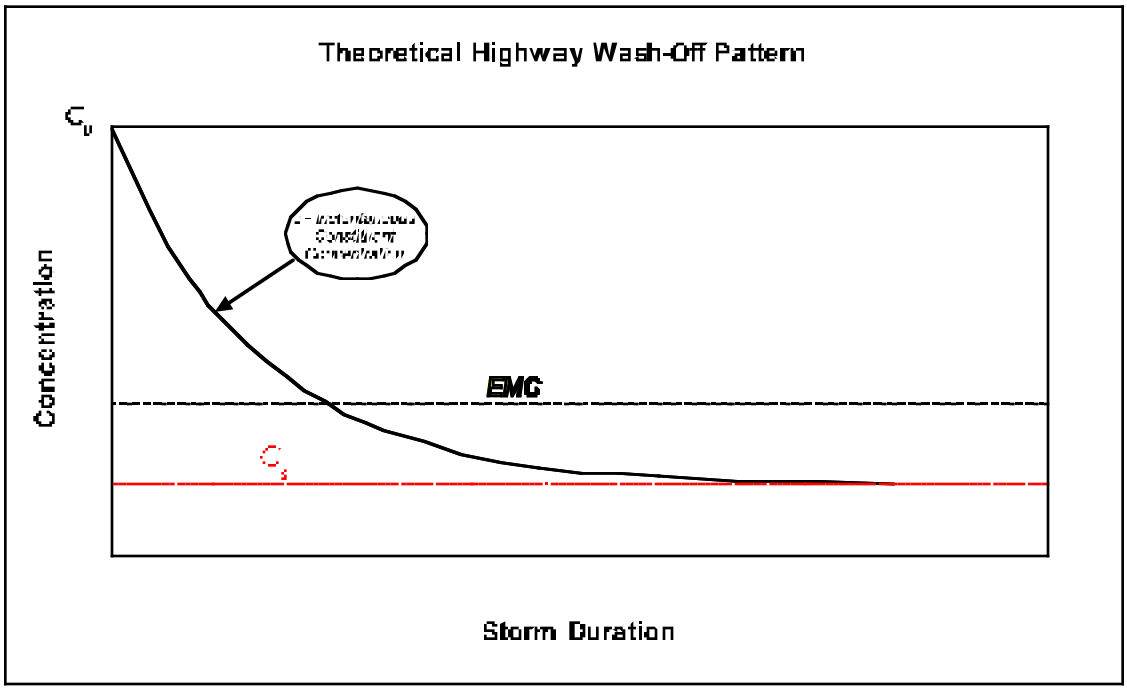
$$c_S = \frac{W}{Q}\left\{1 - \exp\left[-\left(\frac{Q}{V}\right)t\right]\right\} = \frac{W}{Q} \tag{5}$$

Finally, the instantaneous constituent concentration in highway runoff due to an initial accumulation of debris on the highway and constant input from rainfall and traffic can be expressed as:

$$c = c_F + c_S = \frac{W}{Q} + c_0 \exp\left[-\left(\frac{Q}{V} + R\right)t\right] \tag{6}$$

Therefore the theoretical shape of the constituent concentration in highway runoff assumes the pattern displayed in Figure 1.

Figure 1



3.2.1.2 Solids in Highway Runoff

Measurable concentrations of both suspended and dissolved solids are present in detectable quantities in all non-point source stormwater runoff, and highways are no exception. Suspended solids determination is valuable in the analysis of polluted waters. Water with high concentrations of suspended solids have low aesthetic value, inhibit trout and salmonid spawning, and most importantly, act as a vector for the transport of sorbed toxic substances, such as heavy metals and hydrocarbons.

As shown by the table below, TSS concentrations have a large statistical variability from site to site as well as sample to sample. WSDOT will concentrate on developing a statistical basis for estimating solids concentrations based on known critical parameters, such as percent impervious surface, ADT, preceding dry period, BMP effectiveness, etc. Concentrations of total and dissolved solids will be routinely analyzed all WSDOT stormwater and BMP monitoring sites.

Table 4 - Historical Mean Solids Concentrations in Highway Runoff From Western Washington and Oregon

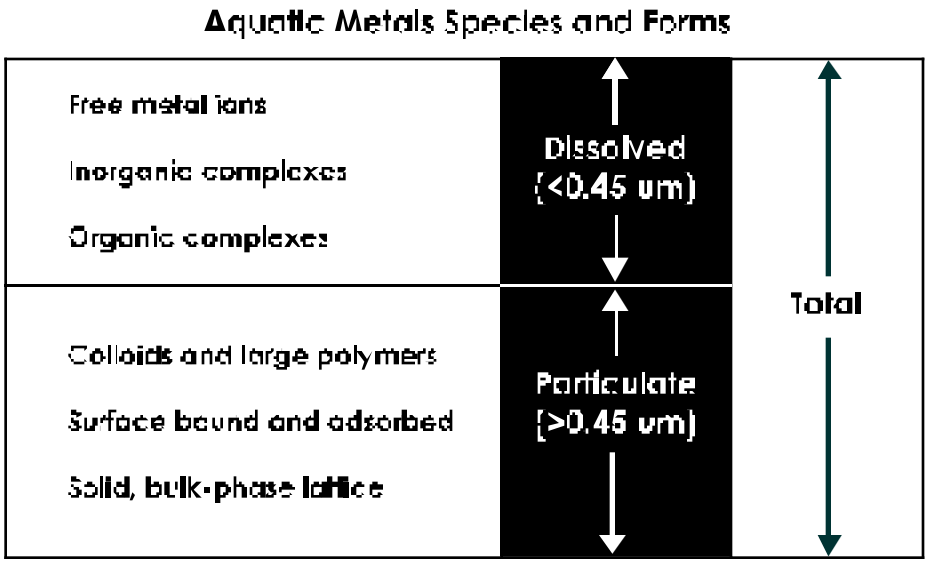
Source	Location	Total Suspended Solids (mg/l)	Volatile Suspended Solids (mg/l)
Farris, 1973	I-90, North Bend	295	4.3
Farris, 1973	S. Bellevue Interchange	246	57
Farris, 1973	Lacey V. Murrow Bridge	374	71
FHWA, 1976-77	6 sites, 151 samples	261	77
Chui, 1981	I-5	106	37
Chui, 1981	Montesano, SR 12	798	45
Chui, 1981	Snoqualmie Pass, I-90	63	12
Chui, 1981	Vancouver, I-205	106	13
Portland NPDES Pt. 2 App., 1993	NW Yeon, Portland	119 CV = 0.43	N/A
I-5 in Olympia, '95-'96	3 sites, 9 total samples	49.7 CV = 0.83	N/A

Note: The high suspended solids concentrations for the Montesano sampling site in 1981 may be mostly attributable to ash fall from the Mt. St. Helens eruption. The sampling for the Chui, et. al. study was performed in 1980, the year of the eruption. The author noted this fact in the publication.

3.2.1.3 Metals in Highway Runoff

Heavy metals are the most commonly cited constituent associated with highway runoff, particularly cadmium, copper, lead, and zinc. All studies of highway runoff quality identify these metals as primary constituents. Washington State Water Quality Standards (WAC 173-201A) has set criteria for these metals based on hardness of the water. Stormwater in Washington State tends to have very low amounts of hardness, because of the low concentrations of bivalent cations (primarily calcium and magnesium) in Washington's native soils. WSDOT will concentrate its efforts on 4 metals, Cadmium, Copper, Lead, and Zinc. From the characterization data in Portland's Part 2 NPDES MS4 application, these 4 metals showed the highest concentrations in roadway stormwater runoff (as judged by total concentration, the sum of solid and aqueous phase concentrations) and 32 of the 34 exceedences of State of Oregon's freshwater acute criteria. Detectable levels of chromium, nickel, and silver were detected, but were shown have much lower probabilities for water quality exceedances.

In the aquatic environment, the speciations and form of individual metals constituents determine their toxicity effects. Only the bioavailable species and forms are toxic to aquatic organisms. For copper, for example, it is the divalent free cation and possibly some inorganic complexes that have substantial toxicity, whereas particulate, dissolved organic, and most inorganic complexes are significantly less toxic. Over the past few years, EPA and others have begun to reevaluate approaches to metals toxicity and bioaccumulation. Commonly, the dissolved fraction of metals are considered to be somewhat more accurate indicators of bioavailability and toxicity. The analytical protocol for dissolved metals uses estimates by filtration of effluent through a 0.45 µm filter and analyzing the resulting supernatent for metals content using a mass spectrometer / gas chromatograph. For most metals even the "dissolved" fraction may overestimate toxicity because some metal complexes smaller than 0.45 µm exert minimal toxicity. All receiving waters also contain colloid-sized, naturally occurring organic matter that bind to metals and act to reduce their bioavailability to aquatic organisms.



Cadmium – Is found in very low concentrations in highway runoff, but cadmium also exhibits acute and chronic toxicity at very low levels. Few studies have assessed the solid to dissolved phase characteristics for cadmium in highway runoff, but WSDOT will make determinations of solid/dissolved phase partitioning as part of its routine stormwater analysis.

Table 5 - Historical Mean Cadmium Concentrations in Highway Runoff in Western Washington and Oregon

Source	Location	Cadmium (total) (mg/l)	Cadmium (dissolved) (mg/l)	dissolved fraction
Farris, 1973	I-90, North Bend	0.012	N/A	N/A
Farris, 1973	S. Bellevue Interchange	0.004	N/A	N/A
Farris, 1973	Lacey V. Murrow Bridge	0.016	N/A	N/A
FHWA, 1976-77	6 sites, 151 samples	0.040	N/A	N/A
Portland NPDES Pt. 2 App., 1993	NW Yeon, Portland	0.0014 CV = 0.96	0.0004 CV = 0.82	28%
I-5 in Olympia, '95-'96	3 sites, 9 total samples	0.0004 CV = 0.98	N/A	N/A

Copper – Detectable concentrations of copper are ubiquitous for all published characterization studies of highway runoff. Copper brake pads, a key element in anti-lock braking systems, are a recognized source. WSDOT will routinely monitor for both total copper and dissolved copper at all of its stormwater characterization and BMP monitoring project locations.

Table 6 - Historical Mean Copper Concentrations in Highway Runoff from Western Washington and Oregon

Source	Location	Copper (total) (mg/l)	Copper (dissolved) (mg/l)	dissolved fraction
Farris, 1973	I-90, North Bend	0.11	0.02	18%
Farris, 1973	S. Bellevue Interchange	0.152	0.034	23%
Farris, 1973	Lacey V. Murrow Bridge	0.10	0.03	30%
FHWA, 1976-77	6 sites, 151 samples	0.103	N/A	N/A
Chui, 1981	I-5	0.043	N/A	N/A
Chui, 1981	Montesano, SR 12	0.089	N/A	N/A
Chui, 1981	Snoqualmie Pass, I-90	0.022	N/A	N/A
Chui, 1981	Vancouver, I-205	0.025	N/A	N/A
Portland NPDES Pt. 2 App., 1993	NW Yeon, Portland	0.039 CV = 0.94	0.012 CV = 1.08	31%
I-5 in Olympia, '95-'96	3 sites, 9 total samples	0.012 CV = 0.71	N/A	N/A

Lead – The presence of lead in highway runoff has been recorded in all characterization studies. Notable in the table below is the apparent trend of lowered lead concentrations in highway runoff in Western Washington and Oregon. This may be attributable to the gradual elimination of lead additives to automobile gasoline. Western Washington, with its mild climate and low snowfall totals, tends to have a relatively large percentage of older vehicles because of the relatively small volumes of corrosive deicers used on roadways. These older vehicles use leaded gasoline, which may have influenced the lead concentration data.

Table 7 - Historical Mean Lead Concentrations in Highway Runoff from Western Washington and Oregon

Source	Location	Lead (total) (mg/l)	Lead (dissolved) (mg/l)	dissolved fraction
Farris, 1973	I-90, North Bend	0.68	0.09	13%
Farris, 1973	S. Bellevue Interchange	1.16	0.17	15%
Farris, 1973	Lacey V. Murrow Bridge	1.78	0.15	8%
FHWA, 1976-77	6 sites, 151 samples	0.96	N/A	N/A
Chui, 1981	I-5	0.466	N/A	N/A
Chui, 1981	Montesano, SR 12	0.556	N/A	N/A
Chui, 1981	Snoqualmie Pass, I-90	0.086	N/A	N/A
Chui, 1981	Vancouver, I-205	0.076	N/A	N/A
Portland NPDES Pt. 2 App., 1993	NW Yeon, Portland	0.036 CV = 0.69	>0.001 CV = nd	nd
I-5 in Olympia, '95-'96	3 sites, 9 total samples	0.019 CV = 0.56	N/A	N/A

Note: Only 2 out of 9 samples detected dissolved Lead above its minimum detection limit of 0.001 using EPA Method 239.2.

Zinc – Zinc is recognized as the most "soluble" of the metals associated with highway runoff. The other metals of concern appear to be strongly associated with the solid phase, i.e. attached to solids. Lead particularly has a strong solid phase affinity. Zinc appears to have a marginally higher tendency to remain in the dissolved phase, although from the historical data, the majority of zinc concentration still resides in the solid phase. This retains consistency with WSDOT's strategy of developing and designing BMPs that remove solids, and the metals sorbed to the solids, from WSDOT's highway runoff before discharge to receiving waters.

Table 8 - Historical Mean Zinc Concentrations in Highway Runoff from Western Washington and Oregon

Source	Location	Zinc (total) (mg/l)	Zinc (dissolved) (mg/l)	dissolved fraction
Farris, 1973	I-90, North Bend	0.14	0.05	46%
Farris, 1973	S. Bellevue Interchange	0.170	0.059	35%
Farris, 1973	Lacey V. Murrow Bridge	0.40	0.08	20%
FHWA, 1976-77	6 sites, 151 samples	0.41	N/A	N/A
Chui, 1981	I-5	0.638	N/A	N/A
Chui, 1981	Montesano, SR 12	0.556	N/A	N/A
Chui, 1981	Snoqualmie Pass, I-90	0.101	N/A	N/A
Chui, 1981	Vancouver, I-205	0.056	N/A	N/A
Portland NPDES Pt. 2 Application	NW Yeon, Portland	0.253 CV = 0.85	0.098 CV = 1.51	39%
I-5 in Olympia, '95-'96	3 sites, 9 total samples	0.054 CV = 0.91	N/A	N/A

3.2.1.4 Nutrients in Highway Runoff

Nitrogen and phosphorous compounds, particularly in their soluble forms, can cause water quality problems because they stimulate algal growth and reduce oxygen levels in receiving waters through bacterial autotrophic conversion. Stormwater conveyance systems aerates runoff to a significant degree, hence ammonia concentrations tend to be very low for highway runoff by volatilization or conversion to nitrates and nitrites.

In most aquatic systems, available phosphorous is the limiting nutrient for planktonic organisms. In general, only the inorganic compounds of phosphorus, primarily orthophosphates, are the main water quality concern. Organically bound phosphorous is usually a minor concern except for drainages that discharge to eutrophic lakes and reservoirs, where anaerobic conditions in lower hypolimnion facilitates conversion to inorganic, soluble compounds.

WSDOT will analyze stormwater for nitrates, total phosphorous, and orthophosphate, when feasible (maximum sample holding times for nitrates and orthophosphate are 48 hours, many times samples cannot be collected and analyzed in time).

Table 9 - Historical Mean Nitrogen Compound Concentrations in Highway Runoff from Western Washington and Oregon

Source	Location	Ammonia – N (mg/l)	Nitrate-Nitrite (mg/l)	Total Kjeldhal Nitrogen (mg/l)
Farris, 1973	I-90, North Bend	0.07	0.15	0.58
Farris, 1973	S. Bellevue Interchange	0.22	0.75	0.50
Farris, 1973	Lacey V. Murrow Bridge	0.22	1.19	0.76
FHWA, 1976-77	6 sites, 151 samples	N/A	1.14	2.99
Chui, 1981	I-5	N/A	1.281	1.175
Chui, 1981	Montesano, SR 12	N/A	1.067	1.586
Chui, 1981	Snoqualmie Pass, I-90	N/A	0.693	0.335
Chui, 1981	Vancouver, I-205	N/A	1.636	55.0 [1]
Portland NPDES Pt. 2 Application	NW Yeon, Portland	0.7 CV = 0.73	N/A	1.6 CV = 0.67

Table 10 - Historical Mean Phosphorous Compound Concentrations in Highway Runoff from Western Washington and Oregon

Source	Location	Total Phosphorous (mg/l)	Orthophosphate (mg/l)
Farris, 1973	I-90, North Bend	0.23	0.05
Farris, 1973	S. Bellevue Interchange	0.31	0.05
Farris, 1973	Lacey V. Murrow Bridge	0.50	0.08
FHWA, 1976-77	6 sites, 151 samples	0.79	N/A
Chui, 1981	I-5	0.226	N/A
Chui, 1981	Montesano, SR 12	0.441	N/A
Chui, 1981	Snoqualmie Pass, I-90	0.150	N/A
Chui, 1981	Vancouver, I-205	0.113	N/A
Portland NPDES Pt. 2 Application	NW Yeon (SR 30), Portland	0.30 CV = 0.50	0.18 CV = 4.00

3.2.1.5 Hydrocarbon Compounds in Highway Runoff

Oil and Grease – It would intuitively be expected that oil, grease, petroleum hydrocarbons, and the combustion products of motor fuels would be constituents in highway runoff, and historical evidence shows that this is factual. Oil and grease is usually singled out for special attention because of its poor solubility in water and its tendency to separate from the aqueous phase. Not all oil and grease separates from the aqueous phase by gravity separation. Appreciable amounts of oil & grease remain dispersed in water in a finely divided emulsified form. Total petroleum hydrocarbons is a subset of oil and grease derived solely from petroleum products. WSDOT will analyze stormwater runoff for Oil & Grease and/or TPH whenever feasible. Although it would be desirable to analyze all samples for oil & grease and TPH, suitable samples for analyzing these pollutants cannot be collected using automated samplers, because of surface films are difficult to accurately sample and a tendency to coat intake lines and sample bottles. Therefore manual grab samples are required to collect viable samples for testing oil & grease and TPH.

Table 11 - Historical Mean Oil & Grease / TPH Concentrations in Highway Runoff from Western Washington and Oregon

Source	Location	Oil & Grease (mg/l)	Total Petroleum Hydrocarbons (mg/l)
Farris, 1973	I-90, North Bend	24.0	N/A
Farris, 1973	S. Bellevue Interchange	14.9	N/A
Farris, 1973	Lacey V. Murrow Bridge	27.0	N/A
Portland NPDES Pt. 2 Application	NW Yeon (SR 30), Portland	8.9 CV = 0.57	6.5 CV = 0.54

Polynuclear Aromatic Hydrocarbons – A category of combustion products that have come under a great deal of scrutiny are Polynuclear Aromatic Hydrocarbons (PAHs). PAHs are by-products of petroleum processing or combustion. PAHs are organic compounds with multiple ringed molecular configurations. Although they are relatively insoluble in water, their apparent carcinogenic nature merits monitoring in potable waters. Previous investigations have proposed that the types and concentrations of PAHs in a sample may be indicative of the source of the PAHs. These investigations suggest that lighter 2-ring PAHs are dominant in crude oil and lighter petroleum products, while heavier 3-ring and 4-or-more-ringed PAHs are dominant in soot and combusted petroleum products.

The only comprehensive background data for PAHs from roadway runoff comes from Portland's NPDES Part 2 application. The Portland data used an ultra-sensitive GC/MS analytical method that enabled analysis of PAHs at detection limits 5 to 100 times lower than EPA methods 610 or 625. Results were reported in total PAHs and in ring number categories rather than by individual PAH compound. The detected concentrations of total PAHs in these four samples ranged form

6.48 to 21.25 µg/l. Approximately 86 percent of the total PAHs detected in the three samples consisted of the heavier 3-ring and 4-or-more ring compounds. This suggests that the primary source of PAHs from highways is the combustion of motor vehicle fuels.

Ecology has set marine sediment quality standards for two broad categories of PAHs in WAC 173-204-320, but has not set any water quality criteria for PAHs or have assessed background concentrations or quantities deposited by atmospheric deposition. In order to assess the magnitude of PAHs from state highways, WSDOT will screen selected stormwater runoff samples for PAHs.

3.2.1.6 Oxygen Depleting Compounds in Highway Runoff

Biochemical Oxygen Demand (BOD) is usually defined as the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions. BOD is widely used to determine the pollution strength of domestic and industrial wastes in terms of the oxygen that they will require if discharged into natural watercourses. BOD is generally measured over a 5 day period (BOD_5), and generally corresponds to the oxygen demand exerted by carbonaceous compounds in the effluent. Ultimate (UBOD) or 20 day BOD (BOD_{20}) is a longer duration analytical test that estimates the oxygen demand from both carbonaceous and nitrogenous compounds in the effluent. No historical data for BOD_{20} from highway stormwater runoff is currently available.

Chemical Oxygen Demand (COD) is another broad-based indicator of pollution strength measured in terms of total oxygen needed for complete oxidation of all constituents to carbon dioxide and water. Historical evidence has shown that BOD and COD of stormwater runoff are relatively minor to other categorical sources and natural background levels.

Table 12 - Historical Mean BOD and COD Concentrations in Highway Runoff from Western Washington and Oregon

Source	Location	BOD_5 (mg/l)	COD (mg/l)
Farris, 1973	I-90, North Bend	12.7	N/A
Farris, 1973	S. Bellevue Interchange	13	123
Farris, 1973	Lacey V. Murrow Bridge	111	548
Chui, 1981	I-5	N/A	150
Chui, 1981	Montesano, SR 12	N/A	109
Chui, 1981	Snoqualmie Pass, I-90	N/A	44
Chui, 1981	Vancouver, I-205	N/A	45
Portland NPDES Pt. 2 Application	NW Yeon (SR 30), Portland	20 CV = 2.33	123 CV = 1.18

3.2.1.7 Bacterial Contaminants in Highway Runoff

Stormwater runoff from all land uses has historically been known to contain very high concentrations of bacteria as well as extreme variability from sample to sample. Highway runoff is no exception. There are many natural sources of bacteria, including leaf litter, septic tank drainage, organic material, wildlife, etc., that probably contribute significantly to high bacteria counts in stormwater. Due to the large number of bacterial colonies found in stormwater runoff samples, there are problems in interpreting the data. Laboratories typically must dilute stormwater runoff samples to very small volumes to be able to count the number of bacterial colonies. In all published studies, the results indicate very high colony counts and an extreme degree of statistical variability. Enterococcus and fecal coliforms are not human pathogens, but they are used as indirect indicators of the presence of pathogens. Based on the historical evidence and the difficulties of assessing bacterial data accurately, WSDOT will not regularly test for fecal coliforms, enterococci, or streptococcus.

3.2.1.8 Pesticides and Herbicides in Highway Runoff

The 1976-77 FHWA sampling study found no significant concentrations of pesticides/herbicides in any highway runoff sample. The Portland study included priority pollutant scans for 3 highway

runoff events, including complete pesticide scans. Out of 171 parameters analyzed in the organochlorine, organophosphate, and chlorinated pesticide/herbicide scans, 2 detections were indicated, both for pentachlorophenol, a wood preservative not used in roadside or roadway applications by WSDOT. WSDOT maintains a complete and comprehensive list of all pesticides that are used in roadside settings. All pesticides and herbicides used by WSDOT are registered with the EPA under FIFRA, applied by certified professionals, and applied in strict accordance with specified application procedures and standards. During 1995, WSDOT used 187 different types of pesticides and herbicides in its maintenance practices. Of this total, only 0.475 liquid ounces of 4,4-DDT (diazion-3) and 0.0232 lb. of Aldrin (Dursban-1) were used. These substances were both used to control a carpenter ant invasion at a rest area therefore not in a roadside setting. These are the only pesticides that WSDOT used that are listed under 40 CFR 122, Appendix D, Table 2 (Organic Toxic Pollutants). All other pesticides used by WSDOT during 1995 statewide were not cited as Toxic Pollutants. WSDOT will perform pesticide scans in conjunction with annual priority pollutant scans at its long-term stormwater monitoring sites in order to assess their impact on water quality. Annual tracking of pesticide and herbicide usage will continue as part of WSDOT's management programs.

3.2.1.9 Volatile Organic Compounds in Highway Stormwater Runoff

Highway drainage systems are highly aerobic. If volatile organic compounds (VOCs) are present in highway stormwater runoff the turbulence within standard highway drainage systems, they would in almost all cases transform to the vapor phase and escape into the atmosphere. In the Portland NPDES Part 2 characterization study, roadway runoff exhibited 7 detections out of 194 parameters analyzed from 4 storm events. No single VOC parameter was detected more than once.

One "non standard" (not listed in 40 CFR 122, appendix D, Table II) VOC that has gained attention recently is Methyl tert Butyl Ether (MTBE). MTBE is made from methanol in natural gas and is added to gasoline either seasonally or year round in many parts of the United States to increase the octane level and to reduce carbon monoxide and ozone levels in the air. As part of the U.S. Geological Survey's National Water Quality Assessment (NAWQA), it was discovered that MTBE was frequently detected in groundwater samples.

Since MTBE is not used as a gasoline additive in Washington state and the highly aerobic nature of highway drainage systems, WSDOT will not analyze highway stormwater runoff samples for VOCs.

3.2.1.10 Toxicity of Highway Runoff and Direct Impairments of Beneficial Uses

The bacterial bioluminescence test (BBT), commercially known as Microtox™, is a metabolic inhibition test that uses a standardized suspension of luminescent bacteria, *photobacterium phosphoreum*, as test organisms to quickly and directly evaluate the toxicity of a stormwater sample. Luminescent bacteria divert up to 10% of their respiratory energy into a specific metabolic pathway that converts chemical energy into visible light. This pathway is tied to respiration; any change in cellular respiration or disruption in cell structures from aquatic toxicity results in a change in respiration and a concurrent change in the rate of bioluminescence. This effect, coupled with the fact that bacterial respiration is 10 to 100 times greater than mammalian cells, proves to be a highly dynamic, quick, effective, and relatively inexpensive effluent toxicity testing method. In the BBT, the light output of test organisms is measured under standard conditions and with the test sample. Reduction in light output between the first and second measurements is essentially proportional to the toxicity of the test sample. Conducting these tests will allow WSDOT to directly evaluate stormwater toxicity at its sampling sites.

WSDOT intends to perform Microtox™ wet and dry season testing at its stormwater characterization and monitoring sites to assess toxicity effects of highway runoff.

3.2.1.11 Conclusions: Highway Runoff Constituents of Primary Concern and Stormwater Sampling

WSDOT has determined the primary pollutants of concern that are representative of highway runoff and are identified in the list below. The monitoring program will analyze for these constituents in its monitoring program and will also incorporate BMP effectiveness monitoring whenever possible. Detailed discussions on stormwater sampling protocols, procedures, and methods are contained in section 3.3.7. The pollutants that have of the greatest concern in highway stormwater runoff and will be regularly monitored by WSDOT at its sampling sites are:

Solids:

Total Suspended Solids	Total Dissolved Solids

Metals:

Cadmium (total)	Cadmium (dissolved)
Copper (total)	Copper (dissolved)
Lead (total)	Lead (dissolved)
Zinc (total)	Zinc (dissolved)

Nutrients:

Nitrate-Nitrogen	
Phosphorous (total)	Orthophosphates

Oxygen Demand:

Biochemical Oxygen Demand (5 day)
Chemical Oxygen Demand

When grab samples are collected, the following constituents will be analyzed:

Oil & Grease
Total Petroleum Hydrocarbons

On an Semi-annual basis, WSDOT will perform a priority pollutant scan at its long-term monitoring sites (identified in δ3.3.6.3), which will include:

Polynuclear Aromatic Hydrocarbons
Ultimate (20 day) Biochemical Oxygen Demand
Effluent Toxicity Using the Microtox™ Technique

3.2.2 Best Management Practices for Highway Stormwater Quality and Quantity Control

"Best Management Practices" or BMPs are structural and nonstructural practices that when used singly or in combination, reduce the downstream quantity and quality impacts of highway stormwater runoff. As required by the Highway Runoff Manual, designers should evaluate the potential for stormwater degradation to surface and ground waters and utilize the design that would facilitate the least impact. WSDOT is required by statute to allow passage of all off-site flows; however no treatment is required for the off-site flow.

Structural BMPs operate by trapping and detaining unwanted pollutant constituents in stormwater runoff. These trapped constituents are then disposed through periodic maintenance of the BMP in an environmentally sound manner. The basic mechanisms of pollutant removal operating in structural BMPs are the gravitational settling of pollutants, filtration of solid-phase pollutants, infiltration of soluble constituents through the soil profile, sorption and ion exchange processes, and biological/chemical conversion of pollution constituents. Structural BMPs are passive stormwater control systems in that they require little to no "hands on" operations and labor. Some structural BMPs also require minimum amounts of land on which to locate. Such "ultra-urban" BMPs can also exhibit high pollutant removal efficiencies, but at the cost of having increased maintenance and operations costs. This illustrates a general paradigm of stormwater BMPs: they can be built to any

size specifications, but with smaller physical size the maintenance and requirements increase exponentially for the BMP to maintain its effectiveness.

Nonstructural BMPs are typically "source control" systems, designed to minimize the accumulation of pollutants, and reduce their initial concentrations in stormwater runoff. Nonstructural BMPs include both passive systems, such as land use planning or vegetative buffers, and active operational systems, which require continuous labor and can include street sweeping or litter removal. Some nonstructural BMPs, such as public education or trip reduction programs, can be difficult or impossible to evaluate for their effectiveness in terms of water quality performance. Nonstructural BMPs are often used in conjunction with structural controls, which are more consistent and reliable, to create a more effective overall treatment system.

3.2.2.1 Permanent Stormwater Control Features - Conventional Structural BMPs Used By WSDOT To Control Stormwater Runoff

The following structural stormwater BMPs are listed and their design criteria are specified in WSDOT's Highway Runoff Manual, which has been approved by the Department of Ecology in February 1995 using the procedure specified in WAC 173-270-030(1), the Puget Sound Highway Runoff Program. WSDOT will initiate amendments to the HRM according to WAC 173-270-030(2) as BMP design specifications are upgraded and modified.

BMP RB.05 - Biofiltration Swales

Biofiltration swales are shallow, flat-bottomed vegetated channels to convey stormwater where pollutants are removed by filtration, particle settling, infiltration, adsorption, and biological uptake of constituents. They require shallow slopes and soils that drain well. Biofiltration swales provide both water quality treatment and conveyance to highway stormwater runoff. It does not provide stormwater quantity treatment but can convey runoff to BMPs designed for that purpose. Biofiltration swales are used extensively by WSDOT because roadside and median "borrow ditches" are easily modified to biofiltration swale specifications, as detailed in the HRM, chapter 8-3.1.

Biofiltration swale designs have achieved mixed historical performance in pollutant removal efficiency. Many swales suffer from incomplete or nonuniform vegetative cover, some of which display extensive channelization (Koon, 1995). Some the more effective biofiltration swales for removing pollutant constituents have been found to have incorporated check dams into their designs or have developed wetland vegetation species (Virginia Transportation Research Council, 1994). WSDOT will investigate enhancements such as these to improve the pollutant constituent removal performance of its biofiltration swales.

BMP RB.10.T - Vegetative Filter Strips

Filter strips, also known as vegetative buffer strips, are used along rural roadways where "sheet flow" from the roadway passes through a section of gently sloping, vegetated land surface before entering a conveyance system (ditch or catch basin) or a quantity control BMP. They may appear in any vegetated form from grassland to forest, and are designed to intercept upstream flow, lower flow velocity, and distribute water as sheet flow. Dense vegetative cover facilitates convention pollutant removal through detention, filtration by vegetation, and infiltration into the soil. Successful performance of filter strips relies on maintaining shallow unconcentrated flow regimes and dense vegetation (Colorado DOT, 1992). The WSDOT vegetative filter strip design is still in an interim phase of development. Filter strips are intended to be incorporated as one component in an integrated stormwater management system. As such, they can lower runoff velocities, slightly reduce runoff volume, watershed imperviousness, and contribute to groundwater recharge (Schueler, 1987).

WSDOT is current conducting performance monitoring of vegetative filter strips at a test site at MP 15.8 on SR 8 in western Thurston County.

BMP RD.05 - Wet Ponds

A wet detention pond is a facility that treats stormwater for water quality by utilizing a permanent pool of water to remove conventional pollutants from runoff through sedimentation, biological uptake, and plant filtration. A wet pond may also be designed to provide stormwater quantity control through the use of a live storage area above the permanent pool. The ability to provide both water quality and water quantity treatment make wet ponds one of the more viable stormwater BMP options. Also, wet ponds have low maintenance and operations requirements to retain their effectiveness.

The WSDOT wet pond design, detailed in section 8-3.3 of the HRM, emphasizes long, narrow, multi-celled, irregularly shaped wet pond designs which are less prone to hydraulic short-circuiting and have a more natural appearance. WSDOT wet ponds are designed with a permanent pool volume equal to the runoff volume of the 6-month design storm in the area. Biological processes occurring in the permanent pond pool aid in reducing the amount of soluble nutrients present in the runoff, such as nitrates and orthophosphates (Schueler, 1987). Nutrient removal efficiencies of wet ponds have been shown to vary directly with the ratio of the volume of the permanent pool to the volume of runoff produced form the mean storm. To achieve high pollutant removal efficiencies, the volume of the permanent pool should be at least three times the water quality volume (the volume to be treated which is usually assumed to be the first flush or 13 mm of runoff per impervious hectare) (Northern Virginia Planning District Commission, 1992).

BMP RD.06 - Nutrient Control Wet Ponds

This BMP is similar to RD-0.5 but also includes an additional cell which has a shallow constructed wetland area which provides additional removal of nutrients through vegetative uptake. Stormwater quantity control can also be provided by adding a live storage area above the permanent pool. This BMP is particularly useful when discharging to nutrient sensitive water bodies, such as lakes or ponds. Developing a standard removal efficiency rate is problematic because the wetland design can vary widely. Hydrology of the soils at the site is generally the most important factor in determining the effectiveness of this BMP because of its effect on sedimentation aeration, biological transformation and adsorption onto bottom sediments (Colorado DOT, 1992).

WSDOT will be monitoring the constituent removal effectiveness of a nutrient removal wet pond that will be constructed in 1997 as part of the I-5 164th St. SW to SR 526 HOV project in Snohomish County.

BMP RD.15 - Wet Vaults/Tanks

Wet vaults and tanks are underground storage facilities that treats stormwater through the use of a permanent pool of water that acts as a settling basin, and are used only when other BMPs cannot be built due to space limitations. Wet vaults/tanks have two cells which are divided by a baffle. Wet vaults/tanks use gravity settling of suspended solids as the primary removal mechanism but are unlikely to be as effective as open ponds in removing highway runoff constituents because of the paucity of detention time, vegetation, or soils to facilitate physical or biochemical removal mechanisms. Regular maintenance is a critical aspect for retaining the pollutant removal effectiveness of wet vaults/tanks.

BMP RI.05 - Water Quality Infiltration Ponds

A water quality infiltration pond is facility that provides water quality treatment by storing runoff from the 6-month 24-hour storm and infiltrating it into the soil. Treatment is provided through particle settling, biological uptake, filtration, sorption, chelation, and ion exchange processes in the upper layers of the soil, and the water is then released to groundwater. Water quality infiltration ponds are generally used for drainage areas between 2 ha and 50 ha and having type A or B soils. Runoff from larger storm events must be routed to a quantity control BMP. Infiltration rates must be between 0.5 and 2.5 inches per hour (maximum 2.0 inches per hour in sole source aquifer areas). Water quality infiltration ponds differ from BMP RI.06 (listed below) by the allowable infiltration rate. BMP RI.06 requires a *minimum* of 6.0 inches per hour

infiltration, while BMP RI.05 has an allowable *maximum* of 2.5 inches per hour. From a design perspective, this amounts to a minimum 240% difference in surface area, making the water quality infiltration pond impractical in areas where available land is limited.

WSDOT will monitor water quality infiltration ponds beginning in 1997 located at the DuPont interchange located at MP 118.55 of SR 5 in Pierce County.

BMP RI.06 - Infiltration Ponds, Trenches, and Dry Wells

An infiltration pond is a surface pond that provides stormwater quantity control by containing excess runoff, allowing that runoff to infiltrate into the soil. As the stormwater percolates into the ground, physical, chemical, and biological processes occur which remove both sediments and soluble constituents. Infiltration basins effectively remove soluble pollutants because processes such as adsorption, ion exchange, and biological processes remove these constituents from stormwater. For drainage areas less than 2 ha, an infiltration trench or dry well is more appropriate. Infiltration BMPs create visible surface ponds that dissipate because water is infiltrated into the underlying substrata. Infiltration ponds are designed to infiltrate the 10-year storm within 24 hours after precipitation has ended and the 100-year storm within 48 hours.

Dry wells are subtypes of infiltration BMPs and are deep slotted concrete sumps designed to allow stormwater to infiltrate to the subsurface and acts primarily as a water quantity BMP. Historically, WSDOT installed dry wells in relatively small drainage areas (< 2 ha) that possessed highly transmissive soils. Dry wells are common throughout Pierce County in the South Puget Sound NPDES MS4 permit area.. Current design standards specify water quality pretreatment for the 6 month 24 hour storm event for stormwater discharge to dry wells.

WSDOT will be evaluating methodologies for retrofitting pre-existing dry well systems for compatibility with current design standards during the term of the permit.

BMP RD.11 - Dry Ponds

A dry pond is a facility that stormwater quantity control by containing excess runoff in a detention basin, than releasing the runoff at allowable levels using a set of engineered orifices in a riser outlet pipe. Although dry ponds do remove small amounts of stormwater constituents, a water quality BMP designed to treat a 6-month 24-hour storm must precede a dry pond.

BMP RD.20 - Dry Vault/Tanks

A dry vault/tank is a facility that treats stormwater for water quantity control by detaining runoff and then releasing reduced flows at established standards. Dry vaults/tanks are not to be used for stormwater quality treatment because of their limited pollution removal capabilities. Newly installed dry vaults/tanks must always be preceded by a water quality BMP designed to treat the 6 month storm (biofiltration swales are particularly well suited for this purpose). Because dry vault/tanks are underground, they are more difficult to inspect and maintain. Vaults/tanks will be used only on small drainages (< 2 ha), and then only after it has been demonstrated that more desirable BMPs are not practicable.

3.2.2.2 Nonstructural or Source Control BMPs

Effective implementation of nonstructural BMPs require establishing specific criteria and standard procedures for the various types and of equipment, facilities, operations and extensive personnel training. In each case, the objective is to prevent or reduce the amount of constituents released to receiving waters using "environmental housekeeping". This discussion of non-structural BMPs emphasizes practices to achieve source control, pollution containment, and biological filtering and treatment. Used alone, it is unlikely that none of the individual nonstructural BMPs will provide sufficient stormwater treatment for a given site. However, these BMPs offer options to augment on-site structural or other stormwater management facilities (FHWA, 1996).

Kramme, et. al. (1985) performed a comprehensive study for the FHWA investigating the impact of common highway maintenance practices on stormwater runoff quality. It was found that the proximity of the activity to a body of water increases the likelihood of adverse effects. The number of factors increase the probability of adverse water quality impacts, including:

- Proximity to receiving water bodies,
- Exposing or moving soil or sediment,
- The use or disposal of toxic components, particularly leachable substances,
- The use or disposal of materials containing leachable nutrients,
- The use or disposal of decomposable organic materials,
- The use or disposal of materials that could change the turbidity, pH, or solids content of the receiving water.

Table 13 contains a list compiled by Kramme et. al. organized by probability of adverse effects to stormwater quality.

Table 13
Highway Maintenance Practices and Impacts to Stormwater Quality

Highway maintenance practices which can have a **probable impact** on stormwater quality:

- Sanding and deicing
- Repairing slopes, slips, and slides
- Cleaning ditches, channels, and drainage structures
- Repairing drainage structures
- Bridge painting
- Subsurface repair
- Chemical vegetation control

Highway maintenance practices which can have a **possible impact** on stormwater quality:

- Full depth repairs
- Surface treatments
- Blading and restoring unpaved berms and/or ditches
- Bridge surface cleaning
- Bridge deck repairs
- Mowing
- Planting or care of shrubs, plants, and trees
- Seeding, sodding, and fertilizing
- Application of abrasives
- Care of rest areas
- Washing and cleaning maintenance equipment
- Bulk storage of motor fuels
- Disposal of used lubricating oils

Maintenance practices which have **no probable impact** on stormwater runoff quality:

- Blading unpaved surfaces
- Pothole patching
- Surface repairs
- Filling and sealing joints and cracks
- Pavement jacking
- Planing pavements - bituminous and concrete
- Bridge joint repair
- Superstructure repair
- Cleaning pavement
- Guardrail repair

- Snow plowing
- Crash attenuator repair
- Snow fence installation and removal
- Highway lighting
- Flat sheet, side-mounted, and overhead sign maintenance
- Pavement marking
- Bulk storage of non-fuel materials
- Controlling and disposal of roadside litter

Presented in the following sections are a variety of nonstructural BMPs which have been thoroughly evaluated in empirical studies for their effectiveness in reducing the amount of constituents in highway stormwater runoff. Many of these practices have been developed and implemented by commercial, industrial, and municipal facilities, yet may be applied to highway operations. Table 14 summarizes the BMPs discussed in this section (FHWA, 1996).

Table 14 - Nonstructural Highway Stormwater BMPs and Affected Constituents

Nonstructural BMP	Sediments	Nutrients	Metals	Pesticides, Petroleum, & Other Toxics	Debris	Runoff Rate
Land Use Planning	●	●	●	●		●
Landscaping & Vegetative Practices	●	●	●	●		●
Pesticide & Fertilizer Management		●		●		
Litter and Debris Controls			●	●	●	
Illicit Discharge Controls			●	●	●	
Bridge Cleaning and Deck Drainage	●		●	●		●
Bridge Painting	●		●	●		
Chemical Storage			●	●		

Land Use and Comprehensive Site Planning

Land use management and planning is widely viewed as the most cost effective approach to control stormwater quality and stormwater runoff (Camp, Dresser, and McKee, 1993). Through land use planning, existing or potential water quality problems can be identified and specific goals and measures can be defined for preventing, reducing, mitigating, or restoring water quality impacts. WSDOT participates with local jurisdictions and the local comprehensive plans, ordinances, zoning, and site development regulations in all of its transportation projects. WSDOT intends to enhance its efforts in identifying potential impacts to the environment well in advance of project initiation. In doing so, WSDOT can identify those stormwater outfalls that need structural BMP retrofits. The Snohomish Watershed Demonstration Project, detailed in section 3.1.3.3, has been developed to allow WSDOT to identify unmet needs in advance and redirect transportation project funds toward those priority needs. In doing so, WSDOT can serve the dual purposes of satisfying unmet needs in the environmental and water quality arena, while improving the benefit to cost performance of highway transportation projects.

Landscaping and Vegetative Practices

Vegetation of any sort provides several advantages in stormwater management. By increasing the surface roughness, vegetation helps control quantity as well as quality of stormwater.

Typically, vegetative measures alone will not be sufficient to serve all stormwater management purposes on a site, but such practices can be incorporated into an integrated "treatment train" (Horner, et. al., 1994). Some structural BMPs, such as biofiltration swales and vegetative filter strips, are dependent on dense contiguous vegetation growth in order to maintain their effectiveness. Vegetation also diminishes the impact of precipitation and slows runoff, thereby reducing soil erosion.

Pesticide and Fertilizer Management

Pesticides, because of the obvious potential for misuse, are used sparingly in roadside applications. The primary usage are to control noxious weeds and for occasional infestations of invasive insects, such as carpenter ants. Fertilizers are not used by WSDOT. Instead, WSDOT uses exclusively low maintenance native plants which require no fertilization other than that supplied by atmospheric deposition and/or in-situ decomposing vegetation. Pesticide and fertilizer management prevents pollution by applying the chemicals at the proper time, applying only the types and amounts necessary, and considering the environmental conditions and hazards that may be present at the site.

Integrated pesticide management is part of WSDOT's integrated vegetative management program that is currently being implemented and is detailed in section 3.3.4 of this document.

Litter Control and Steet Sweeping

Litter and debris accumulations originate from littering, illegal dumping, rough and damaged road surfaces, uncontrolled construction runoff, deicing treatments, leaves, tree and grass cutting, dirt and debris dropped from trucks and vehicles, surface runoff from adjacent lands, wind-blown from nearby sources, atmospheric deposition, and vehicular traffic. Historically, efforts to control street waste has been focused on safety and aesthetic concerns. Street sweeping has often been considered as a possible method of reducing pollutant loads in highway stormwater runoff. Contradictory findings on the effectiveness of sweeping have been reported in several studies of highways and urban streets. EPA (1983) compared results of street sweeping projects in 5 cities which evaluated sweeping as a management practice for controlling constituents in urban runoff. Researchers at four of these projects concluded that street sweeping was not effective for this purpose. At the fifth site, which had pronounced wet and dry seasons, researchers concluded that sweeping just prior to the rainy season could produce some constituent removal benefit. It should be noted that WSDOT's maintenance program includes such a component (section 3.3.6.8).

A large database was compiled by EPA at 10 street sweeping study sites which evaluated a total of 381 control (not sweeped) storm events and an additional 277 events that were monitored when street sweeping was in effect. Analysis of this data indicated that no significant reduction in pollutant concentrations were produced by street sweeping. EPA concluded that the changes in site EMCs were likely due to random sampling than the actual effects of the sweeping operations.

Pitt (1979) studied the effectiveness of street sweeping using wet-dry vacuum unit to clean test areas before and after sweeping. He found that frequent street sweeping (once or twice *per day*) on smooth asphalt streets could remove up to 50 percent of the total solids in urban runoff. Organics, nutrients, and hydrocarbon compounds were found to be unaffected by street sweeping, even for daily cleaning. The conclusions of the study sere that a cost increase of a factor of 10 were needed to obtain significant runoff control for solids and metals. This cost increase was estimated to increase the control of stormwater runoff constituents from street cleaning from less than 10% to 25%.

Sartor and Boyd (1972) conducted a street sweeping study for the EPA, and concluded that street sweeping practices are essentially for aesthetic and safety purposes and that, even under well-operated and highly efficient street sweeping programs, their efficiency in the removal of the dust and dirt fractions of street surface constituents was low. Further, they found that the very fine material (<43 μm) accounts for only 6% of the total solids of the total solids but accounted for 25%

of the BOD, 33% to 50% of the algal nutrients, 50% of the heavy metals, and 75% of the total pesticides. Removal rates for these very fine materials was measured at only 15%.

Maestri, et. al. (1985) reported that street cleaning is effective only for large solids and does little to reduce stormwater constituent loading.

Irish, et. al. (1995), in a controlled evaluation of the factors affecting the quality of highway runoff in the Austin, Texas area, compared 29 precipitation events during a "no sweep" period to 26 events sampled while sweeping occurred once every two weeks. Statistical differences between the two groups were compared using a *t*-test. The only constituents of the 13 that showed a statistically significant decrease between the sweeping periods were the solids, TSS and VSS. 7 constituents (BOD, COD, total carbon, dissolved total carbon, total phosphorous, copper, and zinc) showed a statistically insignificant decrease and 4 others (nitrates, oil & grease, iron, lead) showed a statistically insignificant increase during the sweeping period.

The conclusions that can be culled from these studies are:

- Street sweeping machines, whether mechanical, vacuum assisted, regenerative, or street flushing, removes primarily large debris, leaving fine to very fine particles unaffected.
- The effectiveness of street sweeping in reducing constituent loading is marginal to nonmeasureable in most case studies. Generally, street sweeping is ineffective unless it is done very intensely, i.e. several times a week or daily.
- The ability to conduct intensive street sweeping can be severely impeded by the need for multiple vehicles for lane closures and curbside parking.
- Significant capital and O&M budgets are required for extensive street sweeping programs. A large cost increase, up to 10 times, is required to deliver a small (<10 to 25%) reduction in constituent loading in highway stormwater runoff.
- Routine street sweeping programs are needed primarily for safety and aesthetic purposes, e.g. to remove debris that clog catch basins, reduce the amount of curbside litter, and to eliminate large debris which may create safety hazards if struck. Reduction of stormwater constituent loads resulting from street sweeping is an ancillary, but not an expected or predictable benefit, if it actually occurs.

Illicit Discharge Controls

Storm sewer systems provide direct conduits for materials to be conveyed to receiving waters. Illicit discharges to MS4 systems typically occur as illicit connections to storm sewers or illicit dumping at storm drains. Techniques for preventing, detecting, and investigating illicit discharges include (Camp, Dresser, and McKee, 1993; Driscoll and Mangarella, 1990; Terrene Institute, 1994):

- Inspection during sewer construction,
- Routine outfall inspection,
- Interior pipe inspection and/or testing of the sewer, and interior building,
- Storm drain labeling,
- Personnel training regarding proper disposal procedures,
- Increase personnel and public awareness of the implications of illicit dumping and of available waste oil recycling stations and hazardous materials disposal locations.
- Encourage personnel and citizens to report evidence or indications of illicit discharges,
- Investigate reported complaints.

WSDOT utilizes information gathered by highway maintenance and outfall inventory crews to identify potential illicit outfalls to WSDOT's MS4 systems.

Bridge Painting, Cleaning, Maintenance, and Deck Drainage

Bridge cleaning can result in cleaning solutions, desiccated paint, bird guano, and other substances that have accumulated on the bridge structure to enter receiving waters. Ideally, runoff of wash water should be controlled to allow treatment of the water prior to discharge. However, drainage

systems of many bridges discharge runoff directly beneath the bridge via scuppers. Bridges are generally cleaned only prior to painting. WSDOT employs several bridge painting BMPs which are dependent on the receiving water. These activities are regulated on a project-by-project basis through short term modifications of water quality standards, administered by Ecology, and hydraulic project approvals, administered by the Washington State Department of Fish and Wildlife. Bridge retrofits and new bridge designs address stormwater runoff based on the sensitivity of the associated water body. Bridges over high sensitivity water bodies, i.e. freshwater streams and small lakes with anadromous fish populations, are designed to collect and convey stormwater, with storm drains routed to discharge to structural stormwater BMPs. The following BMPs are used to minimize runoff water quality problems associated with bridge activities:

- Avoiding paving during rain,
- Maintenance wastes are collected and kept from entering bridge storm drains,
- Saw-out slurry and broken asphalt are collect for removal from the site,
- When saw cutting, liquid cleaning or wash down is performed on the bridge deck, storm drains are blocked or covered to divert runoff to a collection area,
- Drip pan or absorbent materials are kept on site and used below leaking or dripping paving equipment and vehicles or other spill areas on the site,
- Structural cleaning solutions are non-toxic and use of chlorine or solvents are minimized when removing paint or bird guano accumulations,
- Hanging tarps are used to trap, contain, and collect wash water from bridge cleaning activities,
- Booms are used in underlying surface waters to trap and remove floating debris,
- Train workers on the methods and need to reduce water quality impacts.

Chemical Storage

Safe chemical storage and management practices are routinely implemented at all WSDOT project and maintenance operations using hazardous or toxic materials. In addition, stormwater quality management necessitates protecting other materials from exposure to rainfall and runoff to avoid leaching of constituents to and discharge to receiving waters. Vehicle and storage areas, fueling areas, parking areas, weigh stations, food service facilities, as well as road surfaces can potentially contribute excess constituent levels to runoff. Of particular concern and consideration for WSDOT are deicing chemicals, fuels, oils, solvents, cleaning solutions, paints, and pesticides. WSDOT has detailed protocols and procedures for controlling these substances other than sediments at construction sites, which are detailed in Chapter 8-1 of the HRM. Among these controls are:

- Pesticide control (BMP C1.10),
- Handling of petroleum products (BMP C1.20),
- Nutrient application and control (BMP C1.30),
- Solid waste handling and disposal (BMP C1.40),
- Use of chemicals during construction (BMP C1.50),
- Managing hazardous products (BMP C1.60),
- Equipment washing (BMP C1.70),
- Spill control planning and cleanup (BMP C1.80),
- Treatment and disposal of contaminated soils (BMP C1.90), and
- Concrete trucks (BMP C2.00).

WSDOT will intermittently conduct classes on spill control and chemical containment methods for its construction contractors during the term of the NPDES permit.

BMP Maintenance

Regular maintenance of structural stormwater BMPs must be performed to keep the system efficiently conveying stormwater runoff and water quality control. Lack of maintenance has been shown to significantly impair the performance of biofiltration swales (Koon, 1995). Maintenance of structural BMPs also minimizes local flooding caused by blocked or constricted conveyance systems. An unknown factor is the life-cycle maintenance costs and schedules required to maintain BMP performance. Particularly, what visual cues, such as sparse vegetation, channelization, siltation, etc. indicate significant impairment of BMP performance? WSDOT will attempt to investigate life-cycle maintenance costs of stormwater BMPs during the term of the permit through a

research project funded either internally or through national transportation organizations such as FHWA, or the National Cooperative Highway Research Program (NCHRP).

BMP Selection

The selection of stormwater BMPs begins with an investigation of the need for treatment and existence of additional restrictions, such as space limitations. Then project, then each subbasin, is evaluated for the applicability of dual purpose BMPs for both quantity and quality. If no dual purpose BMP is selected, then the designer selects both a quality and a quantity BMP. The chart below shows the decision process WSDOT designers use for BMP selection.

Enter YES (Y) or NO (N) for each question until treatments to meet all requirements are identified. In N, go on to the next question. For each Y use the BMP listed or contact the support group listed. Continue until all required treatment is provided.

Project Wide	**BMP/Contact**	**Y/N**
Does the project include earthwork?	TESC if Y	
Less than 5,000 ft2 of impervious added?	End if Y	
Additional Requirement from area plans?	Hydraulics	
Is nutrient removal required?	Hydraulics	

Answer each question for each on-site subbasin.

Dual Purpose Treatment	**BMP/Contact**	**Subbasin**				
1. Regional treatment facility available?	Hydraulics					
2. Will a wet pond with detention fit the site?	BMP RD.05/RD.06					

Any untreated stormwater must have both a quality and a quantity BMP.

Quality Treatment	**BMP/Contact**	**Subbasin**				
1. Will an infiltration basin fit the site?	BMP RI.05					
2. Will a wet pond fit the site?	BMP RD.05/RD.06					
3. Will a filter strip fit on site?	BMP RB.10T					
4. Will a biofiltration swale fit on site?	BMP RB.05					
5. Possible to purchase more right-of-way?	Project Engineer					
6. Will a wet vault fit on site?	BMP RD.15					
7. No practicable quality treatment?	Hydraulics					

Quantity Treatment	BMP/Contact	Subbasin				
1. Drains to marine water, lake, or large river?	Hydraulics					
2. Will an infiltration pond fit on site?	BMP RI.06					
3. Will a dry pond fit on site?	BMP RD.11					
4. Possible to purchase more right-of-way?	Project Engineer					
5. Will a detention vault fit on site?	BMP RD.20					
6. No practicable detention?	Hydraulics					

3.2.2.3 Temporary Erosion and Sediment Control BMPs

After designing the permanent stormwater controls, WSDOT designers develop BMPs to control erosion and sediment wash off for projects that involve earthwork. This is done by describing the major problem areas and the appropriate BMPs that could be implemented to manage potential problems. The first consideration is to disturb as little of the site for the shortest amount of time during the "dry" season. The Temporary Erosion and Sediment Control (TESC) plan is developed by WSDOT designers to prevent any increase in sediment from leaving the site. The design is prepared to insure that the runoff flow leaving the site is no greater in constituent loading, velocity, or quantity than before construction started. Most projects with earthwork require at least one BMP to retain sediments on the site. The list of *sediment retention BMPs* used by WSDOT in highway construction projects include:

- Filter (silt) fences (BMP E3.10) - used for non-concentrated flows,
- Straw bale barriers (BMP E3.15) - used when flows are concentrated,
- Brush barriers (BMP E3.20) - uses material from the construction site,
- Gravel filter berms (BMP E3.25),
- Storm drain inlet protection (BMP E3.30) - used when functioning storm drains are within the project boundaries,
- Sediment traps (E3.35).

Among the list or *nonstructural erosion control BMPs* used in highway construction projects include:

- Temporary seeding of cleared areas (BMP E1.10),
- Mulching and matting (BMP E1.15),
- Plastic coverings (BMP E1.20),
- Preserving preexisting vegetation (BMP E1.25),
- Establishment of vegetative buffer zones (BMP E1.30),
- Permanent seeding and planting (BMP E1.35),
- Sodding (BMP E1.40),
- Topsoiling (BMP E1.45).

The list of *structural erosion control BMPs* include:

- Stabilized construction entrances and tire washes (BMP E2.10),
- Construction road stabilization (BMP E2.15),
- Dust control (BMP E2.20) - using water or any temporary ground covers,
- Pipe slope drains (BMP E2.25) - bypasses runoff to a stabilized area,
- Level spreaders (BMP E2.50) - converts concentrated flows to sheet flow,
- Interceptor dikes and swales (BMP E2.55),
- Check dams (BMP E2.60),

3.2.2.4 Experimental Water Quality BMPs

WSDOT will, over the term of the 1995-2000 NPDES MS4 permit, develop new, innovative, and experimental BMPs which will be designed to:

1) Improve the water performance of existing BMPs through design modifications,
2) Provide designers with more and better options dealing with site specific constraints for constructing stormwater BMPs, primarily the lack of available land area,
3) Transfer, modify, and adapt accepted technologies currently used in agriculture, waste water, and drinking water treatment systems for use in highway settings.

WSDOT will monitor the constituent removal performance of the following experimental BMPs as part of the evaluation process. Those BMPs which demonstrate the ability to remove stormwater constituents to levels which meet Washington State water quality standards while having acceptable levels of operations and maintenance requirement will be proposed for additions to the HRM for routine implementation at highway transportation projects.

This section will be written to satisfy the information requirements for experimental BMPs specified in WAC 173-270-030(6), The Puget Sound Highway Runoff Program, for official notification and requests for interim approvals for the following WSDOT experimental BMPs to treat highway stormwater runoff.

Applicable construction techniques for all experimental BMPs:

Materials for all WSDOT will meet the requirements of the following sections of WSDOT's Standard Specifications For Road, Bridge, and Municipal Construction:

Guide posts	Section 8-10
Mineral aggregate	Section 9-03.4(2)
Gravel backfill for pipe bedding	Section 9-03.12(3)
Gravel backfill for drains	Section 9-03.12(4)
Underdrain pipe	Section 9-05.2(2) & 9-05.2(6)
Wood cellulose fiber	Section 9-14.4(2)
Perlite	Section 9-14.4(6)
Erosion control blanket	Section 9-14.5(2)
Construction geotextile for separation	Section 9-33

Construction and measurement requirements for all experimental BMPs will meet the requirements for these sections:

Structure excavation Class B including haul	Section 2-09.4
Gravel backfill for pipe bedding	Section 2-09.4
Ditch and channel excavation	Section 2-10
Construction geotextile for separation	Section 2-12.5
Underdrain pipe	Section 7-01.4
Gravel backfill for drains	Section 7-01.4
Seeding, fertilizer and mulching,	Section 8-01.4
Guide posts	Section 8-10.4

Monitoring procedures for all experimental BMPs. Chemical constituents and procedures that will be used for monitoring the ecology ditch test site are listed in sections 3.3.7.5, 3.3.7.7, and 3.3.7.8.

Consultation with interested and affected parties for all experimental BMPs. WSDOT will present publish results of all of its experimental BMP studies at public forums such as the American Public Works Association - Stormwater Managers monthly meeting, over the internet at http:\\www.wsdot.wa.gov\eesc\environmental\WQResearch.htm, and in WSDOT's NPDES MS4 annual report. All interested and/or concerned parties will be able and encouraged to comment on the BMP, its applicability, and its viability as a standard stormwater BMP.

Experimental BMP EXP1.0: Ecology Ditch

(i) Description of the experimental BMP. The ecology ditch is a modification of the standard biofiltration swale design for use in areas with very flat gradients (<2%). To provide sufficient drainage in these flat areas, the ecology ditch is constructed with a substrata consisting of highly pervious sand/gravel soils (ecology mix), and a perforated pipe subsurface drainage system. In addition to allowing the ecology ditch to drain sufficiently to maintain vegetation, the underdrain system acts as a sand filter during low intensity precipitation events.

(ii) Why the experimental BMP is being requested and HRM techniques are not appropriate. In many cases in areas with very flat gradients, the depth of flow in a standard biofiltration swale will exceed 4 inches in depth for a 6 mo. / 24 hour storm event. This exceeds HRM design standards. In order to facilitate the transport of stormwater, enhanced infiltration rates are required. The ecology ditch design was developed to facilitate this modification.

(iii) Special construction provisions for the ecology ditch. Cross sections of the ecology ditch are shown in Appendix C. The ecology ditch has a substrate that acts as filtration media. The ecology mix will consist of a mixture of soil amendments and mineral aggregate in accordance with the requirements of Section 8-02 and these specifications:

Soil Amendment	Unit	Quantity (rate)
Perlite	cubic yard (CY)	1 CY per 3 CY of mineral aggregate
Dolomite Lime, #0, #16 to #8 gradation	pound	10 pounds per CY of perlite
Gypsum	pound	1.5 pounds per CY of perlite

The ecology mix will be covered with an erosion control blanket. The ecology mix will then be seeded, fertilized, and mulched and then mulched a second time.

(iv) Ecology ditch testing site(s) and characteristics. An ecology ditch was originally planned to be constructed at SR 167 (Valley Highway), MP 25.35 in Auburn, Washington, but it was eliminated from the project because the road alignment was altered such that space to construct the proposed ecology ditch became unavailable. WSDOT will seek alternate locations for ecology ditch monitoring.

(v) Design criteria. A typical ecology ditch contains a 8 inch PVC underdrain pipe in a 2-foot-wide trench bedded with gravel. Pipe bedding material is a gravel backfill for drains with a maximum size of 1 inch and only 2 percent passing the number 200 sieve. Above the pipe trench the ditch widens to 8 feet and contains a 1 foot layer of gravel aggregate. The aggregate has a gradation of 3/8 inch to number 10 sieve. The surface of the ditch consists of gypsum and alder sawdust mixed onto the top 2 inches of the aggregate. The gypsum is number 0 grade and has a gradation of number 8 to number 16 sieve.

Other necessary design and site criteria for installation of an ecology ditch:

- A minimum length of 200 feet, the maximum bottom width is 10 feet, The bottom width will be specified so that depth of flow does not exceed 4 inches during the 6-month storm;
- Low longitudinal slopes (<2%), which precludes the installation of a standard biofiltration swale;
- The ecology ditch should be sized both as a water quality treatment facility for the 6-month storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm;
- A minimum of three feet of soil between the bottom of ditch to the highest ground water level;

- In-situ soil infiltration rates of at least 2.0 inches per hour;
- Low intensity precipitation events, 50% of the 6-month storm, shouldn't overtop the installed erosion control blanket (dependent on bottom width and side slopes);
- The ideal cross-section of the ditch should be a trapezoid with side slopes no steeper than 3:1.

(vi) Proposed maintenance procedures.

- Remove sediments during summer months when they build up to 4 inches at any spot, cover vegetation, or otherwise interfere with hydraulic performance of the ditch.
- Inspect ecology ditch periodically, especially after periods of heavy runoff. Remove sediments, mulch, fertilize, and reseed as necessary. Be careful avoid introducing fertilizer to receiving waters or ground water.
- Clean curb cuts when soil and vegetation buildup interferes with flow introduction.
- Remove litter to keep the ecology ditch free of external pollution sources.

(vii) Cost estimates. Because of additional excavation, fill, and materials requirements, ecology ditches should cost 50-100% greater than an equivalently sized biofiltration swale. This amounts to (roughly) $7,500 to $20,000 per acre of impervious surface drained. Using this as an basis for estimation, the cost of an ecology ditch could range from $10,000 to over $200,000, depending on the size of the drainage area and the amount of right of way that would have to be acquired.

(viii) Anticipated results. It is anticipated that the ecology ditch will remove suspended solids and constituents associated with solids at rates which vary between 25% and 90%, depending on the intensity of the precipitation event. Higher removal rates is anticipated to be associated with low intensity (<0.25 inch/24 hour) events. Dissolved constituents (nutrients or dissolved-phase metals) are anticipated to be removed at rates which range between 0% and 50%. Concentrations of nutrients in stormwater may actually increase after passing through the ecology ditch in its early life-cycle because of the application of fertilizer during construction to establish vegetation. Consideration should be given to sodding, mulching without fertilizer, or other vegetation methods which do not use fertilizer in drainages discharging to lake basins or water quality limited water bodies because of excessive nutrients.

(ix) Approved BMP(s) that can be used if the experimental BMP fails. Depending on the characteristics of the drainage basin, soil characteristics, and available right of way, biofiltration swales, wet ponds, infiltration ponds, or wet vaults may be suitable alternatives to the ecology ditch.

(x) BMP status. Based on the results of the monitoring program for the ecology ditch, WSDOT will evaluate the BMP for effectiveness in protecting water quality and beneficial uses, its reliability, cost, ease of construction, and maintenance requirements. After evaluation of the results of a monitoring program designed to evaluate the BMP's constituent removal effectiveness, WSDOT may then propose that the ecology ditch be included as a standard BMP in the Highway Runoff Manual.

Experimental BMP EXP1.5: Ecology Embankment

(i) Description of the experimental BMP. The "ecology embankment" is an experimental BMP that is intended for use in areas were wetlands, riparian buffer zones, buildings, or structures do not allow space to install conventional BMPs. The ecology embankment is strip of roadside embankment which receives stormwater runoff via sheet flow from the highway surface. The embankment is constructed of very highly pervious gravel at its upslope end and grades into a mixture of soil amendments and mineral aggregate, the *ecology mix* . The ecology embankment is designed to infiltrate a maximum volume of runoff and acts as a filtration unit for highway stormwater runoff. The filtered stormwater is then conveyed by a perforated pipe system away from the roadside embankment. The outside slope of the embankment is covered with a porous synthetic mat to prevent erosion.

(ii) Why the experimental BMP is being requested and HRM techniques are not appropriate. In many cases, land adjacent to highways are not available or suitable for construction of conventional stormwater BMPs, natural wetlands being one example. The ecology embankment design was developed to provide water quality treatment of highway stormwater runoff using the space

available in the side slopes of the highway prism to filter out solids suspended in highway stormwater runoff.

iii) Special construction provisions for the ecology embankment. A cross section of the ecology embankment is included in Appendix C. The ecology embankment will use the ecology mix (detailed in the ecology ditch section) as a filtration media. The ecology mix is overlain by a synthetic geotextile mat.

The synthetic mat will be heavy weight and consist of three-dimensional structure of entangled nylon monofilaments, melt-bonded at their intersections, forming a stable mat of suitable weight and configuration. The mat will be crush-resistant, pliable, resilient, water-permeable, and highly resistant to chemicals and decomposition.

(iv) Ecology embankment testing site(s) and characteristics. Two ecology embankments are planned to be constructed at SR 167 (Valley Highway), and will discharge stormwater at SR 167-16.38-L-33 in Kent and SR 167-25.35-R-45 in Auburn, Washington. These sites are described in detail in Section 3.3.7. These embankments differ only in that the embankment at MP 16.38 will have a 2.5:1 slope and the embankment at MP 25.35 will have a 6:1 slope. WSDOT has funding to monitor one of these ecology embankments and will use the site at MP 16.38, because the steeper slope will theoretically cause a greater probability and higher volumes of stormwater bypass. WSDOT will monitor the ecology embankment located at MP 25.35 (2.5:1 slope) only if a source to fund monitoring equipment, laboratory analytical costs, staff time, and ancillary costs can be located.

(v) Design criteria. A typical ecology embankment contains a 8 inch PVC underdrain pipe in a 2-foot-wide trench bedded with gravel at its base. Pipe bedding material is a gravel backfill for drains with a maximum size of 1 inch and only 2 percent passing the number 200 sieve. Above the pipe trench the embankment contains a minimum 1 foot layer of ecology mix identical to that used in the ecology embankment. The ecology mix layer is overlain by porous geotextile mat. The exposed surface of the embankment is seeded, fertilized, and mulched twice.

Other necessary design and site criteria for installation of an ecology embankment:

- Ecology embankments should not receive concentrated flow discharges, just sheet flow directly from road surfaces;
- The embankments may be placed 3 to 4 feet from the edge of pavement to accommodate a vegetation free zone;
- The ecology embankment is designed as a water quality treatment facility for the 6-month storm, and conveyance for all storms;
- Where practicable, once stormwater has been treated by the ecology embankment, is will be collected and conveyed to a stormwater quantity BMP.
- A minimum of three feet of soil between the bottom of embankment to the highest ground water level;

(vi) Proposed maintenance procedures.

- Remove litter to keep the ecology embankment free of external pollution sources.
- Observation of overflow and bypass characteristics will be needed. Frequent overflow may indicate that the unit is clogged by siltation or is impaired by over compaction of the ecology mix during construction.
- Experience with sand filters for stormwater treatment in Austin, Texas has shown that the filter media becomes clogged an must be replaced every 4 to 10 years. Similar replacement rates should be expected for the ecology embankment.

(vii) Cost estimates. Roughly equivalent to the ecology ditch, $7,500 to $20,000 per impervious acre.

(viii) Anticipated results. It is anticipated that the ecology ditch will remove suspended solids and constituents associated with solids at rates which vary between 15% and 90%, depending on the intensity of the precipitation event, which will effect the volume of stormwater bypass. Higher

removal rates is anticipated to be associated with low intensity (<0.25 inch/24 hour) events. Dissolved constituents (nutrients or dissolved-phase metals) are anticipated to be removed at rates which range between 0% and 35%. Concentrations of nutrients in stormwater may actually increase after passing through the ecology embankment in its early life-cycle because of the application of fertilizer during construction to establish vegetation. Consideration should be given to sodding, mulching without fertilizer, or other vegetation methods which do not use fertilizer in drainages discharging to lake basins or water quality limited water because of high nutrient loading.

(ix) Approved BMP(s) that can be used if the experimental BMP fails. None. The ecology embankment is designed to provide a water quality design option where standard BMPs cannot be constructed.

(x) BMP status. Based on the results of the monitoring program for the ecology ditch, WSDOT will evaluate the BMP for effectiveness in protecting water quality and beneficial uses, its reliability, cost, ease of construction, and maintenance requirements. WSDOT may then propose that the ecology embankment be included as a standard BMP in the Highway Runoff Manual. The ecology ditches associated with the SR 167, 15th NW to 84th Ave. So. HOV lane project are scheduled to be built in summer 1997. Monitoring will commence after the construction of the embankments and the monitoring vaults in late summer or fall 1997.

Experimental BMP EXP2.0: Ultra-Urban / Confined Space BMP

(i) Description of the experimental BMP. The overall objective of this project is to develop filtration/sorption/ion exchange media for the treatment of stormwater runoff in ultra-urban areas that provide the highest cost/benefit performance. WSDOT's ultra-urban / confined space BMP is an extrapolation of slow-sand filter, exchanging sand with a mixture of organic and inorganic materials which facilitate filtration with sorption and ion exchange processes to remove solids and dissolved constituents in the stormwater. A rough schematic of the configuration of WSDOT's ultra-urban / confined space BMP is located in Appendix C. The physical unit is a two-cell concrete vault which can be covered or exposed, and consists of a sedimentation chamber and a filtration/sorption/ion exchange chamber:

Highway stormwater runoff is initially routed to a sedimentation chamber. The sedimentation chamber facilitates the removal of larger sediment fractions and will be sized at 20% of volume of the filtration chamber. After passing through the sedimentation chamber stormwater will flow over a longitudinal weir, past an energy dissipation structure, and into the filtration/sorption/ion exchange chamber.

The filtration chamber will contain 18" of filtration/sorption/ion exchange media, underlain by a 8" layer of coarse gravel. The filter media and gravel underlayer will be separated by geotextile fabric. The exact composition of the media will be determined by pilot scale testing at Washington State University's hydraulics laboratory. Within the gravel bed, a network of 6" perforated PVC pipe will be connected to the outfall structure. The stormwater, after passing through the sedimentation chamber, will infiltrate through the media layer, facilitating removal of solids and (anionic) dissolved constituents. The gravel layer and pipe network will then drain the infiltrated water to the outside of the unit for discharge. The second chamber will also have an overflow structure to convey larger storm events (>6 month/24 hour) through the vault.

(ii) Why the experimental BMP is being requested and HRM techniques are not appropriate. Stormwater runoff from transportation facilities such as ferry docks, bridges, shorelines, and highly urbanized areas pose a special problem for designers because of the lack of physical space. This lack of space prevents standard stormwater BMP solutions, such as those detailed in the WSDOT Highway Runoff Manual, from being implemented. In addition, HRM BMPs have no designed capacity to facilitate removal of dissolved-phase metals in stormwater runoff. WSDOT's ultra urban / confined space BMP will do both.

(iii) Special construction provisions for the ultra urban / confined space BMP. A generalized cross section of WSDOT's ultra urban / confined space BMP is included in Appendix C.

The vault housing the ultra urban / confined space BMP will consist of commercially available precast concrete units or specifically casted units of WSDOT design. Smaller drainages will be able to use precast units while larger drainages will require custom-designed and casted vaults. All metal

in the vaults will consist of aluminized or stainless steel. Galvanizing shall not be used on the pipes, doors, grates, or metal fittings. The vaults will be designed and constructed for H_2O loading.

(iv) Ultra urban / confined space BMP testing site and characteristics. Field testing of the ultra urban / confined space BMP will take place beneath the Lake Union ship canal bridge in Seattle. The testing site will receive stormwater runoff from 31.5 acres of SR 5 in downtown Seattle. This segment of roadway is 72% impervious pavement. Details of this testing site are listed in Table From the pilot scale testing at WSU, the three filter media formulations which had the best performance in the lab tests will be installed in 3 identical vaults which will receive runoff at a maximum rate of 1 cfs. All three media formulations will be monitored for water quality effectiveness and maintenance requirements until a statistically representative number of samples are analyzed.

(v) Design criteria.

Design and site criteria for installation of the ultra urban / confined space BMP:

- The filtration chamber will be sized using an infiltration rate of 2.5 gpm/ft^2 and a 6 month / 24 hour storm event;
- The filtration chamber length to width ratio will be a minimum of 2.0:1.
- The filtration media will be a minimum 18" thick, with a minimum 8" underlayer of gravel. Filtration media and gravel layers will be separated by geotextile mat with these specifications:

Property	Test Method	Units	Specification, min.
Unit weight		ounce/yd^2	8
Filtration Rate		inches/sec	0.08
Puncture strength	ASTM D-751(modified)	lb	125
Mullen burst strength	ASTM D-751	psi	400
Tensile strength	ASTM D-1682	lb	300
Equiv. opening size	U.S. Standard Sieve	number	80

- The top of the filtration media layer will be completely level.
- The gravel layer surrounding the collector pipes will be 0.5 to 2.0 inch diameter gravel and provide at least 2 inches of cover over the tops of the underdrain pipes.
- Underdrain pipe will be minimum 6 inch diameter PVC, SDR 35. Underdrain pipes will have a minimum grade of one percent slope. Drain pipe configurations should be designed to adequately drain the filtration chamber at a rate equivalent to a 6 month / 24 hour storm event.
- The sedimentation chamber will be sized at 0.20 times the volume of the filtration chamber or at 0.75 times the volume of runoff from the mean annual storm, whichever is more practicable. A water tight underflow weir, to facilitate trapping of floatable material may be incorporated into the sedimentation chamber design where there is a high risk of spills in the drainage area.
- The inlets for the sedimentation and filtration chambers will be designed to minimize turbulence and dissipate flow energy;
- A flow spreader will be installed at the inlet to the filtration chamber to evenly distribute incoming runoff across the filter bed and prevent erosion of the filter surface;
- Erosion protection will be provided along the first foot of filtration bed adjacent to the spreader. Quarry spalls or other suitable erosion control can be used;
- Access for cleaning all underdrain pipes is needed. Clean-outs of each pipe will extend at least 6 inches above the filtration media surface and will be fitted with a water-proof cap.
- One access point for the sedimentation and filtration cells will be required to permit routine maintenance activities within the unit.

(vi) Proposed maintenance procedures.

- Inspections of the sedimentation and filtration chambers should occur at least once every 6 months during the first year of operation, annually thereafter.
- Observation of overflow and bypass characteristics will be needed. Frequent overflow may indicate that the unit is clogged by siltation.
- Remove sediment and debris from the pretreatment facility when depth exceeds 12 inches.
- Remove debris and sediment from the surface of the filtration media whenever accumulations exceed 0.5 inches.
- Observe operation of the overflow and drawdown time in the filtration chamber. Frequent flow through the overflow structure and slow drawdown indicate media clogging that requires maintenance. Options may include: aerating filter media surface to improve permeability; tilling the filter media surface, and; removing the top 4 to 6 inches of filter media and replacing this layer with new media.
- Very rapid drawdown in the filtration chamber may indicate short-circuiting of the filtration media. Inspect the cleanouts on the underdrain pipe and along the base of the embankment for leakage.
- Formation of rills and gullies on the surface of the filtration media indicate improper function of the inlet flow spreader or uneven media compaction. Refill rills and gullies with filtration media and check the level spreader and quarry spall erosion protection layer for nonuniformity.

(vii) Cost estimates. Sand and compost filter designs similar to WSDOT's ultra urban / confined space BMP range in cost between $21,000 and $140,000 per impervious acre of drainage, depending on size and design modifications. Smaller drainages can utilize standard commercially available precast vaults, which greatly reduce costs.

(viii) Anticipated results. Using data from sand and compost filter testing, it is anticipated that the ultra-urban / confined space BMP will remove suspended solids and constituents associated with solids at rates at rates greater than 90% for storms up to the 6 month / 24 hour volume. It is unknown what removal rates will be associated with nutrients, because the exact composition of the filtration media has yet to be determined. Field testing will determine the removal rates for higher volume storm events, because some proportion of the runoff may bypass the filtration media.

(ix) Approved BMP(s) that can be used if the experimental BMP fails. Wet vaults and tanks, BMP RD.15, would be a possible substitute for the ultra urban / confined space BMP, with the consequences being much lower constituent removal rates for solids and no removal capacity for dissolved constituents.

(x) BMP status. WSDOT will propose addition of the ultra urban / confined space BMP to the HRM as a permanent stormwater BMP once field testing, removal efficiencies, design specifications, and maintenance requirements area determined empirically.

Experimental BMP EXP3.0: Soil Additives for Reducing Infiltration Rates Within Infiltration BMPs Residing in Sole Source Aquifer and Wellhead Protection Areas

(i) Description of the experimental BMP. WSDOT currently has a Memorandum of Understanding with the Environmental Protection Agency regarding the construction of infiltration BMPs. To satisfy the regulatory requirements in the MOU, infiltration rates for water quality infiltration BMPs must be reduced to less than 2.5 inches per hour. Within sole source aquifer areas, infiltration rates must be further reduced to less than 2 inches per hour. Infiltration BMPs gradually develop an accumulated silt layer at the soil surface, which results in a related lowering of the infiltration rate. What is needed from a practical design perspective are soil additives which can impede water infiltration during the interim period, gradually "breaking down" while this silt layer accumulates. Two common and inexpensive soil additives which have the potential to facilitate this process are gypsum and organic mulches. Empirical data on the effectiveness of these soil additives is needed to validate that addition of gypsum and/or organic material to high transmissivity soils can adequately reduce the infiltration rate to meet the regulatory standard while adequately protecting ground water supplies.

(ii) Why the experimental BMP is being requested and HRM techniques are not appropriate. The HRM currently does not address methods for retarding infiltration rates of in-situ soils.

(iii) Special construction provisions for using soil additive to reduce infiltration rates. None are required.

(iv) Infiltration BMP testing site and characteristics. The test site for this research project has been chosen and will be located near the DuPont interchange, located at milepost 118 through 119 of SR 5 in southern Pierce County, Washington which:

- Has glacial outwash soils with infiltration rates ranging between 6 and 20 inches per hour;
- Lies within a designated sole source aquifer area, and;
- Lies within an existing network of groundwater monitoring wells.

Three infiltration ponds that are in the design and/or construction stages to facilitate water quality treatment for stormwater runoff from SR 5 and the DuPont interchange. One pond will be lined with organic mulch, one will be lined with gypsum/plaster of paris, and one will be left unlined. Groundwater sampling wells, one upgrade of the ponds and two downgrade of the ponds will be drilled, cased, and completed for each of the four ponds in the study. Influent water quality to the infiltration ponds will be monitored as well as infiltration rates, and groundwater quality both upgrade and downgrade of each of the ponds.

(v) Design criteria. The pond itself is designed using the same specifications as standard HRM design infiltration ponds, BMP RI.06, except:

- The infiltration pond is designed using maximum soil infiltration rates of 2.5 inches/hour;

- Gypsum used to limit infiltration rate will be wet applied at the soil surface using a plaster of paris slurry at an initial application rate of 4000 pounds/acre while hydroseeding and may be increased to as much as 8000 pounds/acre in areas with extremely pervious soils.

- Organic material used to limit infiltration rates will be sphagnum peat moss incorporated into the top 18 inches of soil within the infiltration pond at a rate of 100 cubic yards/acre. Additional organic material may be added to the surface if needed to inhibit permeability.

(vi) Proposed maintenance procedures. Will be identical as for BMP RI.06.

(vii) Cost estimates. Varies with the size of the infiltration basin. Peat moss cost from $11.00 to $16.00 a cubic yard and gypsum - plaster of paris costs $0.15 - $0.20 per pound.

(viii) Anticipated results. Soils in infiltration basins are known to lose permeability due to silts and clays which enter the pond with the stormwater runoff. The advantage of using gypsum and organic materials rather than a clay liner is that gypsum and organic material both have the ability to constrain infiltration rates while this silt layer accumulates, while gradually decomposing. Clay liners maintain their capacity and only results in clogging the pond soils at an accelerated rate. It is anticipated that either gypsum or organics or both will be able to inhibit infiltration rates while the silt layer forms. Only application rates to accomplish this infiltration rate need to be determined.

(ix) Approved BMP(s) that can be used if the experimental BMP fails. None.

(x) BMP status. The infiltration ponds associated with the DuPont interchange project will be constructed in spring or summer, 1997. Groundwater monitoring wells will be completed in spring 1997. Monitoring will commence once the sites are stabilized.

Experimental BMP EXP4.0: Porous Pavement Shoulders

(i) Description of the experimental BMP. Using porous pavements for roadway shoulders has been suggested as a means to reduce the volume of runoff as well as a water quality treatment method. A study of the relative hydraulic, hydrologic, and surface water quality characteristics produced by conventional paved surfaces, permeable pavement material, and gravel for use as roadway shoulders is currently in its field-scale testing phase. Gravel shoulder surfaces provide environmental benefits insofar as it increases the potential for infiltrating significant amounts of stormwater runoff, but has serious safety and maintenance liabilities. Conventional dense graded asphalt shoulder surfaces are durable and low maintenance, but increases net runoff volume during storm events. Porous pavements may present a suitable compromise between paved and gravel shoulder surfaces for low ADT

roadways. Previous attempts to use open graded asphalt mixes, which have void volumes up to 30%, as roadway materials was determined to be unsuccessful because of progressive clogging of the porous matrix from fine particulates. The use of porous open grade asphalt mixes as roadway shoulder material will be evaluated for 1) water quality characteristics, 2) infiltration capacity over time, and 3) safety and maintenance considerations. Preliminary result has shown that porous pavements have the ability to reduce water quantity and improve water quality significantly, at least in its early life-cycle.

(ii) Why the experimental BMP is being requested and HRM techniques are not appropriate. Porous pavement shoulders will be evaluated against vegetative filter strips (BMP RB.10T), ecology embankments, and porous no vegetation zones as part of the evaluation methodology .

(iii) Special construction provisions for porous pavement shoulders. listed in FHWA Publication FHWA-PD-96-032, section 5.2.10.3.

(iv) Porous pavement shoulder testing site and characteristics. The test site for this experimental BMP is located along Woodinville-Duvall Rd. N.E., which has an ADT of 20,000 vehicles per day, 10,000 in each direction. The 2 porous pavement shoulder sections are 8 feet wide and 50 feet long each. Runoff from the roadway and each of the porous pavement shoulder were collected by slot drains and routed to a flume-type flow splitter for flow-weighted sample collection. The soils were poorly graded to well graded sand with silt and gravel.

(v) Design criteria. Porous pavement shoulder design will conform to the design specifications listed in FHWA Publication FHWA-PD-96-032, section 5.2.10.3, with these inclusions:

- All adjacent areas should be stabilized using erosion and sediment control methods to prevent any sediment from washing onto the pavement surface, leading to premature clogging;
- The subgrade will not be within 3 feet of the seasonally high groundwater table;
- The underlying soils should have an infiltration capacity of at least 0.50 inches/hour.

(vi) Proposed maintenance procedures. It is uncertain whether any maintenance activities will have any effect on the performance of porous pavement shoulder. Street sweeping equipment have had a historically poor track record in removing fine sediments from roadways, the same fine sediments that clog the void spaces in porous pavements.

(vii) Cost estimates. The limiting factors for the use of porous pavements are life cycle costs as compared to conventional pavements and standard stormwater BMPs. Additional costs that can be anticipated include:

- Project staging - Since the road surface itself would be conventional pavement, paving would have to be staged twice: once for the conventional pavement and again for the porous pavement shoulders. Dual staging alone would increase costs by 10 - 25%.
- Additional depth of stone reservoir - Extra excavation and increased amounts of crushed stone are required to construct porous pavement shoulders.
- Porous asphalt currently costs 2 to 3 times more than conventional asphalt ($9-10 per yd^3 compared to $3 per yd^3). Increased demand for porous asphalt may eventually reduce this differential as asphalt contractors become more familiar with the mixing and construction procedures.
- Sediment and erosion control - It is imperative to keep sediments from being washed onto the porous pavement surface both during and after construction.

Certain cost savings may also be realized with porous pavement shoulder BMPs, including the reduction and/or elimination of conventional stormwater BMPs and conveyance structures. Porous pavement shoulders will become viable BMP options when the life cycle costs and performance can be evaluated.

(viii) Anticipated results. Two long-term monitoring studies in the Washington, D.C. area have shown to be very efficient in reducing the constituent levels in stormwater runoff. Sediment removal rates between 82-95%, total nitrogen removal rates between 80-85%, total phosphorous removal rates of 65%, and lead removal rates of 98% have been documented in the early life cycle

of porous pavements. The nutrient removal efficiencies are particularly promising. Similar results have been demonstrated at the Woodinville-Duvall N.E. test site. Pavement clogging over the life cycle of the pavement, which is inevitable, is the limiting factor for using porous pavements as a stormwater BMP.

(ix) Approved BMP(s) that can be used if the experimental BMP fails. Vegetative filter strips, BMP-RB.10.T; biofiltration swales, BMP RB.05; ecology embankment, BMP EXP1.5.

(x) BMP status. Monitoring results from the Woodinville-Duvall N.E. site will continue to be examined to determine clogging characteristics. State highways are repaved on 7 to 10 year cycles. If porous pavement shoulders resist clogging for equivalent time frames, then WSDOT will request that porous pavement shoulders be included as a stormwater BMP in the HRM.

Experimental BMP EXP5.0: Polyacrylamides For Soil Erosion Control at Highway Construction Sites

(i) Description of the experimental BMP. A type of long-chain organic polymers, polyacrylamides (PAM) have been demonstrated to be effective for reducing agricultural furrow irrigation soil erosion when added at relatively low concentrations (<10 ppm) to irrigation water. PAM reduces soil erosion by two separate mechanisms: improving the stability the soil aggregates and flocculating suspended solids, thus aiding deposition. PAM-use for erosion control has been shown to be a formidable tool for achieving agricultural sustainability. It provides a potent environmental benefit by halting furrow erosion by about half ton of soil per ounce (16 kg/g) of PAM used. It removes most sediment, phosphorus and pesticides from return flows, and greatly reduces return flow BOD (Sojka and Lentz, 1996). It increases infiltration, which results in a reduction of runoff water quantity (Roa, 1996). Reduced sediment and nutrient loading of riparian areas can ultimately be expected to reduce the frequency and intensity of algal blooms and reduce turbidity and sedimentation of stream bottoms.

Anionic (negatively charged) forms or PAM has an extensive history of use as a flocculant in the potable water treatment, dewatering of sewerage sludges, washing an pealing of fruits and vegetables, clarification of sugar juice and liquor, in adhesives and paper in contact with food, as thickeners and suspending agents in animal feeds, in cosmetics, for paper manufacturing, for various mining and drilling applications and for various other sensitive applications. (*Managing Irrigation-Induced Erosion and Infiltration with Polyacrylamide*, University of Idaho Publication No. 101-96, 1996). *It is important to note that no environmental issues have surfaced with anionic PAM use.* WSDOT intends to investigate the applicability of using PAM as a soil erosion control BMP at highway construction sites. It is important to emphasize the need to use anionic PAMs or nonionic PAM which exhibit low toxicity in these applications. Some nonionic and especially cationic PAMs have been shown to have LC50s low enough for concern to certain aquatic organisms, whereas anionic PAM has not. It should be noted, however, that when PAMs, regardless of ionicity, are introduced into waters containing sediments, humic acids, or other impurities, the toxicity effects of the PAMs on biota are greatly buffered (Buchholz, 1992; Goodrich, et.al, 1991).

Studies conducted by the USDA-NRCS in Kimberly, Idaho, report that when applied at 10 ppm, PAM provided a 94% reduction in runoff-sediment in three years of testing. When used properly, PAM has no measurable toxicity either to humans, plants, or aquatic organisms. WSDOT will use the application standards established by the U.S. Department of Agriculture - Natural Resources Conservation Service in Kimberly, Idaho (NRCS, 1995) and monitor the effectiveness of PAM to abate water and wind erosion at controlled test sites and at some carefully selected construction sites.

(ii) Why the experimental BMP is being requested and HRM techniques are not appropriate. Other BMPs are available and have varying degrees of effectiveness. PAM reportedly has several advantages over other erosion control BMPs: 1) PAM can be applied using irrigation equipment and can be effective for controlling erosion over large areas, as has been demonstrated in eastern Washington and Idaho; 2) PAM is very effective on fine silt/clay soils; 3) Preliminary research conducted in Kansas and California has indicated that PAM is effective at abating wind erosion; 4) Ancillary benefits as a water quality BMP, by enhancing precipitation of fine silts and clay particles, and as a water quantity BMP, since PAM increases soil infiltration capacity that reduces runoff volumes, and; 4) High benefit to cost ratio.

(iii) Special construction provisions for PAM in erosion control applications. When wet applied a concentration of 10 ppm, the NRCS standard, will be used initially. It is important to note that even though all PAMs are polymers, not all polymers are PAMs. PAM becomes very slippery and viscous when wetted (Malik and Letey, 1992) and care must be take to prevent spillage on road surfaces for safety reasons.

(iv) PAM testing sites and characteristics. WSDOT will be constructing or provide funding to construct test sites for erosion control BMPs, including PAM, in Western Washington and in the Wenatchee, WA area (specific sites undetermined). PAM is intended for use as erosion control on the SR 18 S.E. Auburn to Black Diamond Road project, where clayey soils has made erosion control problematic.

(v) Design criteria.

- PAM in its granular form will be dissolved in the tank of the irrigation or hydroseed truck to a concentration of 10 mg/l. Dry application of granular PAM directly to soil surfaces may augment or replace wet application at a approximate rate of 1.2 lbs/acre. Application rates may adjusted based on observation of site-specific soil erosion patterns.
- All adjacent and areas should be stabilized using standard erosion and sediment control methods to prevent any PAM or PAM-dosed sediment from washing onto roadways;
- The types of PAM used for erosion control should have an approximate molecular weight of 8-20 Mg/mole, with an 0-22% negative charge density, and containing no greater than 0.05% acrylamide monomer. Only anionic or nonionic PAM that demonstrates low aquatic toxicity in its Materials Safety Data Sheet (>130 mg/l 96 hour rainbow trout LC50) will be used in field trials or uses.

(vi) Proposed maintenance procedures.

- PAM will have to be reapplied at regular intervals to offset the effects of aerobic biodegradation, photodegradation, and physical disturbance of soil structure. Polyacrylamide in bulk soil systems has been reported to decompose at a rate of about 10% per year (Azzam, et.al., 1983). Reapplication rates will be determined empirically by visual inspection and monitoring runoff for turbidity .
- PAM will enhance precipitation of fine solids in pipes, channels, and detention basins Stormwater conveyances and BMPs should be inspected monthly where PAM is used. Sediments should be removed when conveyances or detention structures accumulates greater than 10% or the structure's mean depth.

(vii) Cost estimates. Fifteen pounds of commercially available anionic polyacrylamide produced by manufacturers such as Allied Colloids, Cytek, Nalco, et.al. costs approximately $60.00, resulting in soil erosion control at approximately $5 per acre.

(viii) Anticipated results. In three years of studies in agriculture, using PAM for controlling irrigation furrow erosion provided a 94%-97% reduction in runoff-sediment (McElhiney and Osterli, 1996). WSDOT expects similar results when used at construction sites.

(ix) Approved BMP(s) that can be used if the experimental BMP fails. Standard erosion control BMPs, described in section 3.2.2.3.

(x) BMP status. Full-scale implementation of this PAM for erosion control BMP is dependent on approval by resource agencies. PAM's effectiveness for abating soil erosion is extensively documented and standard practices, including dosing rates, commercial products, and application procedures are well established.

Experimental BMP EXP5.5: Polyacrylamide Coagulation/Flocculation Agents For Enhancing Pollutant Removal Rates in Detention Ponds

(i) Description of the experimental BMP. In 1995, WSDOT initiated a research project which investigated the feasibility of using chemical coagulants and flocculants to enhance sedimentation of particulates and associated pollutants in highway stormwater detention basins. The resulting research "Enhancing Contaminant Removal in Stormwater Detention Basins By Coagulation" by Dr. David

Yonge and Falcon Price from Washington State University, concluded, through the use of a scale model detention basin, that sediment removal rates could be significantly enhanced by using coagulants and flocculants at all but the highest flow rates, i.e. flood events.

Solids contained in stormwater runoff and all aqueous solutions are found in three forms, settleable, suspended, and dissolved. Settleable solids rapidly precipitate out of the water column and is the predominant fraction of the solids removed in stormwater detention ponds. Coagulants are chemicals whose properties destabilize suspended solids in solution both electrochemically and physically, thereby enhancing the precipitation of the suspended fraction of solids. The process of destabilizing suspended solids using by rapidly mixing chemicals with wastewater is known as coagulation. The second stage of the process involves a period of less intense mixing to increase the rate of particulate encounters or collisions without breaking up the aggregates being formed. This part of the process is called flocculation. Visually, this is indicated by the formation of "floc", open crystalline snowflake-like structures. The third and final stage of the process, precipitation, involves a further reduction in flow velocities, which allows the aggregated floc to settle out by gravity separation. The hydraulics of many highway stormwater detention ponds simulate these processes.

A group of long-chain polymers, polyacrylamides (PAM), have been shown to be powerful flocculant at very low dosage rates in water and wastewater treatment (<1 ppm), in addition to having very low toxicity to aquatic organisms. PAM has an The advantage of PAM relative to other coagulation / flocculation agents, including other polymers, is the wide gap between effective dose and toxic dose to aquatic organisms. For anionic and some nonionic PAM products, the difference between effective and toxic doses can be greater than three orders of magnitude (factor of 1000), and is never less than two orders of magnitude.

Cationic PAM formulations will not be used in WSDOT's experimental BMP, because of relatively toxicity considerations. The toxicity of cationic polymers does not result from classical chemical toxicity of the residual monomer, but rather but rather from mechanical suffocation caused by binding of the cationic polymer with anionic sites on fish gills. In their normal usage for solids/liquids separation in wastewater treatment plants (cationic PAMs are widely used at wastewater treatment plants in Washington including Tacoma, Olympia, and Seattle), the products are used in the presence of high suspended solids concentrations, where the polymer binds irreversibly and migrates with the biosolids rather than with the finished water. Goodrich, et. al. (1991) demonstrated that the LC50 values for rainbow trout exposed to cationic polymers were increased by about an order of magnitude in the presence of as little as 5 ppm humic acid, commonly present in natural surface waters and stormwater runoff. This toxic effect does not occur with anionic and many nonionic PAMs. Data summarized by Buchholz (1992) indicates that some species of fish appear to be unaffected by anionic PAM at concentrations of 100 ppm in 90 day tests. However, minnows were killed by 2500 ppm solutions of anionic PAM due to the extreme viscosity of the fluid. This is more than 5000 times an effective PAM dose for stormwater flocculation.

(ii) Why the experimental BMP is being requested and HRM techniques are not appropriate: In many areas where native soils have high clay content, stormwater runoff from construction sites remains turbid even after being detained and passing through a HRM-design wet pond, many times resulting in exceedences in water quality standards for turbidity. Great quantities of colloidal particles remaining in suspension are due to the stabilizing conditions that exist between electrostatic forces on the particle and gravitational forces. Turbidity and suspended solids concentrations in these instances can only be reduced by destabilizing these electrostatic forces between clay particles by coagulation.

(iii) Special construction provisions for PAM for flocculating stormwater detention ponds:

There are no special construction provisions need for using PAM to enhance sediment removal in stormwater detention ponds. Standard construction and design practices for stormwater detention ponds are adequate.

(iv) PAM testing sites and characteristics. WSDOT plans on using PAM for enhancing sediment removal at Detention Pond #3 of the S.E. Auburn to Black Diamond Road project located at SR18-6.72-R-42 in southern King County. This area has predominately clay loam - glacial outwash soils which has a history of problems with mass wasting, erosion control, and water quality because of high levels of turbidity. This project has an active NPDES Stormwater Construction Permit and Stormwater Site Plan and is in the Cedar Green NPDES MS4 area. Detention Pond #3 was

constructed using HRM design specifications. Slope stability problems preclude construction of additional BMPs. The site receives runoff from approximately 15 acres, 4 of which are currently paved. Currently there is no traffic on the newly paved section. Monitoring of grab samples of pond effluent registered turbidity readings which, on occasion, has exceeded 200 ntus. This section of road will not be used by traffic until the entire project is constructed, which will take several construction seasons. A solution is currently needed for the turbidity problem. Using PAM both for erosion control and for flocculating Detention Pond #3 is proposed.

Other potential test sites for using PAM for flocculating detention ponds are:

34R detention pond - SeaTac airport: WSDOT is actively considering enacting a partnership with the Port of Seattle for another test site for using PAM for flocculating a stormwater pond built to treat stormwater runoff from the 34R Safety Area project at SeaTac airport. The 34R site used excavation material from WSDOT's S.E. Auburn to Black Diamond Road project as fill and has encountered many of the same water quality - turbidity problems. The 34R pond was designed using specifications from *Storm Water Management Manual for the Puget Sound.* This project has an active NPDES Stormwater Construction permit, Stormwater Site Plan, and SeaTac also is regulated under an NPDES Industrial Stormwater Permit.

SR 12 - Aberdeen Bluff detention pond: SR 12 at Aberdeen Bluff has a long history of mass wasting (slope failure), the soils are very clayey, and the detention pond has been unable to clarify stormwater runoff to the satisfaction of WDFW. Additional land to construct other BMPs is unavailable because of slopes in the area and shoreline constraints. PAM is a potential solution to the erosion and water quality problems at the site.

SR 5 - Leverich Park detention pond: A detention pond which receives SR 5 runoff in Vancouver, Washington was constructed in 1978. WSDOT currently monitors stormwater quality entering the pond at it's characterization site located at SR5-2.82-R-65, which is described in detail on Table 20, section 3.3.7.4. During large precipitation events, high levels of turbidity has been observed in the Leverich Park detention pond because of influent highway runoff and resuspension of sediments residing in the pond. PAM can enhance the effectiveness of this detention pond by flocculating suspended sediments and preventing resuspension of sediments that may get discharged to Burnt Bridge Creek. The Leverich Park pond is not presently under NPDES regulations since it in the City of Vancouver, which is presently exempted from the Columbia Gorge NPDES MS4 permit area.

WSDOT will notify Ecology and discuss PAM testing options and procedures when test sites are identified that would benefit from using PAM for erosion control or pond flocculation.

(v) Design criteria for PAM for stormwater pond flocculation.

Flocculation, by physical linking of clay particles by polymers, is well known process and has been extensively researched and reviewed. PAM has the following properties:

1) Toxicity properties. PAMs are remarkably stable molecules. PAM degradation to yield acrylamide (AMD) monomer is thermodynamically impossible (MacWilliams, 1978) and has never been demonstrated in laboratory or field testing. However, commercial PAMs can contain residual AMD up to 0.05%. The LC50 acute toxicity parameters of the **AMD monomer** are:

Goldfish:	460 ppm
Fathead minnow:	120 ppm
Rainbow trout:	110 ppm
Bluegill sunfish:	100 ppm
Daphnia magna:	160 ppm
Midge larvae:	410 ppm

(Chemical review: Acrylamide, Dangerous Prop. Ind Mater. Rep. 11:2-18)

It is important to note that the above values are >10,000 times greater than would result from current recommended practices.

Barvenik (1994) stated "dry anionic PAMs that are effective in soil systems show no toxicity to fish (LC50>100 mg/l)". It should be emphasized that the LC50 did not equal 100 mg/l, but rather, was undetermined, because 50% lethality never occurred in that concentration range.

Two PAM products which will be given consideration in WSDOT's experimental coagulation / flocculation BMP will be Cytek Industry's Magnifloc™ 866 A and Magnifloc™ 905N flocculants. Magnifloc™ 866A is a very high molecular weight, highly anionic, polyacrylamide, which has been demonstrated to be effective in clarifying stormwater detention ponds at a golf course construction project by Dane County (Wisconsin) Land Conservation, when combined with lime as a primary coagulant. Magnifloc™ 905N is an ultra-high molecular weight, nonionic polyacrylamide (actually it has a very small negative charge <2%), which has demonstrated an ability to clarify turbid construction site runoff quickly and at doses <<1 mg/l in jar tests, but is unproved in field applications. Cytek has tested aquatic toxicity of these two products and reported the LC50s in their MSDSs:

Test	Magnifloc™ 866A LC50	Magnifloc™ 905N LC50
Bluegill, 96 hour	180 mg/l	>1000 mg/l
Trout, 96 hour	130 mg/l	750 mg/l
Fathead minnow	670 mg/l	>1000 mg/l
Daphnia, 48 hour	>1000 mg/l	>1000 mg/l

WSDOT will use PAM toxicity data a key parameter when designing a PAM dosing systems. A process using toxicity data and the buffering / dilution capacity of detention ponds will be used to devise dosing systems that *preclude any possibility of delivering an acutely toxic dose to receiving streams*. This process involves the following steps:

a) Flow-weighted composite samples of detention pond influent and effluent will be collected using ISCO™ automated sampling equipment or flow splitters (see section 3.3.7.7 for details). The samples will be analyzed for standard highway runoff parameters (section 3.3.7.5) as well as turbidity, the key parameter for construction site runoff. This data will be used to determine constituent removal efficiencies for the pond and will reveal which sediment sizes are removed by gravity settling in the pond.

b) Conduct jar tests to select a flocculant or coagulant/flocculant mixture. This will be accomplished by adding each flocculant/mix to the stormwater in 0.1 ml increments to 1 liter of stormwater and slowly stirring (10-20 rpm) until the first evidence of floc is observed.

c) A second series of jar tests to determine the effects of flocculant/mix dosage levels.

d) If the flocculant selected in the jar tests has not been analyzed for aquatic toxicity, either select another flocculant or contract an certified environmental laboratory to perform these tests for fathead minnow, trout, sunfish, and daphnia. The lowest toxicity value from the data or tests will then be used to calculate the *maximum PAM weight* that can be used in the dosing system, an d therefore the maximum concentration of PAM that can potentially reach receiving waters..

e) Calculate the maximum dosage that can be applied without creating toxicity in the effluent. All detention ponds are designed using HRM to have *live storage capacity*. The live storage capacity is designed to the volume of a 6 month/25 hour storm and is the amount of volume the pond holds prior to discharging. The logic is that in the case of a catastrophic failure of the dosing system, regardless of the mechanism, limiting the amount of PAM available to less than a toxic dose when diluted in the pond *precludes any possibility of delivering a toxic dose of PAM to receiving waters*. An additional 20% safety factor will also be incorporated into the calculation. This will be done using the following procedure:

step 1: Determine the live storage capacity of the pond prior to discharging:

Live storage capacity (m^3) = [mean length (m)]x[mean width (m)]x[mean depth (m)]

step 2: From the toxicity data calculate the maximum PAM dosage that can be put into the detention pond without creating toxic conditions in the pond effluent (with a 20% safety factor):

Maximum PAM dosage (lbs) = [(0.80)x(Lowest toxic dose (~~mg/l~~))]x[Volume (~~m~~^{3})]x[10^3 ~~l/m~~^{3}]x[1 pound/(4.56x10^5 ~~mg~~)]

f) Determine effective dose to flocculate one pond volume = total flow from a 6 month/24 hour storm:

Effective PAM dosage (lbs) = [effective PAM concentration (~~mg/l~~)]x[live storage capacity (~~m~~^{3})]x[2.196x10^{-3} (lbs-~~l/mg-m~~^{3})]

<u>Example - Detention pond #3 @ S.E. Auburn to Black Diamond Rd. project:</u>

step 1:

Live storage capacity = [53.04 m]x[4.25 m]x[2.45 m] = 552.25 m^3

step 2: For this example let's assume Magnifloc™ 866A exhibited the best performance in the jar tests. The lowest LC50 dose was 130 mg/l for the 96 hour trout test. The maximum allowable dose of PAM will be calculated using 50% of this value as a safety factor.

Maximum PAM dosage = [(0.5)x(130 mg/l)]x[552.25 (~~m~~^{3})]x[10^3 ~~l/m~~^{3}]x

[1 pound/(4.56x10^5 ~~mg~~)] = 78.72 lbs.

This indicates that a dosage of more than 78.72 lbs. could cause acute toxicity to trout in the event of a catastrophic release of PAM into the pond and subsequently to the Green River.

step 3: PAM has been shown have effective flocculating doses in the range of <0.1 mg/l to 0.5 mg/l. For this example we'll use 0.5 mg/l as a "worst case scenario":

Effective PAM dosage (lbs) = [0.5 (~~mg/l~~)]x[552.25 (~~m~~^{3})]x[2.196x10^{-3} (lbs-~~l/mg-m~~^{3})]

= 0.606 lbs= 9.7 ounces

PAM can be purchased over the counter in 15 and 30 lb. containers. If effectively mixed and flocculated, a 30 lb. container can clarify 49.47 pond volumes, while eliminating any possibility of PAM-related toxicity being delivered to streams from detention pond effluent.

2) Sorption properties. PAM has an extremely high affinity for solids and is irreversibly adsorbed. They adsorb on solids by a number of mechanisms, including electrostatic attraction or charge neutralization, hydrogen bonding, as well as bridging between adjacent particles due to their extremely large molecular dimensions, resulting in large aggregates or flocs (Mortimer, 1991). Adsorption of PAM on solid surfaces has been demonstrated to be rapid and irreversible (Tanaka, et.al., 1990). PAMs are considered to have molecular sizes too large to be transported across biological membranes (Stephens, 1991), and the fact that they tend to be adsorbed to soil aggregates makes such biological transport even less likely. Once sorbed to soil or suspended sediments, PAM does not dissolve back into the aqueous phase. Because of this property, PAM does not infiltrate into soil or pond sediments for more than a few millimeters (Sojka & Lentz, 1994). This property precludes any possibility of PAM passing through the soil to groundwater. Likewise, in detention ponds, the only way a PAM residual can pass through the pond is when the PAM in the water doesn't encounter any solids, which can only occur in a pond which: 1) has no bottom sediments, or 2) has no suspended solids, i.e. "too clean". This is not the case at WSDOT construction sites or historically in stormwater detention ponds throughout the country.

3) Fate and transport properties. Once adsorption of PAM to soils or solids in detention PAM has occurred, biodegradation of PAM and the AMD monomer proceeds at varying degrees of biological and photochemical degradation (Barvenik, 1994). The AMD monomer, which is strictly limited by U.S. regulation in PAMs to no more than 0.05% in weight, decomposes in hours in soils and water. The large PAM molecule can be degraded by physical breakage due to

mechanical forces such as abrasion, freeze-thaw action, and particle shrinking and swelling. PAM in bulk soil systems has been reported to decompose at a rate of about 10% per year (Assam, et. al., 1983). PAM may potentially be used by soil bacteria as a source of nitrogen, resulting in at least a partial degradation of the PAM molecule and the of degradation is very site specific (Kay-Shoemake & Watwood, 1996). Degradation of PAM in pond-bottom sediments has not been empirically determined, but probably occurs a slower rates than for soil applications due to the oxygen-limited and sunlight-limited environments on pond bottoms.

4) Product specifications and polymer dosing to detention ponds. PAMs come in four major forms: granular powders, aqueous concentrates, emulsified concentrates, and block or cubes.

Granular PAM powders are easy to store and transport, but requires agitation over an extended period of time to dissolve into water. Granular and partially hydrated granular PAM has virtually no flocculating capacity (Roa, 1996). Granular powers are widely used in agricultural furrow erosion control practices. In agriculture, they are dosed in furrows by pouring a "patch" at the head of the furrow immediately above the source of substantial turbulence. This patch immediately forms a gel-like mat and slowly dissolves over the course of the irrigation delivering PAM in a way that strongly mimics delivery by a constant 10 ppm dose (Sojka, 1997). PAM delivery using this method may not be feasible for highway drainage systems since the flow velocities tend to be much greater than in agricultural irrigation. This may result in PAM being washed, undissolved, into the detention basin, where it would settle out in a low velocity zone and mixing action would be significantly less. This could result in undissolved and unmixed PAM sinking to the bottom of the pond, where it low flocculation rates would result.

An method for using granular PAM to dose detention ponds could be facilitated by developing a permeable enclosure, a "tea bag" device, which could hold granular PAM and anchored within the influent pipe or channel. During precipitation events, stormwater would wash through the granular PAM tea bag. PAM dissolves very slowly and takes quite a while to reach full hydration and become activated. Because PAM has such high molecular weights (6 to 20 million), transition from granular solid to dissolved state has an intermediate state where the molecules "unravel". This intermediate phase between granular and dissolved is known as the "fisheye effect", because of the appearance of the partially hydrated PAM grains. These "fisheyes" would not be able to pass through the permeable enclosure. As the PAM proceeds to the dissolved state through mixing with stormwater, it would pass through the permeable enclosure material and be added to stormwater at a place where turbulence would simulate a rapid mix system, inducing coagulation (particle destabilization). The PAM mixed with the sediment-laden stormwater would flow into the detention pond, where velocities would be reduced and the flocculation (particle bridging and encapsulation) would result.

Aqueous PAM concentrates or Emulsified concentrates are polyacrylamides in liquid form. The main advantage of concentrates is that PAM is already in an activated state, making mixing and flocculation quicker. Aqueous concentrates are solid PAMs dissolved in water, and are limited as to the strength of concentrate that can be prepared before viscosity impairs practical use. Aqueous concentrates of PAM are limited to about 3% active ingredient, because the viscosity gets very high, with a "maple syrup" type of consistency. Emulsified concentrates are PAMs dissolved in oils or solvents, such as naptha, and provide the same benefits as aqueous concentrates but has about ten times the amount of active ingredient per unit volume. Dosing concentrates into detention ponds presents technical, economic, and operational problems. Dosing can be facilitated with a relatively high-tech device using a DC-driven flow meter/controller/peristaltic pump system that can deliver a flow-weighted dose to influent stormwater. An aqueous dosing system as described would cost between $7,000 - $10,000 per unit. With these large costs incremental costs per site, it is doubtful that designers or project managers would consider it a viable BMP option. Secondly, a high tech dosing system would be also be operationally intensive. Inspectors, contractors, or operations personnel would need specialized training in order to keep the units working efficiently. Specific budget categories and detailed contract specifications would have to be developed to fund training and the labor-intensive operations. Thirdly, concentrate dosing systems would be difficult to inspect for operational effectiveness. The controller's microprocessor would need to be interrogated using a laptop PC. Flow and dosing information would need to be databased, cross-correlated, and

interpreted. For these reasons WSDOT does not consider high tech liquid dosing systems and therefore PAM concentrates to be viable options for flocculating stormwater ponds.

PAM Blocks and cubes are easy to handle, place, and inspect. Solubility of block and cubes, and therefore PAM dosing rates, can be controlled in two ways: mechanically and chemically. Mechanical control of PAM dosing can be facilitated by varying size (thus varying reactive surface area which affects solubility rates) and shape (round shapes minimize surface area). Chemical methods for controlling PAM dosing can be facilitated by making composite PAM/calcium carbonate blocks or cubes, where $CaCO_3$ would act as a solubility inhibitor as well as a primary coagulant. Blocks and cubes have been used successfully by Dane County Land Conservation (Roa, 1996) to flocculate stormwater detention ponds in the Madison, Wisconsin area, and by the University of California Cooperative Extension in Modesto, California (McElhiney and Osterli, 1996) to control furrow erosion and reduce TSS loading in irrigation runoff. WSDOT intends to investigate using PAM blocks and cubes for flocculation of stormwater ponds because of its practicality and it provides methods to control PAM dosing rates using simple mechanical/chemical methods.

Dosing using granular application using a "tea bag" apparatus or with solid blocks will be the emphasis of WSDOT's experimental BMP procedure. It needs to be emphasized that WSDOT will take all precautions to ensure, by limiting the amount of PAM using the described process, that delivering toxicity to receiving waters is an impossibility.

(vi) Proposed maintenance procedures.

- PAM will increase sedimentation in low velocity areas of conveyance systems and within detention ponds. In the initial stages of evaluating PAM as an experimental BMP, the pond, conveyance, and PAM dosing/delivery systems will be inspected after every precipitation event for:

  1) The amount of PAM dissolved (by weight). This will be done by comparing the original weight of the "tea bag" or block to the weight after the precipitation event;

  2) Characterization of influent water quality prior to being dosed by PAM, using the procedures listed in section 3.3.7.5 through 3.3.7.9;

  3) Characterization of effluent water quality from the detention pond after coagulation / flocculation / sedimentation with PAM, using the procedures listed in section 3.3.7.5 through 3.3.7.9;

  4) Turbidity of the influent, effluent, and water in the detention pond itself, using a Hach 2100P laboratory grade turbidimeter;

  5) Visual observations of sedimentation in conveyance structures, the detention pond, and accumulations PAM "gel", a result of insufficient mixing.

- Conveyance structures will be cleaned whenever sediments fill more than 10% of the structure.

- Detention ponds will be cleaned whenever sediment accumulates to more than 10% of the mean depth of the pond.

- Dosing systems will be recharged with PAM or PAM/$CaCO_3$ composite mixture when it is observed that there is no PAM or PAM residual gel. The amount of PAM used in the dosing apparatus will never exceed the amount determined using the calculation in step 1 in part iv of this section.

(vii) Cost estimates. Fifteen pounds of commercially available anionic polyacrylamide produced by manufacturers such as Allied Colloids, Cytek, Nalco, et. al. costs approximately $60.00. For an effective dose of 0.5 mg/l, which is a conservative estimate, it will cost $20.23 to clarify one million gallons of stormwater runoff.

(viii) Anticipated results. Studies conducted in West Stanislaus, California, (McElhinney and Osterli, 1996) on TSS reduction using PAM in irrigation furrows and dosed using a solid block placed at the head of the furrow reported TSS reduction rates between 96% and 98%. This study also measured 10-40% increase in soil infiltration rates, and 95-98% reduction in soil loss. WSDOT expects similar

results. Another study (Bahr and Stieber, 1996) reported 96% total phosphorous and 86% total nitrogen removal rates of using PAM in irrigation furrows. WSDOT expects similar results for using PAM to enhance constituent removal rates in detention ponds.

(ix) Approved BMP(s) that can be used if the experimental BMP fails. None.

(x) BMP status. Full-scale implementation of PAM for to enhance performance of detention ponds is dependent on approval by resource agencies. PAM's effectiveness as a flocculant has extensively documented and standard practices, including dosing rates and commercial products are well established and documented.

Experimental BMP EXP6.0: Biofiltration Swale Design Enhancements

(i) Description of the experimental BMP. Biofiltration swales have been found to have highly variable constituent removal efficiencies (Koon, 1995). But, because of the narrow, linear nature of biofiltration swales, they fit the spatial constraints that are common along state highways. Virginia DOT (1994) and FHWA (1996) conducted independent studies that suggest that the incorporation of level spreaders with wetland plants into biofiltration swales may improve their constituent removal performance. The incorporation of "pocket wetlands" create greater detention time, increase infiltration rates, and create low velocity zones which allow for increased sediment removal. WSDOT plans to investigate modifying biofiltration swale design criteria so that they are based on detention times rather than using predetermined physical dimensions. modifications to empirically determine whether they provide performance improvements over conventional designs between 1997 and 2000.

(ii) Why the experimental BMP is being requested and HRM techniques are not appropriate: Currently, biofiltration swales designs are determined by physical dimensions, rather than detention time. Using detention time as a primary design criteria, which can be modified by the installation of check dams, may be more appropriate criteria affecting the constituent removal efficiency of swales.

(iii) Special construction provisions for biofiltration swale design enhancements: None.

(iv) Biofiltration swale sites and characteristics: None has been identified as of the drafting of this document. Grant funding and internal funding will be requested to facilitate the applicability of biofiltration swale design enhancements.

(v) Design criteria for biofiltration swales design enhancements: The side slopes for the check dams should be between 5 and 10 to 1 to facilitate mowing operations. The berm height should not exceed 2 ft. and water ponded behind the berm should infiltrated into the soils within 24 hours. Check dams should be spaced so that the toe of the upstream dam is at the same elevation as the top of the downstream dam. Check dams should be constructed using quarry spall. For best performance, check dams should have a level upper surface.

The number of check dams required for maximum ponding needs to be computed, by first determining the length behind each check dam:

$L_d = \frac{H}{s}$, where L_d is the length behind the check dam, H is the depth of the swale, and s = slope

Number of check dams = L/L_d, where L is the total swale length.

The top width (wt) for each check dam is computed by: $w_t = w_b + 3d_s z$, where w_b is the check dam bottom width (corresponding to swale bottom width, calculated using standard HRM criteria), and 3 is the side slope ratio.

(vi) Proposed maintenance procedures: Same as standard biofiltration swales, section 3.3.6.11.

(vii) Cost estimates. Typically, vegetated swales cost less to construct than curb, gutters, and underground pipe, and may run from $5 to $15 per linear foot. Quarry spall used to create detention structures and level spreaders costs and additional $12 per cubic yard and it between 5 and 60 cubic yards of spall would be needed per swale.

(viii) Anticipated results. VDOT reported an additional 40% solids removal rate when check dams are incorporated into swale designs. WSDOT expect similar improvements in constituent removal efficiency.

(ix) Approved BMP(s) that can be used if the experimental BMP fails: None

(x) BMP status. Funding sources are being identified to conduct tests on this experimental BMP. Testing is dependent on acquiring funding.

Experimental BMP EXP7.0: Stormceptor™ Vault

(i) Description of the experimental BMP. The Stormceptor™ is commercially available vault system. It is a dual-level vault designed for ultra-urban settings to enhance the removal of sediments and oil. The Stormceptor™ is divided into a lower storage/separation chamber and upper by-pass chamber. Normal flows are diverted into the lower treatment chamber where oil and other light non-aqueous phase liquids rise and become trapped and suspended solids settle to the bottom of the chamber by gravity and centrifugal forces. During high flow conditions, the by-pass chamber conveys water to the down stream storm sewer directly circumventing the lower chamber and preventing the resuspension and scour of settled pollutants.

(ii) Why the experimental BMP is being requested and HRM techniques are not appropriate: The Stormceptor™ is intended for use in areas where other, more conventional stormwater BMPs, cannot be constructed. The Stormceptor™ can be installed beneath pavement in lieu of a catch basin or manhole.

(iii) Special construction provisions for the Stormceptor™: Standard excavation, fill, and storm drainage conveyance practices listed WSDOT's *Standard Specifications for Road, Bridge, and Municipal Construction* are adequate.

(iv) Stormceptor™ testing sites and characteristics. WSDOT will begin to monitor a Stormceptor™ vault installed along SR 522 between Lake Forest and Bothell in northern King County to evaluate its constituent removal effectiveness in 1997. Details on the monitoring site and sampling specifications are listed in sections 3.3.7.4 through 3.3.7.9.

(vii) Cost estimates. Stormceptor™ vaults, excluding excavation, fill, mobilization, etc., costs between $28,000 to $45,000 per unit.

(viii) Anticipated results. The manufacturer reports solids removal rates at greater than 85% for low flow events, with significantly less removal capacity at higher flow events. One of the objectives of monitoring the Stormceptor™ (and swirl concentrators, experimental BMP EXP7.5) is to acquire statistically representative empirical verification of removal rates independent of manufacturer claims.

(ix) Approved BMP(s) that can be used if the experimental BMP fails: Wet vaults or tanks, BMP RD1.5

(x) BMP status. The Stormceptor™ unit was installed at the SR 522 site in March 1997. Monitoring will commence in summer 1997 and will continue until a statistically representative set of stormwater samples are collected. Since this experimental BMP emphasizes oil and grease removal as one of its main features, manual grab sampling will be perform regularly to provide better estimates of floatable hydrocarbons in stormwater influent and BMP effluent.

Experimental BMP EXP7.5: Swirl Concentrator Systems

(i) Description of the experimental BMP. Vaults generally described as "swirl concentrators", by manufacturers such as Vortechs™, H.I.L.™, et.al. are multilevel, baffled vaults designed to enhance sediment removal and to contain oil & grease. Swirl concentrators differ from the Stormceptor™ in that they induce centrifugal forces to create a low velocity zone in the center that allows sediments and debris to be deposited through a narrow opening. Swirl concentrators are intended for use where conventional BMPs cannot be constructed due to spatial constraints and dissolved constituents (nutrients, metals) are not primary concerns.

(ii) Why the experimental BMP is being requested and HRM techniques are not appropriate: Swirl concentrators are intended for use in areas where other, more conventional stormwater BMPs, cannot be constructed. Swirl concentrators, much like the Stormceptor™, can be installed beneath pavement in lieu of a catch basin or manhole.

(iii) Special construction provisions for swirl concentrators: Standard excavation, fill, and storm drainage conveyance practices listed WSDOT's *Standard Specifications for Road, Bridge, and Municipal Construction* are sufficient .

(iv) Swirl concentrator testing sites and characteristics. WSDOT will install and begin to monitor a swirl concentrator system known as Vortechs™ at SR 405, MP 24.54, north of Bothell in King County in summer/fall 1997. Details on the monitoring site and sampling specifications are listed in sections 3.3.7.4 through 3.3.7.9.

(vii) Cost estimates. Swirl concentrators, excluding excavation, fill, mobilization, etc., costs between $25,000 to $55,000 per unit, depending on design flows for the drainage.

(viii) Anticipated results. The manufacturer reports net solids removal rates at 80% for a mean of all flow events. One of the objectives of monitoring the swirl concentrators is to acquire statistically representative empirical verification of removal rates independent of manufacturer claims.

(ix) Approved BMP(s) that can be used if the experimental BMP fails: Wet vaults or tanks, BMP RD.15.

(x) BMP status. The Vortechs™ swirl concentrator is scheduled for installation at the SR405-24.54-R-12 site in summer/fall 1997. Monitoring will commence once construction is completed in the drainage area, tentatively scheduled for winter 1997/98 and will continue until a statistically representative set of stormwater samples are collected.

3.2.3 Stormwater Program Priorities and Unmet Needs

Expectations Document S7.B.2

WSDOT's Stormwater Management Program incorporates a variety of structural and non-structural control measures, as detailed in section 3.2.2. Structural controls include both temporary erosion and sediment controls (i.e. silt fences, straw bales, rock check dams, etc.), continuing operations / maintenance (vegetation management, noxious weed control, litter removal, etc.), and permanent controls (i.e. retention/detention ponds, grassy swales, wet vaults, etc.). Structural controls differ from non-structural controls in that they are designed to reduce the amount of pollutants already in the stormwater system. Structural controls can usually be evaluated using well-defined engineering principals and procedures, although there still exists imprecision in measuring pollutant removal efficiencies because of site-specific variables and non-uniqueness of BMP designs. Historical data indicates a high degree of statistical variability for both stormwater runoff quality and removal efficiencies of BMPs. WSDOT will emphasize the addition and quality control of structural stormwater BMPs as the key element of its stormwater management program. Table 15 illustrates the paucity of structural BMPs throughout the South Puget Sound, Cedar-Green, and Island-Snohomish NPDES MS4 permit areas.

Table 15 - WSDOT Outfall and BMP Totals for the South Puget Sound, Island-Snohomish, and Cedar-Green NPDES MS4 Permit Areas (1995)

NPDES MS4 Permit Area	*Number of Outfalls*	*Number of Major Outfalls*	*Number of Structural BMPs*	*Percentage w/ BMPs*
South Puget Sound	421	21	29	6.9%
Island-Snohomish	485	6	2	0.4%
Cedar-Green	936	42	72	7.7%
TOTALS	1842	69	103	5.6%

A BMP monitoring program will also be an integral component of WSDOT's stormwater management program to maximize net pollutant removal efficiencies and benefit to cost ratios.

Once constructed, non-structural BMPs can reduce pollutants in highway runoff in almost all situations. These can include some operational and maintenance practices, contractual changes specifying erosion and sediment control practices, minimizing illicit discharges from other sources, source control activities, WSDOT staff training, and public education (particularly trip reduction) programs.

There are numerous difficulties that make assessing the effectiveness of non-structural controls problematic or impossible. Additionally, studies conducted by EPA (1982) and FHWA (1986) indicate that most non-structural controls are largely ineffective for reducing constituents in highway stormwater runoff in statistically significant amounts. On the other hand, structural controls are passive, operate continuously, and can be monitored for efficiency. They do not need operators or attention in order to be effective. Non-structural controls do not have these advantageous features. Examples of the factors that can influence the predictive success of evaluating non-structural controls include:

- Most controls rely on modifying internal or external group behavior which cannot be relied upon with any predictable level of certainty.
- Many non-structural controls are aimed at preventing actions that people generally try to hide or avoid drawing attention to (spills, littering, etc.).
- Control action and budgets allocated for these purposes will be influenced by changing economic conditions or by acts of nature. A series of avalanches in the Cascades or catastrophic flooding have and will continue to deplete funds which would otherwise be used for roadside maintenance programs which would have a more direct effect on stormwater runoff quality. WSDOT has a comprehensive list of service objectives which have to be continually modified to maintain applicability with current conditions. Sometimes water quality issues have to take secondary consideration to other needs, such as safety.
- Community response to a non-structural control or activity can be time dependent and may be influenced by a unique event or incident, such as a disaster or flood.
- Non-structural controls such as street sweeping and drainage system maintenance often involves closing lanes on busy highways, large operating crews, heavy equipment allocation and operation, and high safety risks. These factors make these types of controls very expensive and risky. Over the two year period 1994-1996, 27 people and 8 WSDOT employees have died in roadside accidents at WSDOT construction and maintenance operations.

This does not mean that WSDOT will totally ignore non-structural and operational controls as part of overall stormwater management plan. As part of the long-term (beyond the term of the permit) monitoring program, WSDOT will evaluate the water quality effects of non-structural controls. First, baseline conditions must be evaluated. Stormwater sampling will correlated with operational activities, such as street sweeping, catch basin waste removal, pesticide/herbicide applications, etc. Some roadside techniques that will be investigated include: evaluating different seed mixes for their ability to encapsulate metals in organic complexes, incorporating structures for increasing conveyance system detention times, enhancing vegetation density using composed materials and biosolids, introducing wetland plant species to stimulate update of nutrients, etc.

A combination of approaches will be developed and implemented to reduce pollutant loading from the highest priority outfalls throughout the state. The following sections summarizes WSDOT's priorities in managing highway runoff. Four "highest priority" areas will receive the focus of attention over the 5 year duration of the permit. The "other priorities" will be addressed as financial and partnering opportunities arise, however they do not lend themselves to a large scale program focused on stormwater management because of funding limitations and WSDOT's other main commitments to transportation service objectives.

3.2.3.1 Stormwater Planning Through Transportation Project Prioritization and Funding Activities

Expectations Document S7.B.1

As previously stated, WSDOT highest priority in the stormwater management plan is to facilitate construction of structural stormwater BMPs. This is accomplished primarily through WSDOT's highway construction projects. As WSDOT is developing and constructing improvements to highways, many changes in the stormwater conveyance systems can occur. Additional impervious surfaces can increase the amount of runoff and change water quality. The conveyance systems themselves can undergo hydraulic alterations (e.g. from sheet flow to a catch basin/culvert system). Depending on many supporting factors, stormwater BMPs are often installed on new projects to treat highway runoff. During project development activities, WSDOT hydraulic designers and water quality staff evaluate site conditions to determine if BMP development should be included (retrofit) or existing facilities expanded in the project. In some cases, permits from regulatory agencies will require BMP retrofits for existing as well as new impervious areas.

Needs for stormwater management improvements will be taken from the prioritized stormwater needs list and matched with project construction schedules. Cost/benefits ratios will increase retrofits opportunities in the design and construction phases of highway projects.

Cost benefit effectiveness of mobility projects is prioritized using five factors, one of which involves environmental considerations. In the stormwater cost/benefit analysis, the (-) points assigned to stormwater mitigation costs are balanced by the (+) value given to mitigation benefits. For situations where stormwater impacts can be mitigated (presumed to be the vast majority of situations), stormwater will have a null effect in the environmental cost/benefit calculation.

State highway transportation projects are normally evaluated on the basis of net benefit versus cost, which results in a Benefit/Cost (B/C) ratio. Political considerations aside, projects which have the highest B/C ratios will most likely to be chosen for funding. Project costs include land or right-of -way acquisition, engineering, environmental mitigation, construction, support functions (payroll, MIS, administration, etc.), and annual operating and maintenance. Project benefits include a multitude of items such as direct revenue or fees, job creation, education, reduced travel time, flood control, and accident prevention. Benefits for public works projects are always hard to quantify because, unlike private projects likely to be narrowly defined as profit directly generated by the facility, many public works benefits are intangible, non market, or very subjective. This is particularly true for projects involving stormwater quality improvements since the benefits are never present as direct revenues.

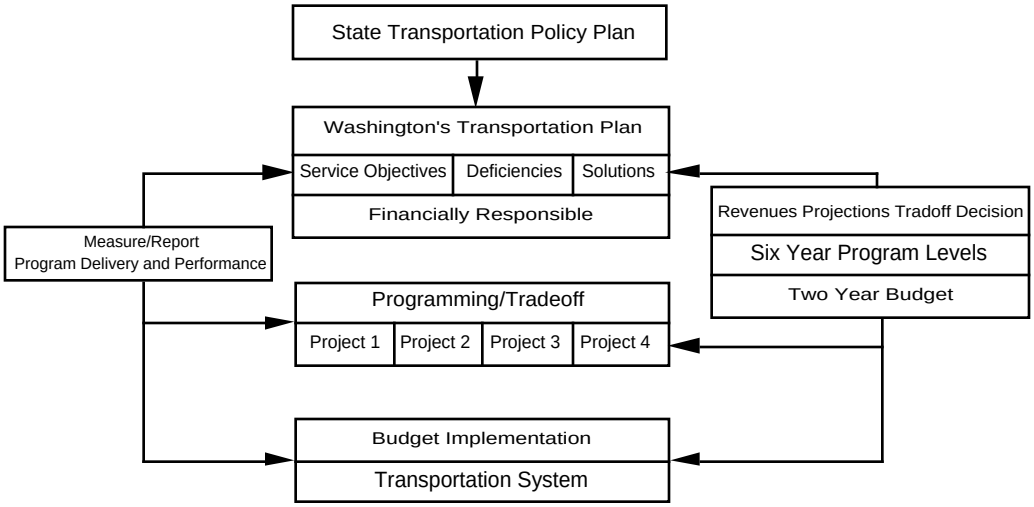
Federal standards require that stormwater runoff be treated to the “maximum extent practicable” (MEP). The MEP standard is defined by the provisions contained in an approved stormwater management plan. Some combination of technology-based controls, water quality-based controls, best management practices (BMP), hydrology-based controls are selected as the elements of MEP. Regardless of the control components, stormwater BMPs cost considerable sums of money to construct. The range of BMPs range from $15,000 for a biofiltration swale constructed from an ideal roadside borrow ditch, to over $500,000 for a wet pond that requires significant land acquisitions. Since costs are real and quantifiable and benefits are imperceptible (during the project scoping phase) and difficult to determine, obtaining funding for projects which solely address stormwater improvements presents a real and difficult challenge for WSDOT's stormwater management program

3.2.3.2 WSDOT Transportation Project Classifications and Funding Options

There is a continuous process required by both state and federal law to decide which transportation projects should be proposed as part of the state’s twenty-year plan and two-year budget.. This process begins with the development of goals and policies through the State Transportation Policy Plan. The transportation plan defines needs on state-owned facilities and state-interested facilities. Stormwater facilities and best management practices are included in the comprehensive, multi-objective list of transportation needs and objectives at a cost of $790

million of the $27 billion of the fully funded 20-year plan. Specific projects within the plan are chosen to advance within a two-year program and budget.

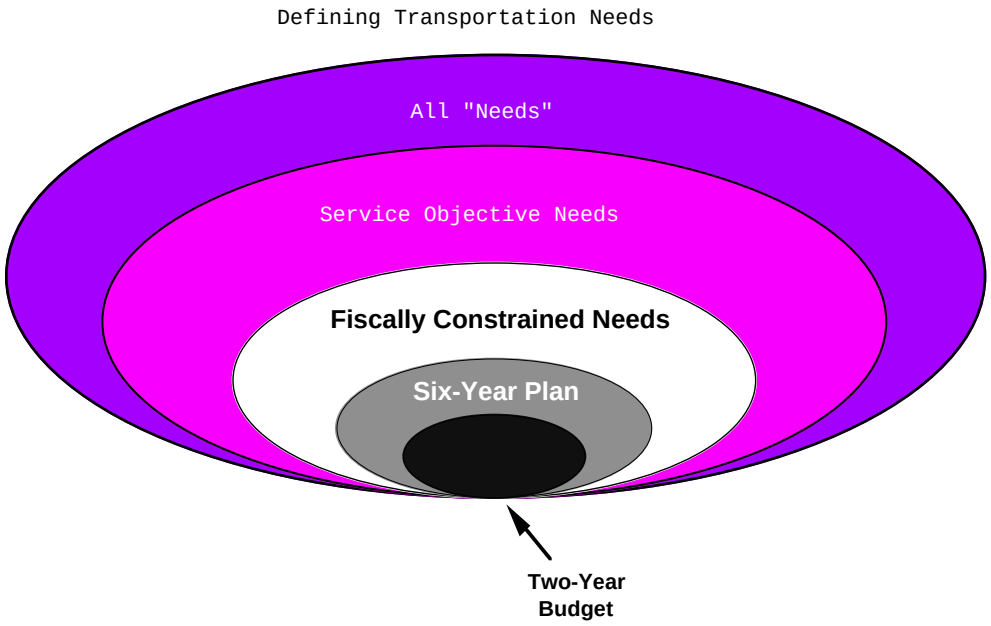
Figure 1
Implementing Transportation Policy



Through the state transportation planning process the term “service objective” has been developed to define transportation needs. While total needs reflect what anyone could ever want (for example, water quality treatment BMPs for every WSDOT outfall), service objectives represent cost-effective desirable outcomes that we can collectively agree are necessary over twenty years to protect the state’s interest in the transportation system. Therefore, service objective needs are targeted to address our most pressing transportation problems, not all identified transportation needs. Stormwater BMP retrofits The only funding that WSDOT can allocate to transportation projects, including stormwater facilities, exists in the current biennial budget. The following graphic illustrates the process of winnowing long range transportation plans to the current biennial budget.

Potential revenues over twenty years probably will not be enough to fund even the reduced level of service objective needs. Therefore, priorities are established to further limit service objective needs to a fiscally realistic level. Washington’s Transportation Plan proposes strategies and actions over twenty years within this financially realistic level. Finally, a two-year budget and six-year program are proposed to advance the most important projects contained in the twenty-year plan. These projects are chosen through the priority program process. These budgeting realities dictate that all stormwater mitigation service objective needs will be constrained to fiscally constrained objectives.

Figure 2

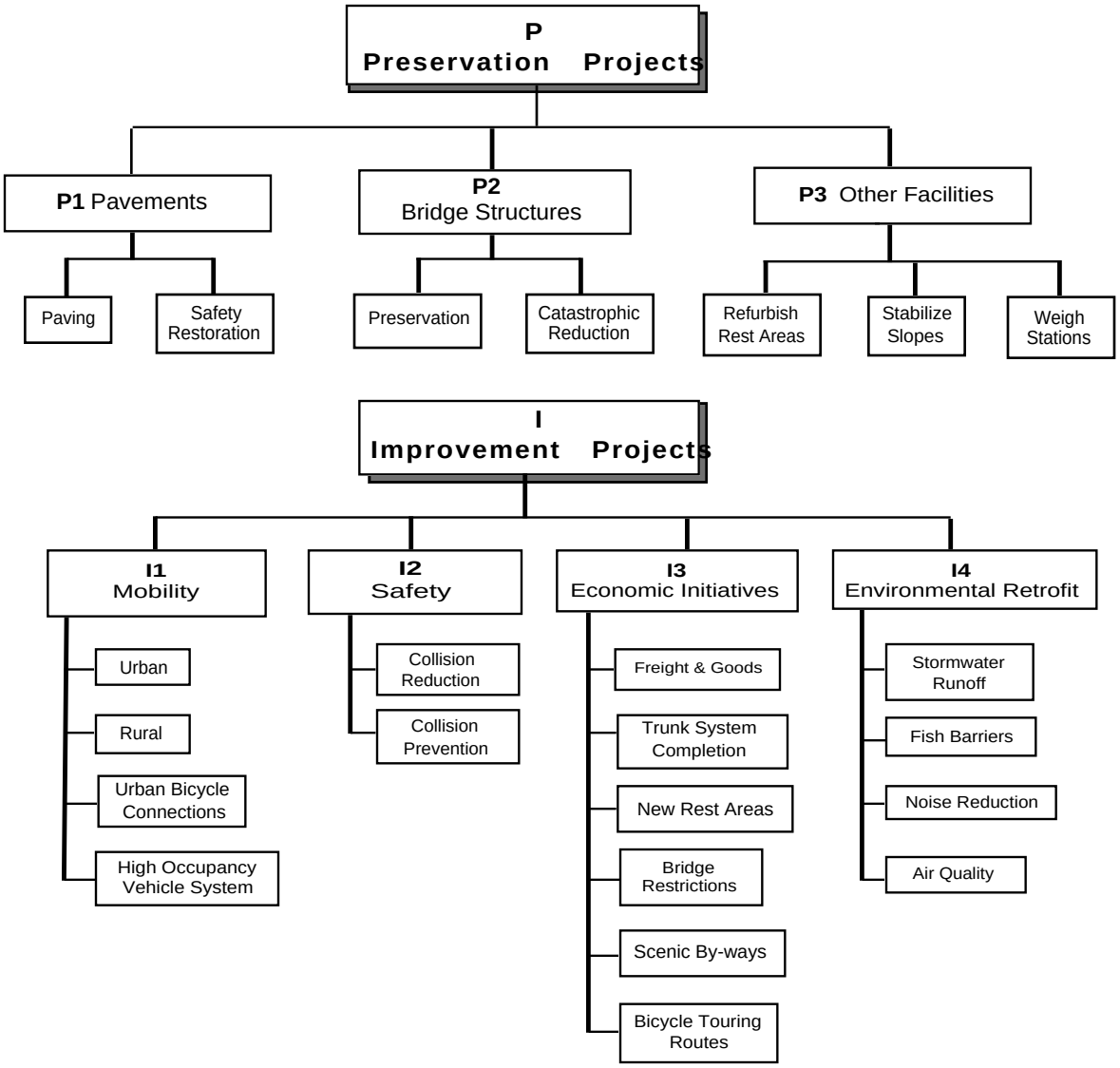


WSDOT highway projects are classified as either *Improvement* or *Preservation* projects. Each classification is sub-classified by broad service objectives, of which Environmental Retrofits is one sub-category. The Environmental Retrofit project subcategory, I-4, is further sub-listed by functional objectives. A new project category specifically for constructing stormwater BMPs for existing highways was initiated during the 1995-1997 biennium, and is listed as an objective under Environmental Retrofits. See the flow chart on the next page for a graphical diagram of WSDOT project categories. The stormwater retrofit category was created to construct water quality BMPs on sections of existing highway that have been identified by WSDOT's outfall inventory/field survey and prioritized using an stormwater BMP retrofit index. The stormwater outfalls which have been prioritized by this index to pose the highest risk to the receiving waters would theoretically be targeted for BMP retrofit construction using I-4 category funding. The I-4 project category was left unfunded for the 1995-1997 budget biennium for the category of stormwater BMP retrofits.

WSDOT, as part of its stormwater program, will attempt to establish funding for the I-4 Environmental Retrofit - Stormwater BMP budget category. Under the Governor's six-year proposed transportation program plan, the following expenditures for stormwater BMP retrofits have been recommended: 1997-1999, $11.1 million; 1999-2000, $13.3 million.

Detailed year-by-year budget estimates and Water Quality Program funding requests are listed in δ3.6.

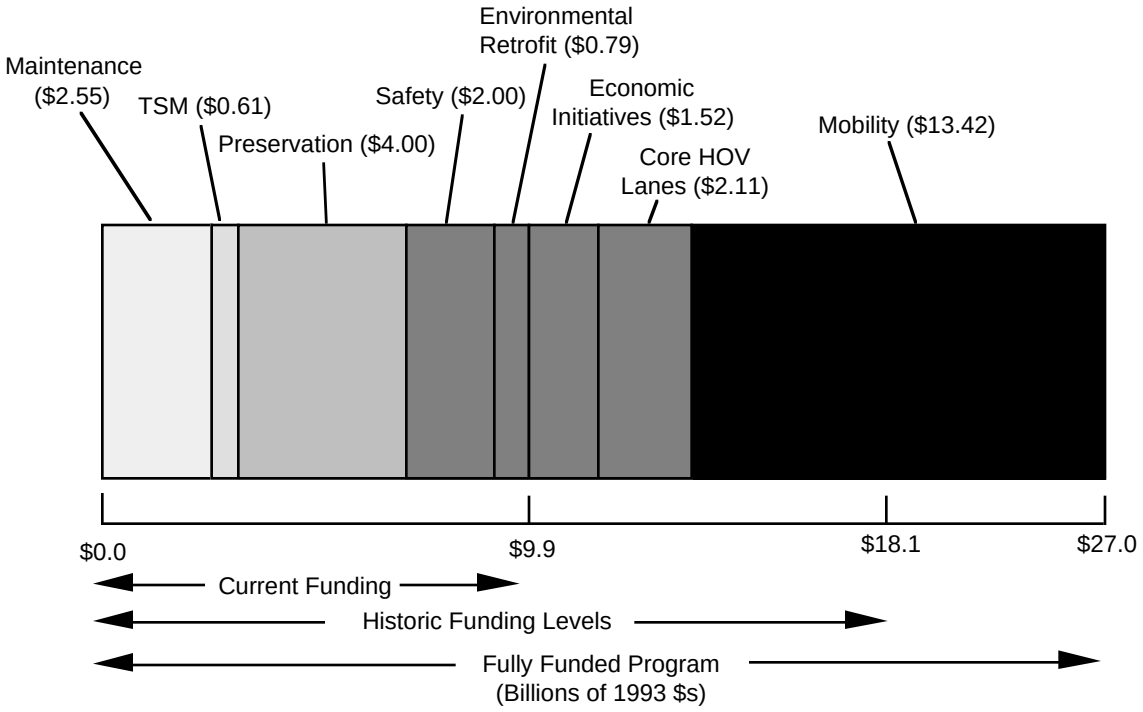
Figure 3 - WSDOT Transportation Project Preservation and Improvement Categories



Since potential transportation revenue over twenty years falls well short of meeting all needs, trade-offs within and between transportation modes and programs are necessary. When Washington's Transportation Plan is completed in early 1996, these types of trade-offs will be included. In 1994, the Transportation Commission started the process of making trade-offs by concentrating on the State Highway elements contained within the 20-year plan. These trade-off decisions will be revisited by the Commission and reflected in the plan they adopt in 1996.

The chart on the following page illustrates the results of the tradeoffs that were made in 1994. The shaded bar represents program needs based on adopted service objectives, placed in order of priority as established by the Transportation Commission. With existing revenue levels, WSDOT can only accomplish maintenance, preservation, safety, and some part of WSDOT's identified Environmental Retrofit service objective needs. If revenues follow the historic trend, we can fund most of our needs over twenty years, including many of WSDOT's stormwater treatment deficiencies. But, long term planning and priority setting aside, the biennial budget is the only funding certainty. The graphic below illustrates funding priorities and how funding levels will determine service objectives. It needs to be noted that this illustration is applicable as of April 1996 and will change as funding and budgetary obligations change with time.

Figure 4 - WSDOT 20 Year Plan Funding Levels



3.2.3.3 Local Stormwater Utility Fees and House Bill 2031

In 1996, WSDOT coordinated development of legislative proposal 2SHB 2031 in response to Legislative Transportation Committee (LTC) concerns about stormwater utility fees and whether these fees were actually used for stormwater projects. 2SHB 2031 is an attempt to influence allocation of moneys paid by WSDOT to local jurisdictions for stormwater utility fees to mitigate stormwater runoff impacts. WSDOT pays nearly $1 million per year to local jurisdictions. Currently, WSDOT ‘s stormwater utility fees are deposited into local utility budgets, where these fees may or may not be expended on stormwater. Under 2SHB 2031, stormwater utility fees paid by WSDOT must be used “solely for stormwater control facilities that directly reduce state highway runoff impacts or implementation of best management practice that will reduce the need for such facilities.” The bill also directs WSDOT, in cooperation with Ecology, cities, towns, counties, tribes, and port Regions to develop stormwater management funding and implementation programs to address state highway-related problems. As part of the program mandated by 2SHB 2031, WSDOT will address:

1. Greater state-wide coordination of the construction of stormwater treatment facilities;
2. Promoting multi-jurisdictional stormwater mitigation projects;
3. Developing priorities and approaches for implementing activities within watersheds;
4. Identification and prioritization of stormwater retrofit programs;
5. Evaluating methods to determine cost benefits of proposed projects;
6. Identifying ways to facilitate the sharing of technical resources;
7. Developing methods for monitoring and evaluating activities carried out under the program, and;
8. Identifying potential funding sources for continuation of the program.

For 1997, $700,000 in federal ISTEA (see δ3.4.1) grant money was been allocated by the legislature to supplement the 2SHB 2031 program to distribute to Washington cities, towns, counties, tribes, and port Regions for implementation of highway-related stormwater control measures. The ISTEA grants are intended to be used in conjunction with the utility fees WSDOT pays to develop solutions to problems caused by highway stormwater runoff. 2SHB 2031 is a progressive step towards solving the needs and priorities created by highway stormwater runoff, local concerns, and watershed-based priorities by reallocating existing funds in more practical and solution-oriented ways.

In December 1996, the 2031 grants were awarded to 6 stormwater mitigation projects. Five of the six projects will retrofit high priority WSDOT outfalls. High priority outfalls determined using WSDOT's BMP Retrofit Prioritization Index, described in section 3.2.3.6. Two of the six projects (listed in bold) retrofit WSDOT outfalls within the Puget Sound area NPDES MS4 permit areas (note - Issaquah and Shoreline are incorporated municipalities with populations less than 100,000 and are therefore excluded from this total, despite being located within the Cedar-Green, WRIA 8 boundary):

Table 16 - Stormwater Projects Funded Through 1996 2SHB 2301 Grants

Grant Recipient	Project Description	Amount Granted	Total Project Cost
City of Olympia	Indian Creek/I-5 Constructed Wetland: A detention pond with a wetland cell will be constructed to remove solids and heavy metals from stormwater runoff from the Plum Street to Martin Way segment of I-5 in Olympia.	$166,231	$340,000
City of Issaquah	I-90 Stormwater Drainage Retrofits / East Fork Issaquah Creek: Source- and treatment-control BMPs along I-90 bordering East Issaquah Creek focused on reducing phosphorus, sediment, and metal loadings.	$144,137	$200,000
WSDOT - Northwest Region	Lake Union Stormwater Treatment & BMP Research Facility - Stormwater runoff from the I-5 Lake Union ship canal bridge will be treated by commercially available and WSDOT-designed treatment units. The facility will also be used evaluate treatment units for removing solids, metals, and hydrocarbons in ultra-urban setting	$123,405	$250,000
City of Shoreline	Ronald Bog Park Stormwater Control - An easy to maintain wet vault will be installed to facilitate removal of sediments from I-5 stormwater runoff prior to discharge to a pond at Ronald Bog Park in Shoreline. This pond has been adversely impacted by sediment loading from I-5.	$37,195	$43,000

Table 16 - Stormwater Projects Funded Through 1996 2SHB 2301 Grants (continued)

Grant Recipient	Project Description	Amount Granted	Total Project Cost
City of Seattle	Thornton Creek Protection BMP - Vaults designed to contain hazardous material spills and remove oil and sediments from I-5 runoff will be installed beneath the Park-and-Ride lot prior to discharging to Maple Leaf Creek, a tributary to Thornton Creek.	$192,182	$260,000
WSDOT - Southwest Region	SR 205 Enhanced Water Quality Biofiltration Swales - Stormwater treatment for a 0.62 mile section of I-205 in Vancouver will be facilitated by the construction of an in-line series of biofiltration swales segmented by 4 small, shallow detention ponds designed to create individual "pocket wetlands".	$36,850	$42,605

WSDOT will introduce legislation during the 1997 session to continue and expand a stormwater grant program similar to 2SHB 2031. There are three principal advantages of continuing this program:

1) Through the 2SHB 2031 process, stand-alone (i.e. not associated with a transportation project) stormwater BMP retrofit projects were funded. This is unprecedented.

2) The process funded stormwater projects that are environmental priorities for both local jurisdictions and WSDOT.

3) Funding for stormwater projects can be leveraged using a combination of local, WSDOT, and federal funding sources.

3.2.3.4 WSDOT's Priority Array Tracking System and the Benefit/Cost Analysis of Stormwater BMPs

WSDOT is in the process of implementing a new and innovative system that will permanently affect the way transportation projects and the individual objectives, including stormwater quality BMPs, are prioritized. The Priority Array Tracking System (P.A.T.S.) uses a condition index which yields an overall Benefit/Cost (B/C) coefficient for all transportation projects and individual project alternatives. The P.A.T.S. system is operational when this document was drafted (1/97). In the P.A.T.S. system: (1) All candidate projects must identify a highway *need*, *problem*, or *deficiency* (stormwater runoff quality considerations are considered in these classifications), (2) All project elements, such as mobility, paving, landscaping, safety, flood control, stormwater BMPs, etc. are assigned B/C multi-component weighting factors (see §3.2.1), and (3) the B/C factors will be used to estimate a net B/C for all projects and all alternatives, without exception. Conceptually, this system will provide an unbiased, quantitative estimation for comparing different projects and different objective needs, thereby eliminating much of the subjectivity (and the affects of political influence) inherent in transportation project funding.

WSDOT recently recognized that there were some positive values to committing resources to environmental restorations within its highway construction projects. This realization has been converted into policy by allowing projects to assume a B/C of 1:1 for stormwater retrofits. However, while this appears to alleviate some of the excess burden of justifying BMP construction, it does not succeed in eliminating the penalty for including environmental enhancements to transportation projects. Many service objective needs are evaluated at B/C ratios much greater than 1, ratios of over 3 are common for safety improvements. For (a purely hypothetical) example, two similar projects each costing $250,000 and providing $750,000 in benefits would yield overall B/C ratios of 3:1. Using the current WSDOT approach, if a stormwater BMP costing $50,000 were added to Project 1, the result would be that Project 1

would now cost $300,000 and produce $800,000 in overall benefits, resulting in an overall benefit of 2.67:1. Since the B/C which included the stormwater BMP would be less than the other project alternative, the decision would be to construct the project without the stormwater enhancement.

A simple solution would be to rank projects which address priority stormwater outfalls and/or sensitive watersheds as priority projects. Unfortunately, this approach would be viewed by many as impractical by most people because there are real safety, mobility, and strategic planning concerns which any transportation plan must adequately address. The criteria of the condition index must be properly weighted so as not to overly emphasize any particular area of a project. In summary, the problems are: (1) prioritizing the overall best projects across a wide range of multi-objective goals, and (2) finding a useful common denominator to evaluate projects. The solution must first identify the list of multi-objective goals and priorities within the proposed project. This will be accomplished by developing B/C weighting factors for all service element needs, including stormwater quality BMPs, which will all be incorporated to assign a total B/C rating to each transportation project and project alternative.

WSDOT's Water Quality Unit and the Washington Transportation Center has sponsored a research project through Washington State University to develop a system to estimate the Benefit/Cost performance of constructing stormwater quality BMPs. The method for developing B/C ratios for environmental enhancements will use a form of condition indexing that will use site-specific parameters. Implementation of this system depends on conducting a contigency market valuation survey, which is a survey that estimates the dollar value that citizens are will to protect water resources in the area where they live. The survey is a way to evaluate non-market benefits of protecting water resources by instituting controls, such as stormwater BMPS. Estimating B/C ratios for environmental enhancements is a technically difficult and contentious issue amongst researchers who have investigated the issue. However, it is essential that such estimates be made and optimized so that optimal benefit for transportation expenditures and stormwater BMP projects are not saddled by a default B/C ratio that has the net effect of degrading the perceived value of a project alternative. The B/C research project was near completion will (hopefully) enhance the status of certain stormwater retrofit projects in the project planning phase and increase the probability of funding for stormwater quality BMP construction.

3.2.3.5 Needs and Prioritization Systems – Condition Indexing

A method for rationally recognizing needs and setting priorities is the *condition index method*. A condition index is a set of rules that defines the physical state of a given problem in terms of a numeric value. The central task of condition indexing is to develop scientifically meaningful definitions of condition levels and methods for assessing proposed facilities among similar facilities which are consistent and reliable. The concept of condition indexing has been commonly used in a number of systems engineering applications. Condition indexing has been adopted by WSDOT for identifying its BMP retrofit priorities (section 3.2.3.6), maintenance program priorities (section 3.2.3.7), and project budget allocation systems (section 3.2.3.2).

Incorporating input from a panel of experts into a developed condition index system is an iterative process. Solving multi-objective problems is challenging because multiple decisions must be made and conflicts between decisions must be resolved. A total systems approach that efficiently represents the complex interactions between system components can be summarized (Hudson, 1992) by the following procedures:

A. Identify specific objectives for evaluation, maintenance, and rehabilitation activities;

B. For each objective in "A", identify the functional system(s);

C. Code each interaction matrix;

D. For each functional system in "B", define ranges between ideal and failed conditions;

E. Develop weighting functions for the condition of each functional system;

F. Repeat A-E for all objectives to form the condition index vector for the entire system;

G. Prioritize the individual objectives to develop multi-component weighting functions.

WSDOT has adopted the conditioning index approach to establish its priorities, including those which directly or indirectly affect the stormwater quality and quantity from its transportation facilities.

3.2.3.6 WSDOT's BMP Retrofit Prioritization Index

Four general factors were estimated to determine the possible impact of highway runoff : waterbody type, beneficial use, pollutant loading, and percent highway drainage were evaluated. WSDOT also took into account the cost/pollution benefits and value trade offs that come to play when determining which of the sites will be retrofitted. To prioritize the outfalls for stormwater BMP retrofits, an outfall ranking index was adopted using a type of condition indexing. Highway stormwater outfalls exist in every imaginable ecological, geographic, and economic setting possible. With this diversity, the index was designed to take these wide variety of factors into account. The indexing system was originally adopted from the *Stormwater Runoff Management Report* (ENTRANCO, 1992). The index has been modified and recalculated twice to account for under or overweighing of certain critical parameters based on expert opinion and the best professional judgment of WSDOT staff. Improvements and modifications will be addressed and implemented on a continuous basis, as needed. WSDOT's BMP retrofit prioritization index is a type of condition index known as a random utility model (Peters, et. al., 1995), which have become popular tools in assigning economic benefits to environmental quality changes. Random utility models define a utility function, U, as the utility of selecting a particular choice or site. This can be written in equation form as:

$$U_i = V_i + \varepsilon_i \qquad (1)$$

where V is the systematic component, ε is the random component and is a subset of the mutually exclusive choices (C_n). The systematic component is that part of the utility function that includes the site attributes and the characteristics of the decision maker. The random component accounts for uncertainties involving unexplained changes in incomplete or inaccurate information and researcher error.

For a particular site i, the systematic component of equation (1) can be expressed as:

$$V_i = \sum_{k=1}^{n} b_k X_{ki} \qquad (2)$$

where b_k is the parameter to be estimated, X_{ki} is the value of each independent variable at stormwater outfall site i, and n is the number of independent variables. Equation (2) must be repeated for C_n choices or solutions, i.e. for each stormwater outfall.

Table 17 - Stormwater Outfall Prioritization Index Parameters

Independent Variable Group	b_i	X_{ki}
Type and Size of Receiving Waterbody	1.0	*Ground Water* = 10 *Small Stream* = 9 *Small Lake* = 6 *Sensitive (class 1, 2) wetland* = 6 *Large stream* = 5 *Large lake* = 3 *River* = 2 *Wetlands (class 3,4)* = 2 *Tidelands* = 2
Beneficial Uses of the Receiving Water Body	1.0	*Drinking Water Violation* = 20 *Drinking Water Protection* = 18 *Public Health Violation* = 16 *Public Health Protection* = 14 *Fisheries Violation* = 12 *Fisheries Protection* = 10 *Aesthetics* = 4 *Flood Protection* = 4
Highway Contribution to Total Runoff in Watershed	ADT Count: *Low* (<10K) = 1.0 *Medium* (10- 50K) = 2.0 *High* (50-100K) = 3.0 *Very High* (>100) = 4.0	Percent Highway Drainage Contributing to Watershed: >5% = 5.0 2-5% = 4.0 1-2% = 3.0 0.5-2% = 2.0 <0.5% = 1.0
Off-Site Pollutant Loading Source	1.0	Yes = 1.0 No = 0.0
Right-of-way Cost	Water Quality Multiplier: *Average* (marine, < 0.5 mi. from marine, inter-tidal, large lake, Class 3 or 4 wetlands) = 0.5 *Sensitive* (groundwater, Class 1 or 2 wetlands, all others) = 1.0	WSDOT owned land = 4.0 Rural (low cost) = 3.0 Suburban (medium cost) = 2.0 Urban (high cost) = 1.0 Prohibitive or unavailable = 0.0
BMP Capital Construction Cost	Water Quality Multiplier: *Average* = 0.5 *Sensitive* = 1.0	Low (0-$25,000) = 4.0 Medium ($25K- $75,000) = 3.0 High ($75K – $150,000) = 2.0 Very High (>$150K) = 1.0

Table 17 - Stormwater Outfall Prioritization Index Parameters (continued)

Independent Variable Group	b_i	X_{ki}
Type of Conveyance Structure	Water Quality Multiplier: *Average* = 0.5 *Sensitive* = 1.0	Impermeable = 4.0 Soil = 3.0 Vegetated = 1.0
Water Quality of Receiving Water	Water Quality Multiplier: *Average* = 0.5 *Sensitive* = 1.0	303 {d} listed = 5.0 305 {b} listed = 5.0 Ground water = 5.0 Class B water = 4.0 Class A water = 3.0 Class AA or marine water = 2.0
Future Construction Plans	1.0	Within 6-year plan boundary = 3.0 Stand-alone project = 1.0
Outfall Within the Boundaries of a Watershed Action Plan	1.0	Yes = 3.0 No = 0.0
Cost Sharing Opportunity w/ Local Jurisdictions	1.0	Yes = 3.0 No = 0.0
Watershed Improvement Financial Support Available	1.0	Yes = 2.0 No = 0.0
Public Relations / Educational Opportunity	1.0	Yes = 2.0 No = 0.0
Permit Obligation	1.0	Yes = 4.0 No = 0.0
Court Mandated Water Quality Standards for Watershed	1.0	Yes = 4.0 No = 0.0
Other Factors – Determined by Best Professional Judgment	1.0	Maximum = 7.0 Minimum = 0.0

Total Maximum Score = 90.0

Total Minimum Score = 10.0

Independent Variable Groups Contributing to WSDOT's Retrofit Index

Receiving Water Body

The type and size of the water body receiving the stormwater discharge was grouped into ten classifications. The rationale behind the ranking values comes from several accepted facts:

- Groundwater typically has much higher quality than surface waters and are generally used for drinking water supplies.
- Stormwater pollutants will have a greater effect on small streams and small lakes because of lower dilution rates, smaller mixing zones and/or background flow rates. A small stream was defined and an intermittent or unnamed tributary or creek less than five miles in length. A small lake was defined as those with surface areas less than 300 acres.
- Wetlands have unique ecological significance and are statutorily protected by a series of state and federal environmental regulations. Wetlands were identified using Basin Plans and the National Wetlands Inventory maps. Sensitive wetlands were defined as an area with unique or rare characteristics (category 1), or containing rare, endangered, or threatened species.

Beneficial Uses of the Receiving Water
Beneficial uses identified the designated uses for the receiving water as determined by the Washington State Department of Ecology in the 1995 *Statewide Water Quality Assessment 305(B) Report*. The use categories included drinking water, public health, fisheries, flood protection and aesthetics. For water bodies not listed in the 305(b) report, beneficial uses were obtained from cities, counties, and basin reports. Since most water bodies have several designated uses, the highest ranking overall designated use was selected. These uses were designated both as prevention and standards violated. If a violation was already present with any of the assigned uses, it received a higher value than areas where use degradation needs to be prevented. The maximum point value for beneficial uses was ten.

Highway Contribution to Pollutant Loading
Pollutant loading is a measure of the potential amount of contaminants from WSDOT right-of-way that mix with runoff and could impact surface water bodies. The loading is based on the ADT. This information was collected from WSDOT's *1992 Annual Traffic Report.* The potential amount of pollution from a road with a low ADT is significantly less than one with a high ADT. State roads in Washington have an ADT range of less than 2000 on many rural roads to over 200,000 vehicles per day on I-5 through downtown Seattle.

The amount of stormwater draining the highway was calculated using the amount of impervious area within WSDOT's right-of-way contributing stormwater to the outfall. This was calculated by multiplying the total length of roadway being drained by the width of the road, assumed to be 12 ft. (3.66 m) per lane.

The total drainage area of the water body receiving outfall discharge was determined from the USGS publication, *Drainage Area Data for Western Washington*, local basin plans, or topographic maps. The drainage area was divided into the percent of rural, urban, and single family residential land uses in each area. These were assigned runoff coefficients that could be used in Rational method or Santa Barbara Urban Hydrograph runoff calculations: single family residential, commercial, and urban 0.90, rural 0.40, and WSDOT highway 1.0.

As a result, an outfall discharging directly into a large water body, such as the Columbia River, would contribute a much smaller proportion of highway runoff to the total drainage area of the river compared to an outfall discharging to a small creek.

Off-Site Pollutant Loading Source
Historically, it has been a common practice to convey stormwater runoff into WSDOT's MS4 system from adjacent land holdings, provided that:

1. The volumes of stormwater were not greater than "pre-development" levels;
2. The volumes of stormwater and conveyance structures, including hydraulic appurtenances and design frequency criteria were in accordance with WSDOT's Hydraulics Manual; and
3. The land was not used for industrial purposes or for storage of fuels, hazardous, or dangerous wastes;
4. The connection(s) to WSDOT's MS4 drainage was done with the approval of WSDOT's design staff.

Case law requires WSDOT to permit passage of stormwater runoff through its right-of-way for natural drainage systems. In most cases the local topography determines whether or not it is feasible for adjacent land to drain through WSDOT's stormwater conveyance system. New off right-of-way source loadings to WSDOT's MS4 systems generally are not recognized until problems occur or until local land developers informs WSDOT of the situation.

Right-of-Way Cost
If there was enough existing right-of-way available to construct a BMP the site received a value of two. If additional right-of-way must to be purchased and cost less than $50,000, it received a value of one. Any costs greater than this received no points. There were less than ten sites where recommendations to purchase additional right-of-way were suggested. These parcels were located in less developed areas of the WRIA and had no structures on them which would significantly increase the cost. In areas where right-of-way costs were prohibitive (such as downtown Bellevue or Seattle), BMPs that use limited amounts of land and could be incorporated into the existing right-of-way were suggested. These included wet or dry vaults, ecology ditches, stormceptor™ or vortechnics™ systems, and biofiltration swales.

BMP Capital Construction Cost
This was determined from the addition of the cost of purchasing additional right-of-way to the cost of the BMP. Property costs were obtained from contacting the Real Estate Division of WSDOT and comparing costs of similar properties in the area. BMP costs were estimated from recently built structures and from costs in the EPA document *Guidance Specifying Management Measures For Sources of Non-point Pollution in Coastal Waters* (*January 1993)* . There are many factors to be considered in the cost of a BMP such as location, size, grading, and construction materials used. Costs can vary significantly from one site to the next therefore, these are preliminary estimates only. Additional research will be needed to determine a more accurate cost. The values assigned were:

a. Low cost BMPs were generally considered to be $15,000 or less.

b. Medium cost BMPs were $15,000- $100,000. Examples include wet or dry ponds and ecology ditches.

c. High Cost BMPs were over $100,000. Examples would include extended wet pond and most vault systems.

Estimated BMP costs include construction, design, mobilization, equipment, inspection fees, and tax. Costs were based on the following assumptions:

1. Availability of right-of-way as determined from contract plans. If a HOV lane is planned for the same location as the BMP this was not considered due to lack of information about the exact location of an HOV lane.

2. Right-of-way costs included any structures on the property and were based on the values of similar parcels in the area. For example a vacant lot in a suburban neighborhood may be less expensive than buying a house on one acre in a rural community.

3. The BMPs recommended are for water quality improvement and except for wet and dry ponds and ecology ditches do not consider detention. For this reason, a biofiltration swale may have been recommended in the median of a road. However, if a detention pond is required also, there may not be sufficient right-of-way available to accommodate the BMP. Purchasing this additional right-of-way and constructing the pond is not be reflected in the cost estimate.

4. All BMPs incorporate the construction and design criteria identified in WSDOT's Highway Runoff Manual, King County Surface Water Management's *Surface Water Design Manual*, and the Department of Ecology's *Stormwater Management Manual for the Puget Sound Basin* .

Points were assigned based on the cost of a proposed BMP. The higher the cost the lower the value assigned. For example, a wet vault, which may cost up to $500,000 to construct, would be unfavorable compared to a $6,000 biofiltration swale discharging to the same waterbody.

BMPs recommended for retrofit included wet ponds, dry ponds, infiltration ponds or trenches (in specific areas), biofiltration swales, ecology ditches, and oil/water separators. Retrofit decision making was also based upon creative problem solving, innovative ideas, and the use of new BMP technology.

Type of Conveyance Structures
The type of conveyance structure has a significant effect on the quality of stormwater discharged to receiving streams. In fact, biofiltration swales, a type of enhanced conveyance structure, are used as stormwater BMPs and can facilitate solids removal rates of up to 80 percent. If the conveyance structure carrying stormwater was a pipe, asphalt lined channel, or other structure that was impermeable, it received four points as these structures do little to attenuate pollutants. If the conveyance structure was a vegetated channel greater than 15 meters in length, it was assigned a value of one as it could potentially attenuate some of the pollutants before reaching the surface waterbody.

Values Trade-Offs and Benefit/Cost Evaluation
The values trade-off and cost pollution benefit sections are designed to adjust the prioritization scheme rating to encourage planning projects that consider social, economical, and political implications. The combined maximum score of these two sections is forty.

Values Trade-Offs: These are factors that could enhance a site based upon values associated with the water body that may not be visible. They can receive a maximum value of twenty six points.

Considerations used in making this determination included:

1. Quality of the Receiving Water.
2. Future Construction Plans.
3. Whether or not the outfall exists within a Watershed Action Plan.
4. Cost sharing opportunity with local jurisdictions.
5. Financial Support in the form of grants, matching funds, etc. is available for BMP construction.
6. A public relations or public education opportunity exists by construction of a BMP.
7. A environmental permit obligation mandates BMPs.
8. The outfall exists in a watershed which has court mandated water quality standards imposed, e.g. total maximum daily load waterbodies, CERCLA sites.

Other Factors – BPJ Considerations
A maximum of seven points can be allocated to a BMP retrofit score at the discretion of water quality staff to account for factors that were not specifically addressed by the other parameters in the index, such as aesthetics, proximity to park or recreations lands, etc.

3.2.3.7 WSDOT's Facilities Operating and Maintenance Program Prioritization System

The emphasis on the facilities capital programs, i.e. road construction projects, at WSDOT and in this document are primarily because of budgetary considerations. If one combines the biennial budgets appropriated for highways in Washington State, capital programs command 85% of the total. Additionally, any structural improvements to roadway systems, which include upgrading or retrofitting stormwater facilities, can only be facilitated through capital programs. Building and upgrading structural stormwater controls is the highest priority for WSDOT's stormwater management plan. Based on limited projected revenues the Commission recommended to reduce funding for the statewide highway maintenance program to make up shortfalls in the Improvement (construction) program.

The Washington State Transportation Commission (the Commission) prioritizes all the needs of the state's multi-modal transportation system. The Commission strives to address the needs of eight programs: Maintenance, Traffic Operations, Highway Preservation, Mobility, Safety, Economic Initiatives and Environmental Retrofit. The Commission develops the *State Highway System Plan* to address the needs of all WSDOT programs over a twenty year planning period.

It provides the overall programmatic objective or goal that WSDOT, the Commission and the Legislature must strive toward to achieve a balanced Statewide Multi-modal Transportation system. The Commission utilizes the information provided by WSDOT in conjunction with

public input and develops strategies to meet all transportation needs or service objectives. Each of WSDOT's programs follow action strategies established by the Commission to achieve the service objectives.

Prioritization of State Highway Maintenance Activities

To "maintain state highways on a daily basis to ensure safe, reliable and pleasant movement of people and goods" is the general service objective established by the Commission for WSDOT Maintenance. The Commission has developed specific action strategies identifying the policy directives that provides the foundation of the highway maintenance program. The action strategies are defined for maintenance as:

1. Minimize travel delay time due to emergency conditions.
2. **Provide safe winter travel (deicing and snow removal) on highways that remain open to the public.**
3. Provide safe, reliable roadway surfaces through pavement patching, sealing, and surface treatments.
4. Maintain visibility of traffic control and safety devices.
5. **Manage roadside vegetation to meet safety, aesthetic and regulatory requirements (integrated vegetation management).**
6. **Maintain drainage facilities and fences in proper working order (BMP and stormwater conveyance system maintenance).**
7. Provide the traveler with safe, clean, reliable and pleasant rest area facilities.
8. **Remove litter from the roadsides (litter removal and street sweeping).**
9. Keep existing structures safe and dependable.

(Bolded action strategies include activities which have the potential to affect stormwater runoff quality to some degree.)

Based on limited projected revenues the Commission recommended to WSDOT and the Legislature a reduction in the funding for the highway maintenance program to make up shortfalls in the highway Improvement (i.e. construction) program, primarily projects associated with mobility and economic development. In response to the decision to reduce full funding of highway maintenance activities the Legislature requested WSDOT Maintenance Division perform a review of all activities. This review evaluates the maintenance activities and determines how to maintain the highway system effectively, efficiently, and with greater consistency.

WSDOT, as part of a Department Quality Initiative, used a condition index process to prioritize all highway maintenance tasks based on weighted criteria. For the Commission to provide funding of highway maintenance activities, WSDOT must prioritize all activities to be consistent with the goals of the Transportation Commission. WSDOT Maintenance Program Management formed a Quality Review Team to identify and prioritize all maintenance activities. The Quality Review Team is composed of maintenance representatives and analysts from the Olympia Service Center, Regional Offices, and Maintenance Districts.

The Quality Review Team focused on identification of what is most critical to achieving the action strategies. Activities not critical to achieving the action strategies are considered non-essential to obtain that strategy and may not be funded when budgets are reduced. WSDOT Maintenance Management can show to the Commission the impact on the maintenance program when budgets are reduced.

The team developed a department wide Maintenance Priority Matrix showing how each highway maintenance activity contributes to the service objective of "Maintain state highways on a daily basis to ensure safe, reliable and pleasant movement of people and goods". In order to develop a matrix the team identified basic program objectives consistent with the Service Objectives and Action Strategies identified by the Plan.

Maintenance and Operations Service Objectives:

1. Improve safety.
2. Operate Systems Reliably.
3. Protect our investment.
4. Support the economy.
5. Address legal mandates.
6. Meet environmental responsibilities.
7. Contribute to comfort and aesthetics.

Listed on the next page is a recent priority matrix for WSDOT's highway maintenance activities. This matrix is recalculated and reevaluated on a regular basis, usually several times a year. Therefore this listing is a snapshot in time of WSDOT's highway maintenance priorities. Stormwater quality issues are addressed, either directly or indirectly, through the service objectives "Address legal mandates" and "Meet environmental responsibilities".

The Draft Service Objectives/Activities Chart was not able to be included in the electronic version of this report at this time. It will be included when it becomes available.

WSDOT's stormwater maintenance program identified the following elements to make up stormwater management activities. The stormwater activities are listed in order of priority.

STORMWATER ACTIVITIES:	TOTAL PRIORITY
Noxious Weed Control	205
Maintain Storm Drainage Systems	125
Grade and Clean Ditches	119
Maintain Culverts	115
Sweeping and Cleaning	86
Nuisance Weed Control	79
Mowing	77
Maintain Silt Basins	43
Miscellaneous Drainage Maintenance	33
Litter Pickup	30

This information will be utilized by the Legislature to gain an understanding of what activities WSDOT Maintenance requires funding to meet the service objectives. The Legislature has the final policy decision on funding the prioritized activities.

The above chart details, in order of overall priority, "What WSDOT Maintenance will ask for" during budget negotiations with the Legislature. There are no assurances the Legislature will agree to the identified critical activities and choose to fund such activities.

WSDOT Maintenance Management has identified a level of funding to provide for the highest level of service and fully implement the entire statewide maintenance program. WSDOT Maintenance staff compared the current program expenditures to the estimated funding level and developed a percentage estimate of the needs of funding levels.

For example WSDOT currently spends $157,636 annually in staff and equipment to maintain culverts in the five Maintenance areas. To adequately fund the current culvert maintenance activities, the program needs $ 260,000 to be fully operating the program. This program operates with a 64% deficit in funding.

The following chart shows the current program expenditures, the estimated of the cost to fully operate the program and the percentage deficit of funding.

Maintenance and Operation Programs

- Unmet Needs in the Puget Sound NPDES MS4 Permit Areas

ACTIVITY	CURRENT $ /YR	UNMET $ /YR	%Unmet
Noxious Weed Control	143,356	188,000	-31%
Maintain Storm Drainage Systems	234,864	303,000	-29%
Grade and Clean Ditches	305,516	388,000	-27%
Maintain Culverts	157,636	259,000	-64%
Sweeping and Cleaning	735,818	898,000	-22%
ACTIVITY	**CURRENT $ /YR**	**UNMET $ /YR**	**%Unmet**
Nuisance Weed Control	126,223	182,000	-44%
Mowing	186,922	234,000	-25%
Maintain Silt Basins	375,924	452,000	-20%
Misc. Drainage Maintenance	3,193	4,000	+15%
Litter Pickup	306,509	435.000	-42
Integrated Vegetation Management	9375	29,000	-68%

3.2.3.8 WSDOT High Priority Stormwater Program Needs

1: Facilitating Construction of Permanent Structural Stormwater BMPs

WSDOT has the greatest potential to minimize adverse affects to water quality from highway stormwater runoff over the long term by constructing structural stormwater BMPs. A predominant amount of WSDOT's Budget is allocated to transportation improvement projects (85 percent) which include the addition of impervious surface, which in turn increase stormwater runoff and trigger water quality and quantity considerations (listed in section . A significant portion of WSDOT's BMPs treat new, existing and off-site stormwater runoff. In any case, all new impervious surfaces added WSDOT will document volumes of stormwater treated, both on and off-site, as part of its stormwater program. A number of construction projects are underway or planned for state roads given population, right-of-way availability, congestion, and dependency on automobiles for travel.

Staff time and resources will focus on designing and constructing new BMPs as defined in WSDOT's HRM. A substantial amount of training is needed to educate designers, project engineers, and inspectors on appropriate temporary erosion control methods and permanent best management practices for both water quality and quantity control. WSDOT's Hydraulics staff has and will continue to hold training classes in Hydraulics, Hydrology, and Water Quality for WSDOT personnel, consulting designers, and contractors.

Three methods for facilitating funding for stormwater quality and quantity BMPs will be utilized during the term of the NPDES MS4 permit period:

a) Transportation mobility project funds - construction of stormwater facilities associated with projects which add new impervious surfaces to the highway prism. In many instances, these projects will also be designed to provide water quality and quantity treatment for *pre-existing* impervious surfaces (dependent on site-specific spatial constraints). This funding source has a very high probability because of its association with transportation mobility projects, a high priority for the Transportation Commission and the Legislature.

   Many transportation projects are scheduled for construction within the three Puget Sound NPDES MS4 permit areas for the six-year period 1997-2003 that involve the addition of new impervious surfaces. Any of these projects may or may not be constructed prior to the year 2000. Appendix A includes a listing of these projects. Typically, around 5% of the total transportation project costs are allocated toward construction of stormwater conveyance and treatment facilities. For the 1995-1997 biennium, $60.7 million dollars in transportation dollars were spent on stormwater facilities in the Puget Sound region. A similar total will be spent on stormwater facilities in the Puget Sound region during the 1997-1999 biennium. For the entire term of the 1995-2000 NPDES permit, WSDOT will spend and estimated $151.75 million dollars on stormwater facilities in the Puget Sound region that are associated with transportation projects.

b) Construction of "stand-alone" stormwater BMP retrofits through funding of the I-4 stormwater retrofit project category. This would require specific allocations through the Washington State legislature and would not be included as part of mobility-oriented projects. Selection of individual stand-alone BMP retrofit projects would be selected through WSDOT's BMP retrofit index, described in section 3.3.2.6. Retrofitting every stretch of highway with BMPs is not practical and will never be accomplished considering the fiscal limitations and the magnitude of WSDOT's highway drainage system. Where runoff from existing roadway commingles with new road runoff, attempts are made to treat to current Washington State water quality standards. When runoff from existing pavement is not affected, but within a project boundary consideration must be given to the cost/benefit of retrofitting. WSDOT may be mobilized for construction in the area but the receiving body of water is low priority for restoration. The funds may better be spent in a non-project area, retrofitting a stretch of roadway that is impacting a high priority stream segment.

Specific details on programs to address new development are included in the program descriptions for Stormwater Planning Process, New Construction Source Control, and Prioritization of Retrofit Sites. WSDOT's water quality program is requesting $11.1 million for

the '97-'99 biennium and $13.3 million for the '99-'01 biennium for this purpose. If funding for I-4 is achieved, the stormwater BMP retrofit projects listed in Table 18 will be initiated:

Table 18 - Stormwater Quality BMP Retrofit Projects To (Potentially) Be Constructed By the Year 2000 if Transportation Project Category I-4 is Funded

Outfall Location (SR-MP-offset)	County	WSDOT Region	Commentary
5-136.09-L-650	Pierce	3 - OL	ROW Purchase necessary.
5-135.94-L-25	Pierce	3 - OL	ROW Purchase necessary
5-118.9-L-18	Pierce	3 - OL	These dry wells may well have to be removed for the HOV lane construction.
5-200.22-R-50	Snohomish	1 - NW	
5-185.92-R-200	Snohomish	1 - NW	Access is easy. ROW is large enough. Existing conveyance does little to improve water quality.
5-120.98-R-100	Pierce	3 - OL	Adequate WSDOT R/W exists for this BMP, which is removal of dry well only.
7-48.54-R-4	Pierce	3 - OL	Cost share with Pierce County to mitigate expense of purchasing extra R/W.
5-204.05-L-160	Snohomish	1 - NW	lack of available R/W precludes other BMP options
405-2.38-R-620	King	1 - NW	Space available for detention pond & biofiltration swale in middle of N.E. cloverleaf and BS in exchange ROW.
520-5.62-L-300	King	1 - NW	Unclassified stream on King Co. sensitive areas map.
90-10.5-L-200	King	1 - NW	
5-187.86-L-40	Snohomish	1 - NW	
18-0.3-R-175	King	1 - NW	enough existing ROW

Table 18 - Stormwater Quality BMP Retrofit Projects To (Potentially) Be Constructed By the Year 2000 if Transportation Project Category I-4 is Funded (continued).

Outfall Location (SR-MP-offset)	County	WSDOT Region	Commentary
5-183.6-L-40	Snohomish	1 - NW	Use of ED provides water quality benefits while avoiding R/W purchase
5-184.61-R-70	Snohomish	1 - NW	ROW is narrow and steep. Adjacent land is semi-rural residential. This outfall has been recognized as a problem (Entranco 1992).
516-2.26-L-60	King	1 - NW	HOV project has a two cell wet pond planned for SE cloverleaf. No BS planned.
405-7.16-R-75	King	1 - NW	Area in NB R/W for BS.
161-20.06-R-47	Pierce	3 - OL	Cost share with Pierce County to mitigate expense of purchasing extra right of way.
5-183.21-L-70	Snohomish	1 - NW	Even a vegetated filter strip would be an improvement. Move ditch out of herbicide zone or stop using herbicide.
5-119.15-L-12	Pierce	3 - OL	These dry wells may have to be removed for the HOV lane construction.
7-50.49-L-10	Pierce	3 - OL	Cost-share with Pierce County to mitigate expense of purchasing extra right-of-way.
7-50.55-R-20	Pierce	3 - OL	Cost-share with Pierce County to mitigate expense of purchasing extra right-of-way.
7-50.61-R-5	Pierce	3 - OL	Cost share with Pierce County to mitigate expense of purchasing extra R/W.
7-50.61-L-12	Pierce	3 - OL	Cost share with Pierce County to mitigate expense of purchasing extra right of way.
7-50.59-R-10	Pierce	3 - OL	Cost share with Pierce County to mitigate expense of purchasing extra right of way.
90-15.45-L-20	King	1 - NW	An ecology ditch may not effectively reduce enough phosphorous for WSDOT to meet potential TMDL. Other BMPs may require purchasing ROW.
5-153.39-L-100	King	1 - NW	
5-121.3-L-45	Pierce	3 - OL	Ample WSDOT ROW.
5-121.05-L-150	Pierce	3 - OL	Ample WSDOT ROW.
7-51.08-R-15	Pierce	3 - OL	Expense of purchasing R/W could be mitigated by cost sharing with Pierce County.
516-2.96-L-200	King	1 - NW	Present conveyance is within asphalt shoulder. Slope nearby is steep. Level space off shoulder may be limited - 2,000 ft. BS & 1,000 ft. ED.
5-120.9-L-420	Pierce	3 - OL	Ample WSDOT ROW exist for this BMP. May require some regrading of gore area.
5-120.89-L-420	Pierce	3 - OL	Ample WSDOT ROW exist for this BMP. May require some regrading of gore area.
5-120.93-R-425	Pierce	3 - OL	Ample WSDOT ROW. Some earth regrading required.
5-120.88-R-550	Pierce	3 - OL	Ample WSDOT ROW. Some earth regrading required.
5-120.91-R-670	Pierce	3 - OL	Ample WSDOT ROW. Some earth regrading required.
5-120.86-R-450	Pierce	3 - OL	Regrading of gore area necessary & installation of new catch basin and culvert.
5-120.78-R-150	Pierce	3 - OL	BMP is removal of existing dry well only.
5-120.85-R-500	Pierce	3 - OL	Installation of new catch basin and culvert and regrading of gore area is necessary.

c) Construction of stormwater facilities through a process similar to the 2SHB 2031 stormwater control grant program implemented during 1996. The successful implementation of this program during 1996 provides momentum for its continuation and expansion for 1997 through 2000. Continuation of a 2SHB 2031-like process will most likely be dependent on the reauthorization of the Intermodal Surface Transportation Enhancement Act (ISTEA) by the federal government or location of other funding sources.

2: Stormwater BMP Monitoring and Research

The second priority stormwater management priority for WSDOT during the term of the permit is to facilitate highway runoff characterization sampling and BMP effectiveness monitoring. It is important for WSDOT to update current information on the quality of highway runoff. In addition, percent pollutant removal capability of existing and experimental BMPs is needed to determine cost/benefit efficiencies and determine the pollutants removal effectiveness of highway runoff BMPs.

A substantial portion of WSDOT's research budget has been devoted directly or indirectly to stormwater projects. Given the large construction budget and volume of materials purchased WSDOT has great incentive to utilize new products and designs. Technology and information transfer regarding BMPs and highway runoff research will continue to be a high priority in WSDOT's stormwater management program. This coordination will continue through the participation in and co-funding of projects with organizations such as the Transportation Research Board-National Academy of Science (TRB), the National Cooperative Highway Research Program (NCHRP), and the U.S. Department of Transportation-Federal Highway Administration (FHWA). There is statewide importance for effective implementation of stormwater BMP research since WSDOT's actions set the trend for local roads and utility governments.

Details on WSDOT's planned stormwater monitoring program can be located in δ3.3.7.

3: Erosion and Sediment Control Programs

All WSDOT project designs that include clearing and grubbing, embankment work, or other earth work now include a Temporary Erosion and Sediment Control (TESC) Plan. The TESC plan is incorporated into the Stormwater Site Plan (SSP) whenever greater than 5,000 ft.^{2} of impervious surface is added to the footprint of a highway . The plans are prepared in accordance with the Highway Runoff Manual, Minimum Requirements of Stormwater Management Manual for the Puget Sound Basin and the requirements of the NPDES/Baseline General permit. For construction sites where the total acreage of earthwork is five or more acres, an NPDES Notice of Intent is filed for coverage under the NPDES/Baseline General permit and, thus, the plans are prepared for that site. For construction sites where the total acreage of earthwork is less than five acres, coverage under the NPDES/Baseline General permit is not required, however, a plan will be prepared for those sites.

Special provisions in addition to standard erosion control practices are sometimes required to comply with the following:

- Local Grading Permits
- Right-of-way Management Sensitive Area Ordinance
- Shoreline Management Substantial Development Permit
- Ecology, Water Quality Certification
- Ecology, Temporary Modification of Water Quality Standards
- Dept. of Fish and Wildlife, Hydraulic Project Approval Permit
- Contractors Addendum for Spill Containment and Control at Construction Sites

Plans are developed using the HRM. Region and Olympia Service Center Hydraulic and Environmental Staff review the plans which are prepared under the auspices of the Project Engineer. Erosion Control work is identified with unit bid items in contracting documents. Project Inspectors evaluate the installation and effectiveness of erosion control measures in the field. Deficiencies are recorded by the Inspector who then inform the contractors of the

deficiencies. If timely corrections are not made, the contractor can be ordered to stop work and can be subject to a claim.

An Instructional Letter was created to outline new permit requirements, contents of the Temporary Erosion and Sediment Control Plans, and the processes for development and implementation of the plans and permit compliance. The new requirements (1994) supersede information contained in the 1991 Standard Specification for Road, Bridge, and Municipal Construction; Design Manual; and Construction Manual. These three manuals serve to communicate standard procedures for a WSDOT construction project and provide detailed guidance on preparing plans, construction management, materials specification, and contract compliance.

In addition to WSDOT inspectors, field inspectors from local jurisdictions and resource agencies who have environmental enforcement authority can arrange inspections of a construction site to determine compliance with local, state, and federal laws.

WSDOT has an erosion control specialist to coordinate the department's compliance efforts. Duties include policy development, technical assistance, program evaluation, staff and contractor training through the WSDOT certification program, and coordination of the development of up to date statewide erosion control contract specifications.

Starting in early 1997, it is proposed that highway construction contractors will be required to designate and make known to the Project Engineer during pre-construction meetings the firm's Erosion and Sediment Control Officer (ESC Officer). This person will have the training and authority to administer an active and effective construction site erosion and sediment control program. On large scale, complex, and/or projects with environmentally critical areas, this person will be required to be on site during all construction activity. The WSDOT Erosion Control Specialist will coordinate with the firm's ESC Officer to ensure that appropriate site personnel receive adequate training in BMP installation and maintenance.

Training in Construction Site Erosion and Sediment Control began in the Fall of 1995 and ran through Spring 1996. The International Erosion Control Association was contracted to teach this initial round of courses. The courses were taught as two one day classes, one for designers titled Plan Design and the other for contractors titled Plan Implementation. The Design course was primarily for WSDOT personnel while the other course was designed for contractors. Over 150 WSDOT personnel attended these courses and over 160 contractors, regulators and hydroseeders attended the implementation course. Participants of the first round of training will receive a certification card enabling them to be designated as Erosion Control Officers by the prime contractor.

Courses will continue to be offered every year during the construction off-season, approximately October through March. Subsequent training will be taught by WSDOT personnel and will focus on highway related construction. These courses will be 2 days, one of classroom, and one of field implementation and installation. A written test must be passed to attain certification. Certification will last approximately three years or until revisions are made to the Highway Runoff Manual.

Full details on WSDOT's planned erosion and sediment control program can be found in δ3.3.2.

4: Regaining Full Funding of Highway Operations and Maintenance Programs

The 1997-1999 budget request includes increases to the 1995-97 base to accommodate system additions and service delivery increases. These requested increases will provide necessary resources to maintain the current level of service, i.e., the 1995-1997 level of expenditure.

WSDOT Maintenance and Operations will request the first of three increases for the identified activities over the next three biennia. The requests will ultimately result in an overall maintenance level of service to strive toward fulfillment of the un-met program needs identified in the previous section.

The Legislature has directed WSDOT that the additional funds granted in 1997 will be applied to Washington's transportation infrastructure, and will lower life-cycle costs for some high-priority roadside maintenance activities.

If the legislature grants any additional funds to maintenance of the highway system, such funds will be applied to maintenance activities that will improve safety for the traveling public and will increase the protection of taxpayer's investment in Washington's transportation infrastructure.

Specific maintenance activities targeted for increases - selected because of their identified priority and current less-than-desirable performance levels - include: snow and ice control, pavement patching and repair, pavement striping, grading and cleaning ditches and maintenance of culverts.

If the requests are granted WSDOT's stormwater management program will be enhanced over current levels 19% for grading and cleaning of ditches and 108% for maintenance of culverts.

ACTIVITY	CURRENT $ /YR	1997-97 $	% Increase
Grade and Clean Ditches	305,516	363,000	19%
Maintain Culverts	157,636	328,000	108%

WSDOT will request funding adequate to maintain the current level all other stormwater program components for the 1997-1999 biennium. Any further increases to the current funding will be based on direction from the Legislature.

5: Encouraging and Participating in Watershed-Based Mitigation Strategies

Identify opportunities for off-site, watershed-based environmental mitigation strategies will be a continuing emphasis at WSDOT. The Snohomish Basin Project that WSDOT is actively developing and promoting through the Washington Watershed Coordinating Council will be an important step in demonstrating the benefits of watershed-based mitigation strategies. Allocating limited monetary resources for the greatest net benefit of watersheds, i.e. watershed management, is a simple but unfulfilled concept whose time has come. Sections 3.1.4.2 and 3.1.4.3 detail WSDOT's involvement and commitments to watershed-based planning and mitigation strategies.

6: Water Quality-Related Training Programs

WSDOT has an extensive training program and offers a wide variety of classes and training in environmental mitigation and processes. In addition, WSDOT sponsors a large number of conferences and workshops. A specific, integrated environmental education and training program is currently being developed by WSDOT's Environmental Office. Each of the Stormwater Management Programs have a training component. These components will be incorporated into the Environmental Training effort. Particular emphasis will be placed on developing training programs for construction site stormwater management and spill prevention/control methods for designers, inspectors, and contractors. Training and public education programs that have been held or that are in development include:

- Temporary Erosion and Sediment Control for Highway Construction Sites.
- Spill Prevention, Containment, and Emergency Response at Construction Sites.
- Hydraulics, Hydrology, and Water Quality.

A majority of the water quality progress to be made in highway maintenance activities is related to training. While maintenance training has traditionally focused on keeping traffic flow moving and maintaining safety features, roadside vegetation management and drainage maintenance have been secondary priorities. The focus of the training will be to explain how maintenance activities maximize water quality benefits. WSDOT operating manuals are routinely updated to reflect new information and priorities. As information on BMP maintenance is generated, portions of the WSDOT Maintenance Manual will be updated to maximize the designed water quality benefits.

Education activities which focus specifically on the impacts of transportation runoff on water quality have not been developed at WSDOT. A wide body of environmental education literature and programs currently exist to encourage people to conserve resources and not dump or spill materials whether at home or while traveling. The public outreach activities of other named parties in the permit is already in place. WSDOT will support their efforts by providing information on BMPs relative to transportation sources. The WSDOT public involvement campaigns that have the potential for reducing pollutants in stormwater runoff are the Adopt-A-Highway (debris removal) and Trip Reduction Programs.

WSDOT offers many opportunities for the public to get involved in transportation planning. Public meetings are held to obtain input on Regional Transportation Improvement priorities and to review alternatives for specific projects such as a road alignments or intersection improvements. In addition, WSDOT frequently produces Public Notices in local newspapers to respond to environmental regulations such as the Baseline General Permit for Construction Activities and inviting public response to environmental impact statements (EISs).

3.2.3.9 WSDOT Medium Priority Stormwater Program Needs

Their are several stormwater program elements which are of interest to WSDOT, have the potential to improve highway stormwater quality, can increase the efficiency of WSDOT's stormwater program, but do not have funding sources or may not be addressed during the term of the NPDES permit because of emphasis on the high priority unmet needs.

1: Public Education Programs

Education activities which focus specifically on the impacts of transportation runoff on water quality have not been developed at WSDOT. A wide body of environmental education literature and programs currently exist to encourage people to conserve resources and not dump or spill materials whether at home or while traveling. The public outreach activities of other named parties in the permit is already in place. WSDOT will support their efforts by providing information on BMPs relative to transportation sources. The only public involvement campaign that WSDOT sponsors that has implications for reducing pollutants in stormwater is the Adopt-A-Highway program.

WSDOT offers many opportunities for the public to get involved in Transportation Planning. Public meetings are held to obtain input on Regional Transportation Improvement priorities and to review alternatives for specific projects such as a road alignments or intersection improvements. In addition, WSDOT frequently produces Public Notices in local newspapers to respond to environmental regulations such as the Baseline General Permit for Construction activities, and inviting public response to environmental impact statements (EISs).

2: Determining Life-Cycle Maintenance Requirements for Stormwater BMPs

WSDOT expends considerable funds constructing stormwater BMP facilities. Stormwater facilities that receive highway runoff require routine maintenance to retain their pollutant removal effectiveness. Monitoring surveys of stormwater BMPs has demonstrated that lack of maintenance can significantly impair their performance. What is unknown is the level of routine and nonroutine maintenance that is required for stormwater BMPs to sustain their functional usefulness and for WSDOT to retain its investment in its stormwater facilities.

WSDOT is considering a study that correlates the physical conditions within existing stormwater BMPs and maintenance schedules with their pollutant removal effectiveness. Several existing wet ponds, dry ponds, biofiltration swales, filter strips, and infiltration ponds of varying ages and conditions would be examined for physical evidence of degradation, such as sediment accumulation, channelization, impaired vegetation growth, etc. and simultaneously monitored for pollutant removal efficiency throughout a three year period. Correlations between physical conditions, maintenance schedules, and facility effectiveness would be documented.

Funding for this program is uncertain and is dependent on the level of funding given to WSDOT's research programs for the '97-'99 biennium.

3: Development of a Continuous Tracking System For Structural Stormwater BMPs Constructed For Transportation Mobility Projects

Stormwater facilities are constructed yearly in conjunction with transportation mobility projects. WSDOT needs a system to systematically track the construction of stormwater facilities and locate the spatial extent of these facilities, influent, and effluent conveyance systems using a geographic positioning system. Such a system would be useful for quickly and efficiently tracking BMP construction for WSDOT's NPDES annual reports.

3.2.3.10 WSDOT Low Priority Stormwater Program Needs

1: Illicit Connection Identification Programs

Through the process of inventorying stormwater outfalls through its Outfall Inventory / Field Screening (OI/FS) process, WSDOT expended a significant amount of person-hours and expense to identify illicit connections throughout WSDOT's MS4 systems in Puget Sound, Clark County, and Spokane County. Because the total number of illicit connections found were so small (16 out of 3518 stormwater outfalls as of December 1996) and discharges were insignificant (both in terms of quality and quantity), a large scale, ongoing, capital intensive program to identify illicit connections was judged to not be warranted, and will not be actively pursued as part of the SWMP.

2: Tracking Maintenance Performance Relative To Highway Runoff Manual and Maintenance Manual Specifications

A tracking system comparing maintenance activities to HRM and MM specifications is a low priority because its impracticality, degree of accounting, lack of funding, and because many maintenance activities are performed in emergency situations where standard protocols are not applicable.

3: Monitoring Highway Maintenance and Operations Practices Relative to Water Quality Impacts

Many studies have already been performed on this subject by FHWA, EPA, and others. Duplication of these efforts would be redundant. Refer to section 3.2.2.2 for more details.

4: Developing Budgetary Mechanisms To Fund Maintenance Activities Associated Solely With Water Quality

The realities of an effective day-to-day highway maintenance program depend on flexibility in allocating personnel and equipment to the highest priority areas and activities. There are no guarantees that *any* service objective in highway operations and maintenance will be funded at pre-specified levels because of yearly weather variations and variable highway infrastructure conditions.

3.2.3.11Conclusions: Stormwater Management Plan Needs and Priorities

There are several programs, priorities, projects, and concepts which can and will be addressed to work towards the continual improvement of WSDOT's highway stormwater runoff quality. It needs to be emphasized that any stormwater enhancements have to work within WSDOT's established program priority and budgeting systems. Stormwater enhancements are just a small portion of WSDOT's overall service objectives. The project prioritization systems that WSDOT will be utilizing mandates that benefit/cost ratios for stormwater enhancements, as well as all other service objectives, be evaluated and incorporated into project prioritization. WSDOT's methodology for facilitating stormwater quality improvements over the term of the permit (until the year 2000) will include the elements in Table 19:

Table 19 - Summary of WSDOT Unmet Needs and Priorities for Implementation of the Stromwater Management Program

WSDOT Stormwater Management Plan **Unmet Needs and Priorities**	'95-'96	'96-'97	'97-'98	'98-'99	'99-'00
High Priority Unmet Needs					
Construction of Structural Stormwater BMPs through Highway Transportation Projects					
Construction of Stormwater BMP Retrofits At Pre-Existing Stormwater Outfalls					
Stormwater BMP Monitoring and Research Programs					
Erosion and Sediment Control Programs					
Full Funding of Operations and Maintenance (O&M) Programs					
Watershed-Based Mitigation Strategies					
Water Quality-Related Training Programs					
Medium Priority Unmet Needs					
Public Education Programs					
Determining Life-Cycle Maintenance Costs For Stormwater BMPs					
Continuous Tracking System For Stormwater BMPs					
Low Priority Unmet Needs					
Illicit Connection Identification Programs					
Monitoring Highway O&M Practices for Water Quality Impacts					
Tracking O&M Performance Relative To Highway Runoff Manual and Maintenance Manual Specs					
Budgetary Mechanisms To Fund O&M Activities Associated Solely With Water Quality					

Certain or High Probability of Funding for the Program Element	
Uncertain or Low Probability of Funding for the Program Element	
None or Negligible Probability of Funding for the Program Element	

3.3 Stormwater Control Practices and Programs

40 CFR 122.26(d)iv.A

3.3.1 WSDOT's Highway Runoff Manual (HRM)

WAC 173-270

WSDOT's HRM contains comprehensive listing, design standards, maintenance requirements, and other related information on stormwater BMPs to guide highway improvements. Development of the HRM was required under the Puget Sound Highway Runoff Program (173-270 WAC) and is consistent with Ecology's Stormwater Management Manual. The HRM was approved by Ecology and published in February 1993.

The HRM is the primary planning tool for WSDOT's highway runoff facility design and management. Its intended audience are engineers and designers which facilitate roadway construction projects. The HRM is divided into eight different chapters.

Chapter 1 is used as an overview to the stormwater problems associated with highways, both in terms of quantity and quality. It is intended to inform the designer which areas will require stormwater treatment and why stormwater treatment is required.

Chapter 2 lists the minimum requirements for stormwater treatment for highway systems. There are nine minimum requirements listed that must be checked for each highway construction project. These requirements are:

1 - Erosion and Sediment Control

2 - Preservation of the Natural Drainage System

3 - Source Control of Pollutants

4 - Water Quality Treatment (Permanent Water Quality BMPs)

5 - Water Quality Treatment (Permanent Water Quantity BMPs)

6 - Wetlands

7 - Downstream Analysis

8 - Sensitive Areas and Basin Plans

9 - Stormwater Site Plans and/or Temporary Erosion and sediment Control Plans

Chapter 3 is a description of the methodology, i.e. hydraulic design parameters that must be used to design the BMPs for the project.

Chapter 4 guides the project designer(s) through the BMP selection process.

Chapter 5 describes what should be included in a Stormwater Site Plan (SSP). The SSP fulfills the requirement of the NPDES Stormwater Construction Program.

Chapter 6 deals with vegetation management. It is in the development stage and is scheduled for completion in fall 1996.

Chapter 7 contains information for design and maintenance personnel on the impact and mitigation of various roadway maintenance practices, including waste disposal, use of traction material and deicers, and the maintenance of certain BMPs.

Chapter 8 is a complete listing of all WSDOT preferred BMPs. This chapter includes precise technical information of BMP design. WSDOT will utilize its research and monitoring programs to update and add to the listings of BMPs as appropriate.

A copy of the draft HRM can be accessed and downloaded through the world wide web at http://wsdot.wa.gov/eesc/environmental/WQManuals.htm or through WSDOT's Technical Publications Department who can be contacted at 360/705-7430.

3.3.2 Construction Site Erosion and Sediment Controls

40 CFR 122.26(d)2.iv.D
Expectations Document S7.B.8.a

3.3.2.1 Temporary Erosion and Sediment Control Plans

Using the WSDOT Highway Runoff Manual (HRM) as the guidance document, a Temporary Erosion and Sediment Control Plan (TESC) is prepared for all WSDOT construction projects that involve any amount of earthwork. Earthwork includes excavation, clearing, grubbing, trenching, or any activity that exposes bare soil to precipitation and/or wind.

When there is to be less than 5,000 square feet of additional impervious surface added, the TESC is prepared as a stand alone document by regional design, environmental, or, hydraulics staff. When 5,000 square feet or more of impervious surface are added, the TESC is incorporated into the Stormwater Site Plan (SSP).

3.3.2.2 NPDES Baseline General Permits for Construction Activities

The TESC plans are prepared in accordance with the Minimum Requirements of the Stormwater Management Manual for the Puget Sound Basin and the requirements of the NPDES Baseline General Permit which are written into the HRM. Construction projects that disturb five or more acres of land require the filing of the NPDES Notice of Intent for coverage under the NPDES Baseline General Permit for Construction Activities. Whenever a TESC plan is prepared, the Contractor is required to develop a TESC plan addendum as discussed below. The WSDOT-prepared SSP/TESC plans fulfill all requirements of the NPDES permit for construction site erosion and sediment control.

For the control of pollutants other than sediment, the contractor is required to develop the "Contractor's Addendum" to the TESC Plan. A General Special Provision (GSP) will be included in the contract to require the development of the addendum. Control of pollutants other than sediment includes, but is not limited to: management of oil, gasoline, and solvents used in the operation and maintenance of vehicles and machinery; spill control and containment measures; identification of proper wood waste fill and stockpile locations; and waste disposal methods and locations.

Since the nature of the contractor’s operations will not be known before the contract is awarded, it is the intent of this procedure to require the contractor to develop and implement an addendum to reflect his or her operations and supplement the TESC Plan, in order to provide comprehensive pollution prevention, containment, and control at the construction site.

3.3.2.3 Other Erosion Control Permits

In addition to the NPDES permit requirements, WSDOT construction projects come under the jurisdiction of numerous state and local government regulations. Some of these are:

- Local grading permits
- Right-of-Way Management Sensitive Area Ordinance
- Shoreline Management Substantial Development Permit
- Ecology Water Quality Certification
- Ecology Temporary Modification of Water Quality Standards
- Dept. of Fish and Wildlife Hydraulic Project Approval Permit

3.3.2.4 Implementation of the TESC Program Through Contractual Agreements

After the plans have been prepared, reviewed, and approved, the Project Engineer and Construction Inspectors make sure that the Temporary Erosion and Sediment Control plan is implemented and that BMPs are installed, maintained, and operating effectively. They do this by administering the contract provisions, monitoring contractor performance, maintaining records of performance, and generally ensuring that the contractor is held responsible. Any deficiencies in BMP installation or maintenance are recorded by the inspector and notice given to the contractor. If corrections are not completed in a reasonable time period, the inspector can order construction stopped until the deficiencies are corrected. In addition to WSDOT inspectors, field inspectors from local jurisdictions and resource agencies who have environmental enforcement authority can arrange tours of a construction site to determine compliance with local, state, and federal laws. This process is described in detail in the WSDOT Instructional Letter - Temporary Erosion and Sediment Control Plans and NPDES compliance dated 18 October 1993.

The instructional letter was created to outline new permit requirements, contents of the TESC plans, and the processes for development and implementation of the plans and permit compliance. The new requirements supersede information contained in the 1991 Standard Specifications for Road, Bridge, and Municipal Construction; the WSDOT Design Manual; and the WSDOT Construction Manual. These three manuals serve to communicate standard procedures for a WSDOT construction project and provide detailed guidance on preparing plans, construction management, materials specification, and contract compliance.

Even under the best conditions changes to the TESC will be necessary to reflect site conditions. Typically, changes to the plan are made by the contractor through the "Change Order" process, under the direction of the Project Engineer. If a major field-change is required because a particular BMP is neither "physically or economically" practical, the local permitting agency (if a grading permit was issued) may need to review and approve plans before work can begin and the Project Engineer may need to write an *Explanation of Non-practicability*. If no grading permit was issued, a *Record of Decision* with justification is needed.

The contractor is responsible for the installation and maintenance of temporary erosion and sediment control BMPs for as long as they are needed, as directed by the Project Engineer. The contractor is also responsible for the removal of BMPs after they are no longer needed. Refer to the 1994 Standard Specifications for Road, Bridge, and Municipal Construction, δ1-07.15, pp. 1-60.

3.3.2.5 Construction Site Erosion and Sediment Control Training

Education will be the foundation of the WSDOT temporary erosion and sediment control program. Training programs have been developed for WSDOT Design, Construction, and Engineering staff as well as for the contracting community. These programs will be specific to highway construction under all state-wide conditions and will give attendees some of the tools necessary to implement an effective program. The goal is to prevent discharge of contaminated stormwater from construction sites. Feedback received from participants in the previous training workshops will be evaluated and used to guide development of future training efforts. The Olympic Service Center (OSC) Hydraulic and Water Quality Unit will jointly coordinate the program.

Past Training

During fiscal year 1994, WSDOT contracted with the University of Washington to present the training course, "Construction Site Erosion and Sediment Control" to WSDOT's design and construction staff. Workshops were held and attended by approximately 150 WSDOT staff. Participants received a copy of the *Construction Site Erosion and Sediment Control Inspector Training Manual.*

In preparation for the Contractor Certification Program, training in Construction Site Erosion and Sediment Control began in the Fall of 1995 and ran through Spring 1996. The International Erosion Control Association was contracted to teach this initial round of courses. The courses

were taught as two one day classes, one for designers titled Plan Design and the other for contractors titled Plan Implementation. The Design course was primarily for WSDOT personnel while the other course was designed for contractors. Over 150 WSDOT personnel attended these courses and over 160 contractors, regulators and erosion control contractors attended the implementation course. Participants of the first round of training will receive a certification card enabling them to be designated as Erosion Control Officers by the prime contractor.

Future Temporary Erosion and Sediment Control Training

Courses continue to be offered every year during the construction off-season, which runs from approximately October through March. Subsequent training will be taught by WSDOT personnel and will focus on highway-related construction. The courses will held over a two day period and will cover the difference between erosion control and sediment control, erosion prevention, proper BMP installation, maintenance, and inspection. A half day of field work with hands-on training in BMP installation will provide the opportunity to become familiar with different erosion and sediment control techniques. Also, information concerning the latest erosion and sediment control technology will be shared. It is proposed that a written test must be passed to attain certification, but this is still under review. Certification will last three years or until revisions are made to the Highway Runoff Manual.

3.3.2.6 Evaluation of TESC Program and Personnel

WSDOT will determine the total number of personnel involved in implementing

the Erosion Control Program and assess the level of training they had previously received. It will be determined if the training program is meeting the identified needs by comparing participant lists with the needs list. Furthermore, course evaluation forms will be reviewed to determine if teaching styles and course materials were suitable for the participants.

3.3.2.7 TESC Monitoring, Research and New Product Evaluation

WSDOT will continue to participate in research efforts to identify cost effective temporary erosion control methods and to evaluate new erosion prevention and sediment control products. Some examples include:

- Current research is underway through the Hydraulics office at OSC to determine optimum filter fence lengths and configurations using slope and soil characteristics as independent variables.
- An internal Materials Review Committee, in cooperation with WSDOT's Materials Lab and the Hydraulics office, will evaluate new commercial erosion control products submitted by contractors. Priority items to be reviewed include filter fence designs and erosion control matting.
- A site on the world wide web will be developed that is intended to distribute new TESC information in a timely manner. Given the remote office locations for WSDOT personnel through its 7400 miles highway system, improved communication can be facilitated through the internet or WSDOT's internal equivalent, the "intranet".
- WSDOT will document case histories of TESC product effectiveness in actual field construction situations. New HRM recommendations and design specifications will be developed based on this experience.
- Construction site erosion and sediment control training facilities will be developed in eastern and western Washington to provide the opportunity for hands-on experience installing various BMPs. Since these facilities will be dedicated to erosion and sediment control training , BMPs installed by course attendees will be evaluated under field conditions for effectiveness in preventing erosion and sedimentation.

3.3.2.8 On Site Technical Assistance and Project Monitoring

WSDOT hired a temporary full-time Erosion Control Specialist in December 1995. This position was upgraded to permanent full-time employee (FTE) status in July 1996. The Erosion Control Specialist will provide on-site technical assistance to Project Inspectors and make field visits to highway construction sites to evaluate planning and implementation of TESC plans. This will provide WSDOT with opportunity to share successful experiences and develop consistency in program implementation. A log book which documents field observations, experiences and questions will be maintained by the Water Quality Unit. Trends, successes, and failures will become evident and will help in determining deficiencies in WSDOT's Erosion Control Program. In addition, statistics on enforcement actions taken against WSDOT will be maintained and used to eliminate future problems.

3.3.2.9 Contractor Certification for Erosion Control

After January 1997, a program will require all prime Contractors to provide proof of attendance at a WSDOT-approved course in Construction Site Erosion and Sediment Control Certification before any earthwork can begin on projects that require the following permits: NPDES Construction Permit; HPA with 0.5 or more acres of earthwork; Section 404 permit with 0.5 or more acres of earthwork; or a Short Term Water Quality Modification with 0.5 or more acres of earthwork.

This WSDOT-approved course prepares attendees to be the Erosion and Spill Control Lead person (ESC Lead) which the prime Contractor will be required to designate and make known to the Project Engineer during the pre-construction meeting. This person will have the training and authority to administer an active and effective construction site erosion and sediment control program. Contract specifications will direct the Project Engineer as to when the ESC Lead is to be available during construction operations that could have a direct impact on water quality and during installation, maintenance, inspection, and removal of BMPs. The WSDOT Project Engineer and Chief Project Inspector will coordinate with the firm's ESC Lead to ensure that appropriate site personnel receive adequate training in BMP installation and maintenance.

3.3.2.10 Regional Erosion Control Liaisons

The Statewide Erosion Control Coordinator communicates with each WSDOT regional office through their Regional Erosion Control Liaison. The responsibility of each Liaison is to make sure that their Design, Construction, Hydraulics, Landscape, and Environmental office staff receive information concerning construction site erosion and sediment control technology and policy. In turn, the Liaisons receive information from their regional staff concerning effectiveness of BMPs and implementation or maintenance concerns, forwarding it to the Statewide Erosion Control Coordinator so that necessary changes in the program or policy can be made.

3.3.3 New Development / Redevelopment Source Controls

CFR 122.26 (d)2.iv.A.2

3.3.3.1 New Development Projects

WSDOT plans to build very few new roads, i.e. new development projects, in Washington over the next 20 years. The majority of the state roads in Washington State were originally constructed in the 1950's, 60's and 70's, during the era when the National Highway System (NHS) was being established. The costs of building new roadways now is extremely expensive, except in the few situations where an outstanding need is identified. WSDOT's plans for the next 20 years to rely on expanding and improving existing state highways while promoting alternative modes of transportation and overall efficiency (HOV, van pools, etc.) improvements.

In April 1996 WSDOT published its State Highway System Plan, 1997-2016, which describes all transportation improvement projects which fit under its fiscally constrained budget structure (reference δ3.2.5 of this document). Of the 236 Mobility projects (subprogram I1) listed in the 1997-2016 plan, only 7 statewide (4 in the permit areas) utilize a new roadway footprint and are thereby classified as new development.

These new development projects are described in Table 20:

Table 20 - WSDOT New Development Projects Scheduled for the Puget Sound NPDES Permit Areas - 1997-2016

SR	Begin MP	End MP	Project Description / Location	No. of lanes	Stormwater Treatment[1]
2	8.80	16.00	Monroe By-pass / Snohomish Co.	4	100%
167	0.00	6.31	New 167 corridor I-5 @ Fife to Puyallup w/ HOV lanes and/or commuter rail. / Pierce Co.	6	100%
202	2.67	6.65	Parallel arterial / City of Redmond / King Co.	4	100%
509	19.61	23.13	SR 509 extension w/ HOV to I-5 / Pierce Co.	4	100%

1 - Percentage of impervious surface that will be provided stormwater quality and quantity treatment using HRM structural water quality BMPs built during project construction.

3.3.3.2 Redevelopment Projects

The remaining projects that are listed in the 20 year mobility plan are High Occupancy Vehicle (HOV) lane additions, road widening, truck climbing lanes, and intersection expansions. These improvements are extensions of existing roadway footprints and are thereby classified as redevelopment projects. For these redevelopment projects, all new impervious surface additions in Western Washington will be provided stormwater quality treatment by constructing structural BMPs as part of the project. Whenever it is practicable, existing impervious surface will be provided treatment by expanding existing or planned BMP capacity. This is usually dependent on the availability of land, as right-of-way purchases tend to be prohibitively expensive, particularly in the Puget Sound region.

3.3.3.3 Stormwater Controls for New Development/Redevelopment Projects

WSDOT has, since the institution of the Highway Runoff Manual, been committed to providing both water quantity and water quality treatment for 100% of all new impervious surfaces that are constructed as part of its highway projects. WSDOT will also attempt to incorporate stormwater treatment for existing impervious surfaces as is practicable. The amount of pre-existing impervious surface that can be incorporated into stormwater BMPs will vary depending on site-specific conditions, including:

- The amount of WSDOT right-of-way available to construct BMPs. Purchasing new right-of-way is always extremely expensive, and in many circumstances impossible because existing land uses, urbanization, shorelines, wetlands/buffers, etc.
- Configuration of the existing hydraulic conduits. In some cases, particularly when the stormwater drainage system has been extensively culverted, it may be extremely expensive and/or logistically and physically difficult to excavate and install new drainage system(s) to re-route the stormwater to a new or expanded BMP.
- Topography. In many situations the topography and road grade may preclude draining stormwater runoff to new BMP, since WSDOT uses gravity as the driving force for all of its drainage systems and BMPs.
- Cost. When the cost of treating existing impervious surfaces significantly raises the project budget, it is very likely that it will be categorized as not practicable.

WSDOT is actively investigating stormwater treatment systems that can be operated and maintained in confined or highly urbanized areas. If such systems can be developed, it would allow WSDOT to provide quality treatment to new and existing impervious surfaces without having to purchase additional right-of-way to construct BMPs.

WSDOT has completed investigations of catch basin inserts at 24 locations in the town of Chinook, located in Pacific County along the lower Columbia estuary. WSDOT found that the inserts reached their solids removal capacity very quickly, were maintenance intensive, and mechanically failed on a few occasions. For these reasons WSDOT has decided not to use catch basin inserts to treat permanent drainage systems, although they still may be used for temporary sediment control and spill control / containment at construction sites.

3.3.4 Roadside Integrated Vegetation Management (IVM) Program

40 CFR 122.26(d)2.iv.6

Expectations Document S7.B.8.f.

Commensurate with WAC 173-270, WSDOT has started an *Integrated Vegetation Management* (IVM) program for roadside maintenance activities. The principals of IVM are much like stormwater management, integrated within the daily maintenance and activities. Due to elimination of previous funding sources, IVM, like stormwater, is not a stand-alone service objective. Within WSDOT's budgeting system, programs which focus on a single service object has little possibility of funding.

Roadside maintenance includes management of vegetation using mechanical and chemical control methods. Roadsides are maintained as nearly as possible in their natural condition or subsequently developed, and in a manner that makes a satisfactory contribution to the safety, reliability, and pleasure of the public and protection of the roadway itself. Pesticides, herbicides and fertilizer (chemical controls) are utilized as a part of the highway roadside management program.

WSDOT uses chemical controls in the optimum weather conditions, using trained licensed operators and with strict adherence to the manufacturer's label directions. These provisions correspond to the maximum extent practicable the prevention of pollutant discharges to stormwater. WSDOT is committed to develop a statewide program of integrated vegetation management to reduce WSDOT's utilization on chemical controls through locally based, long-term planning and good management.

3.3.4.1 IVM Principles

The IVM decision-making process promotes localized, site specific decision making within the current department-wide management strategies. This IVM program is systematic process based on the Quality principal of continuous improvement and contains the following components:

- Monitor for quality (identify and document improvement opportunities).
- Determine action thresholds - priorities and performance measures to determine when action is necessary.
- Select and execute appropriate strategy (take action).
- Evaluate results (document for future assessment & improvement).

WSDOT has developed action strategies for each of the IVM components. They include:

Quality Monitoring:

1. Develop area wide maintenance inventories
2. Begin documenting identified problems in each maintenance area.
3. Develop site specific management plans as needed to address significant problems.

Determine Action Thresholds:

1. Establish maintenance priorities & performance measures
2. Communicate with local weed boards to determine weed control priorities.
3. Identify level of service possible within funding and resource constraints

Select And Execute Appropriate Strategies:

1. Utilize the appropriate methods to achieve long term effectiveness
2. Establish sustainable desirable vegetation to minimize weed invasions.

Evaluate Results:

1. Document results to develop a history of efforts and achievements.
2. Evaluate effectiveness of strategy.
3. Adjust management plans as necessary to reflect finding.

3.3.4.2 Employee Training

WSDOT offers annual training opportunities for vegetation management employees on changing regulations, products, and new developments in vegetation management. Training includes all aspects of vegetation management to develop employee awareness of project development and design concepts. Training and other technology transfer is accomplished by several means: 1. Field Review with local personnel and Region representatives in order to address specific problems and recommend methods and materials to solve these problems. 2. Training seminars and programs on methods and materials for vegetation management. The seminars involve agency and non-agency personnel at both field and management levels. These training seminars include an annual herbicide training program. Maintenance Newsletter which presents information on roadside management to WSDOT employees in a "news" format. WSDOT staff presentations discussing methods of accomplishing and planning roadside management programs. WSDOT has issued the following directives regarding roadside activities: Adopt-Highway Litter Control Program (D 51-0) and Maintenance Manual (M 51-01)

3.3.4.3 Pesticide Applicators Certification and Recertification

All WSDOT employees engaged in pesticide application obtain a pesticide applicators license from the Washington State Department of Agriculture (DOA) prior to handling pesticides or giving recommendation on the use of pesticides. DOA's licensing program requires employees to attend 16 hours of training and completion of an examination in a DOA approved training course. Recertification is accomplished through 40 hours of accredited training courses completed in a five-year period.

WSDOT's annual herbicide training program includes such topics as principles, methods, techniques, safety, record keeping, and public relations. It emphasizes Integrated Vegetation Management (IVM) and stresses the use of pesticides as only a portion of an overall program. A portion of this 16-hour course is approved by DOA and counts toward the pesticides applicators , recertification. Employees making recommendations and/or applying pesticides do not exceed/ label restrictions. The label recommendations on each pesticide restrict the authorized use of the product. Pesticide uses that are inconsistent with label instructions are prohibited by state and federal regulations. All used pesticide containers are triple rinsed and disposed or reused in the proper manner, as listed on the pesticide container.

3.3.4.5 Record Keeping

State law (RCW 17.21) requires that records be kept for a seven year period following all pesticide applications. These records are intended as resources to be used during any pesticide investigation. WSDOT has a developed system of pesticide accountability for all pesticides stored, issued and used by WSDOT. There are two different computer form and record

keeping systems, the *Stores Issue Form* and the *Pesticide Application Record*. The Stores Issue form records the WSDOT region material inventory, amount of material ordered, and designates to whom the material was issued. The Stores Issue record provides information for compliance with standards in handling pesticides and accomplishes the task of accountability of material issue and use.

The Pesticide Application record provides a detail record including: state road, county , date, location of application, "pest" to be controlled, method of control, weather condition (start and finish), material name, type, EPA registration number, lot number, product applied per acre, total daily usage, application information (including equipment number, calibration date, vehicle speed, nozzle pressure, width of spray pattern, method of application), operator name and license number, and pesticide sensitivity registration area. These very comprehensive listings are available upon request.

3.3.5 Identification of Illicit Discharges and Off-Site Disposal of Stormwater Discharges Into WSDOT's MS4 Drainage System

40 CFR 122.26(d) 2.iv.B.1

Expectations Document S7.B.8.g

Maintenance personnel are the primary WSDOT employees that evaluate the functioning and maintenance of WSDOT's MS4 drainage systems, and are the most likely persons to identify unusual flows and contaminated discharges.

Through the process of inventorying stormwater outfalls through its Outfall Inventory / Field Screening (OI/FS) process, WSDOT expended a significant amount of person-hours and expense to identify illicit connections throughout WSDOT's MS4 systems in Puget Sound, Clark County, and Spokane County. Fifteen illicit connections were identified through the OI/FS effort, six of these were confirmed to be illicit. Because the total number of illicit connections found were so small and discharges were insignificant (both in terms of quality and quantity), a large scale, ongoing, capital intensive program to identify illicit connections was judged to not be warranted. The components of WSDOT's program which address illicit discharges on an ongoing basis will focus on risk avoidance through use of Stormwater Utility Permits. The indemnity clause in the permit places the responsibility of complying with water quality laws on the permittee. The permittee will be held liable for any pollution discharged into the highway drainage system. WSDOT will coordinate and develop illicit connection identification program in cooperation with the other MS4 permittees. Highway roadsides are maintained as nearly as possible in predevelopment condition and in a manner that balances public safety, convenience, and pleasure with the preservation and protection of the roadway. All highway maintenance activities are subject to the availability of funds allocated through the Washington State legislature.

3.3.6 Existing Maintenance Programs and Stormwater Control Systems

Highway roadsides are maintained as nearly as possible in predevelopment condition and in a manner that balances public safety, convenience, and pleasure with the preservation and protection of the roadway. All highway maintenance activities are subject to the availability of funds allocated through the Washington State legislature.

The development of highway maintenance goals, requirements, and schedules is documented in WSDOT publication M 51-01: Maintenance Manual 1986. The Maintenance Manual was developed as a guide for maintenance activities but does not establish absolute standards. Guidelines detailed in the Maintenance Manual supplement the judgment of the trained maintenance personnel to facilitate uniform operating procedures and performance guidelines.

WSDOT Maintenance staff supplementally utilizes WSDOT's Highway Runoff Manual: publication M 31-16, 1995. Approved by Ecology for statewide implementation, the Highway Runoff Manual provides minimum requirements and technical uniform guidance for the mitigation of water resource impacts from state highway and transportation systems.

Maintenance of the highway system includes periodic inspections to determine faults, repair and maintenance of systems and structures, litter collection, snow and ice control, maintenance section facilities and vegetation management.

3.3.6.1 Noxious Weed Control

Washington State Department of Transportation is required to control, contain, eradicate, and prevent the spread of noxious weeds from it's rights of way in accordance with the intent of RCW 17.10 and WAC 16-750 through an appropriate level of effort that available resources allow. WSDOT maintenance staff uses Integrated Vegetation Management (IVM) to manage noxious weeds. WSDOT has 4 basic methods to facilitate noxious weed control, and uses 2 of those methods at each control site. The most effective application methods for the particular infestation and climate will be used.

The four basic methods for noxious weed control:

1) Biological Controls - the use of living organisms that destroy the host plant.
2) Cultural Controls - enhancing the vigor of desirable plants so they can eventually crowd out or prevent the establishment of undesirable plants.
3) Mechanical Controls - cutting or cultivating in such a manner as to reduce or prevent undesirable plant growth. Mowing is a frequently used mechanical method.
4) Chemical Controls - WSDOT's policy is that the use of chemical controls in the optimum weather conditions, utilizing trained licensed operators and with strict adherence to the manufactures' label directions constitutes to the maximum extent practicable the prevention of pollutant discharges to stormwater. However, WSDOT is committed to develop a statewide program of integrated vegetation management to reduce WSDOT's utilization on chemical controls through locally based, long-term planning and good management.

3.3.6.2 Nuisance Weed Control

Nuisance weeds are weeds that are not legally required to be controlled under the noxious weed laws. WSDOT maintenance staff uses IVM to manage noxious weeds through the development of locally based, long-term planning. WSDOT uses many methods to control noxious weeds, using two or more of the four basic methods. The most effective application method for the infestation will be used.

The four basic methods for nuisance weed control:

1) Biological Control Methods - the use of living organisms that destroy the host plant.
2) Cultural Control Methods - enhancing the vigor of desirable plants so they can eventually crowd out or prevent the establishment of undesirable plants.
3) Mechanical Control Techniques - cutting or cultivating in such a manner as to reduce or prevent undesirable plant growth. Mowing is a frequently use mechanical method.
4) Chemical Control - WSDOT's policy is that the use of chemical controls in the optimum weather conditions, utilizing trained licensed operators and with strict adherence to the manufactures' label directions constitutes to the maximum extent practicable the prevention of pollutant discharges to stormwater. However, WSDOT is committed to develop a statewide program of integrated vegetation management to reduce WSDOT's utilization on chemical controls through locally based, long-term planning and good management.

3.3.6.3 Snow and Ice Removal

It is the intent and practice of WSDOT to remove snow as it begins to accumulate on the primary and secondary highways. The roadway is plowed and sanded if necessary. Water quality considerations related to snow and ice control are the potential contribution of road abrasives to surface waters and deicing chemicals effects on water quality.

Maintenance activities emphasize removal of melting snow and ice and removal of slush before temperatures decline below freezing. When accumulated snow becomes compact and removal is not possible with available-equipment, the accumulation is treated as an ice control operation.

Implementation Reference(s): Ch. 8 Maintenance Manual pp. 7-8 - 7-10

3.3.6.4 Road Abrasives

Ice control operations consist of the application of abrasives and/or deicing chemicals on both compact snow and ice. Road abrasives must be heavy enough to stay in place, small enough not to damage windshields or paint, and clean enough to avoid polluting water bodies. Application equipment is calibrated to spread materials at a reasonable speed and specific applications are dictated by actual field conditions. Each WSDOT area maintenance facility maintains storage piles of road abrasives for use during the winter season. Emphasis is placed on proper location of the stockpiles to ensure elimination of runoff that could potentially impact near-by surface waters.

1. General Criteria For Roadway Abrasives

Roadway Abrasive Specification 3/8 - #10	
1/2 Square	100%
3/8 Square	90-100%
1/4 Square	50-75%
U.S. #10	0-10%
U.S. #200	0-1.0%

2. At least 75 percent of the material shall have one fractured face. The finished product shall be clean, uniform in quality, and free from wood, bark, roots and other deleterious material.

3. Each stockpile site should be located on a smooth, level surface with a maximum exposure to the sunlight. If stormwater runoff is a problem, the stockpile site may need to be covered or a berm built around the perimeter to collect the drainage.

4. If evidence supports the need to minimize the discharge of suspended solids into an adjacent water body, the following techniques will reduce the fraction of applied sand entering the drainage system:

i. In the spring, pickup sweepers are used to collect accumulations of sand along the roadway.

ii. Sand and silt are vacuumed or pumped from receiving catch basins the following spring.

iii. Do not use high volume after flushing to clean away sand near an adjacent water body that is shown to be sensitive to temporary loading of suspended solids.

3.3.6.5 Chemical Deicing

Improvements related to environmental consequences through snow and ice control activities are measured qualitatively in the field by maintenance personnel and through the development of new and improved deicing chemicals.

WSDOT uses deicers that:

- Prevent snow and ice from bonding to the pavement,
- Dissolve slowly for long lasting effectiveness,
- Contain no phosphorous compounds,

- Melts snow and ice at low temperatures,
- Allow the pavement to dry rapidly and uniformly at normal temperature ranges,
- Are non caking or easily treatable to be non caking for easy storage/ handling and uniform application onto the pavement,
- Are non-hazardous to handle,
- Are non-polluting during storage and application,
- Resist blowing from the pavement by winds,
- Are economical when total costs are considered.

General Criteria for Deicing:
1. The Region Administrator approves the use of chlorides only in those areas where the detrimental effects do not outweigh the benefits of such applications.

2. Primary use is limited to keeping the stockpile of sand workable in freezing weather and to help set the sand into the ice surface. Deicing compound selection is determined on a region level. Emphasis is placed on using non-corrosive deicers. However, due to the expense of the non-corrosive deicers, an 80/20 mixture of deicer is frequently used.

3. Liquid deicers (calcium magnesium acetate) are used as pre-treatment in some areas and on bridges where conventional deicers provide a negative effect (e.g. abating bridge corrosion problems). Liquid deicers applied prior to snowfall prevents ice from bonding to the pavement or forming on the pavement as in the case of black ice.

4. If the deicers are not shipped in water tight containers, they are stored undercover and on pallets until they are mixed with the abrasive. Mixing ratios can be from 30:1 up to 1:1. In most parts of the State, a ratio of 20:1 and lighter can be stored in the same fashion as the abrasive, and is considered the proper ratio for keeping the stockpile workable. Heavier ratios are sometimes kept in smaller amounts for problem areas like stop sign locations, hills or bad curves. These stockpiles will be covered or protected with berms if there are signs of leaching.
Implementation Reference: Ch. 8 HRM pp. 7-8 - 7-10

3.3.6.6 Storm Drainage Systems

Storm Sewers:
Inlets, catch basins, and manholes are to be periodically inspected and cleaned out using a vacuum truck or manual cleaning methods.

Implementation Reference(s): Ch. 5 , pp. 5-5, 5-6; MM
Ch. 7; HRM

Catch Basins and Sediments:
Catch basins are inspected annually or as needed and cleaned to ensure adequate function as needed. Emphasis is placed on cleaning catch basins in Priority One Interstate roadways after the first storm with a rainfall greater than one inch at the beginning of autumn.

1. Emphasis shall be placed on cleaning catch basins in urban traffic areas after the first storm at the beginning of autumn with a rainfall volume greater than 1 inch.
2. Inlets, catch basins, and manholes are to be periodically inspected and cleaned out using a vacuum truck. WSDOT Maintenance staff should conduct inspections during large storms events to ensure the inlet grates are not becoming clogged with water borne debris.
3. If upon inspection the wastes in the catch basins appear excessively oily, of foul odor, or show a fluorescent anti-freeze coloration, illicit dumping may be the cause. The catch basin should not be pumped. Contact either regional environmental or service center environmental maintenance staff to initiate to characterize the contamination.
4. The removal of catch basin sediments shall be done with a vacuum truck. No manual cleaning shall occur.

Monitoring For Catch Basins and Oil/Water Separators:

a. Reporting needed repairs or unusual visual observations (i.e., antifreeze, excessive oil, odor, illicit dumping) and

b. Tracking corrective actions for problems identified in these reports.

Maintenance Criteria For Catch Basins:

1. Vacuum trucks typically decant water two to three times a day depending upon the weather, truck capacity, and the system being cleaned. Vacuum trucks must decant water from the storage tank to allow more room for sediment storage. Frequent decanting prevents excessive weight and load shifting problems. The vehicle operator determines when decanting is necessary.

2. The practical method of handling the water associated with catch basin sludge has been to decant the water directly back into the cleaned storm drain system 5 catch basins up line.

3. Region maintenance staff shall utilize available options for disposal of decant liquid to municipal decant stations and/or sanitary sewer access where available and WSDOT is approved to use.

Catch Basin Solids:

Catch basin solids are the solid material generated from the vacuum truck after discharge of the liquid fraction. Until practical options exist for catch basin solids disposal, a two step process (interim and final) will be used. For interim disposal catch basin solids or sludge will be stored at WSDOT Region "pit site" properties. Placement of catch basin solids shall not occur within 100 feet of property boundaries, surface or drinking water sources, or in areas of geologic sensitivity.

WSDOT is committed to the development of multi-jurisdictional street waste treatment and disposal statewide. In recent budgets, WSDOT received approximately $375,000 per biennium from the Legislature to develop street waste treatment and disposal facilities. WSDOT has communicated extensively with Snohomish Public Works, King County Public Works, City of Tukwila, public and private entities in Pierce County Aberdeen and Clark County for this purpose.

As of Fall 1996 there are no permanent catch basin solids disposal facilities available for use by WSDOT.

Sedimentation Ponds (including vaults and tanks):

Debris and sediment should be removed by vaccuming when the accumulated depth is greater than 10% of the diameter of the tank/vault. A 72-inch diameter storage tank/vault would require cleaning when the depth of the sediments reaches 7 inches.

Maintenance Criteria for Sedimentation Ponds:

1. Emphasis shall be placed on cleaning vaults in urban traffic areas after the first storm at the beginning of autumn with a rainfall volume greater than 1 inch.

2. Vaults are to be periodically inspected and cleaned out using a vacuum truck.

3. If upon inspection the wastes in the vault appear excessively oily, of foul odor, or show a fluorescent anti-freeze coloration, illicit dumping may be the cause. The vault should not be pumped. Contact either region environmental or service center environmental maintenance staff to initiate to characterize the contamination.

Oil/Water Separators:

Generally, the same conditions that determine the schedule of inspection and cleaning required for standard catch basins and manholes also applies to units with oil/ water separators.

Maintenance Criteria For Oil/Water Separators:

1. Oil/Water Separators should be inspected annually and maintained for proper function as needed.
2. Cleaning should focus on preventing accumulated oil from escaping during storms. Emphasis shall be placed on inspection of and cleaning as needed by October 15 to remove material that has accumulated during the dry season.
3. All removal of oil/water separator sludge shall be done with a vacuum truck. No manual cleaning occur. Care should be taken to prevent mixing catch basin wastes (potentially the more contaminated) and the liquid from the oil/water separators.
4. All solid material produced from oil/water separator shall be have interim storage for characterization, and disposal options similar to the methods prescribed for catch basin solids.
5. Where available and permissible, the liquid waste shall be disposed of at decant stations or municipal sanitary sewer systems.

Implementation Reference(s):Ch. 5; p. 5-7; MM

Ch. 7, pp. 7-8; HRM

3.3.6.7 Grading and Cleaning Drainage System Ditches

Drainage facilities are maintained to preserve the condition and capacity for which they were originally designed and constructed. Maintenance practices for erosion and sediment control best management practices (BMPs), water quality and quantity BMPs, and construction site pollution control BMPs, are found in Chapter 8 of the Highway Runoff Manual.

Maintenance Criteria for Grading and Cleaning of Drainage System Ditches:

1. Maintenance of ditches uses the hydraulic performance of the drainage facility as an surrogate indicator for its water quality functions.
2. Ditches should be inspected twice each year to identify sediment accumulations, localized erosion and other problems. Ditches should be cleaned on an annual basis or frequently if needed.
3. Ditches and gutters must be kept free of rubbish and debris. Cracks and breaks must be repaired as required.
4. Water should not pond in ditches and a ditch should never be deeper than the culvert flow lines, unless the ditch is designed for storage.
5. Vegetation in ditches often prevents erosion and cleanses runoff waters. Remove vegetation only when flow is blocked or excess sediments have accumulated. Emphasis shall be placed performing ditch maintenance in late spring to enable the vegetation the opportunity to re-establish by the next wet season thereby minimizing erosion of the ditch as well making the ditch effective as a biofilter.
6. Open ditches must be routinely checked and maintained to the line, grade, depth, and cross section to which they were constructed. Where practical, ditches should be modified to produce a relatively flat shallow ditch to enhance motorist safety.
7. Diversion ditches on top of cut slopes that are constructed to prevent slope erosion by intercepting surface drainage must be maintained to retain their diversion shape and capability.
8. Surplus material derived from regular maintenance of ditch cleaning can often be used for shoulder widening, as long as the material placed into adjacent portions of the highway or disposal areas and does not obstruct impair other roadside drainage areas. Care must be taken to avoid causing erosion problems or loose unstable fills.
9. Ditch cleanings are not to be bladed across the roadway surfaces. Dirt and debris remaining on the pavement after the ditch cleaning operations shall be swept from the pavement.

10. Culverts shall be inspected on a regular basis for scour around the inlet and outlet, and repaired as necessary. Priority shall be given to those culverts near streams in areas of high sediment load, such as near construction activities.

Implementation Reference(s): Ch. 5; MM

Ch. 7 & 8 HRM

3.3.6.8 Maintaining Drainage System Culverts

All culverts are inspected at least once a year and kept clean and in good operating condition. In some areas, frequent inspections, particularly after heavy storms or after periods of high runoff, are necessary to enable maintenance personnel to take corrective measures if damages have occurred. Under drains are inspected on the same schedule as culverts and their outlets kept open and clean.

Implementation Reference(s): Ch. 5 MM

Ch. 7 HRM (Channel Conveyance)

3.3.6.9 Street Sweeping and Cleaning

Sweeping operations are scheduled to prevent the accumulation of leaves, road abrasive sand, litter and other debris than can impact the safety and hydraulic performance of highway system. The performance of a street cleaning program depends on the condition of the street surface, the particle size distribution of pollutants, the amount of pollutants present initially, the number of passes per treatment, and the interval between treatments.

Maintenance Criteria For Sweeping and Cleaning:

1. Sweeping operations are scheduled to prevent the accumulations of leaves, paper and other debris that will clog the highway drainage system. WSDOT has found that sweeping captures predominately large debris but very small quantities of fine particulates. Debris accumulation may require sweeping to occur as frequently as twice a month. Scheduling is dictated by debris accumulation.
2. Until more practical options exist, street sweepings will be disposed of in a two step process: interim and final disposal. For interim disposal sweepings will be stored at WSDOT Region “pit site” properties. Placement of sweepings shall not occur within 100 feet of property boundaries, surface or drinking water sources, or in areas of designated geologic sensitivity.
3. Highest priority shall be given to recycling, reuse, and permanent solutions rather than landfill disposal.

Implementation Reference(s): Ch. 7 HRM

3.3.6.10 Mowing

1) Mechanical mowers are used to selectively remove undesirable trees, brush and weeds as part of an integrated vegetation management program.
2) Turf and erosion control grasses are managed by mowing. Only roadside areas level enough to accommodate mechanical mowing will be mowed.
3) Not more than one-third of the total grass height should be removed in a single mowing activity, unless the grass has produced seed and died.
4) Mowing frequency is dictated by height of mowing for grasses shall not be less than two inches, and preferably between 4 and 6 inches.
5) Newly seeded erosion control grass stands are not to be mowed until the grass has been in place one full year.

Implementation Reference(s): Ch. 7 MM

3.3.6.11 Maintaining Biofiltration Swales, Dry Ponds, Wet Ponds, Infiltration Basins, and Filter Strips

Biofiltration swales

1) Maintenance: Swales are mowed during summer. Remove sediments during summer months when they build up to 4 inches at any spot, cover biofilter vegetation, or other wise interfere with biofilter operation. Focus is to have a level surface to provide even flow - to the pond bottom.
2) Inspect biofilters periodically, especially after heavy runoff. Remove sediments, fertilize and reseed as necessary. Be careful to avoid introducing fertilizer to receiving waters or groundwater. Remove litter to keep biofilters free of external pollution.

Dry Ponds

1) Maintenance of sediment forebays and attention to sediment accumulation within the pond is important.
2) Remove litter to keep the pond free of external pollution.
3) Check pond for damage caused by erosion and restabilize areas where potential for erosion exists.
4) Remove sediments when accumulation in pond bottom exceeds the depth of the sediment zone plus 6 inches.
5) The sediments shall be handled the same way as catch basin solids.

Wet Ponds

1) The pond bottom shall be level to facilitate sedimentation.
2) Exposed earth on the side slopes shall be sodded or seeded with the appropriate seed mixture.
3) Establishment of protective vegetative cover shall ensure erosion protection.
4) Remove litter to keep the pond free of external pollution.
5) Check pond for damage caused by erosion and restabilize areas where potential for continued erosion.
6) Remove sediments when accumulation in pond bottom exceeds the depth of the sediment zone plus 6 inches.
7) The sediments shall be handled the same way as catch basin solids.

Infiltration Basins

1) Maintenance of side slopes is necessary to promote dense turf with extensive root growth.
2) Tiling may be necessary to restore the natural infiltration capacity by overcoming surface compaction and to control weed growth on the pond floor.
3) Grass bottoms in infiltration ponds need replacement since grass serves as a good filter material. Well-established turf on the pond floor will grow up through sediments' deposits forming porous turf and preventing the formation of an impenetrable layer.
4) Sediment accumulations that exceed a percolation test indicate only 90% function.
5) Sediment accumulation shall be removed by either vacuum truck or by manual methods.
6) The sediments shall be handled the same way as catch basin solids.

Vegetated Buffers and Filter Strips

1) Inspect filter strips periodically especially after periods of heavy runoff.
2) Remove sediments and reseed as necessary. Sediment shall be removed when depths exceed 2 inches
3) Remove litter to keep filter strip free of external pollution and ensure sheet flow through the filter strip.
4) Vegetation is mowed to a height between 4-9 inches.
5) Sediment accumulation shall be removed by either vacuum truck or by manual methods.
6) The sediments shall be handled the same way as catch basin solids.

3.3.6.12 Miscellaneous Drainage Maintenance

WSDOT utilizes chemical controls using a variety of methods to control small infestations of noxious and nuisance weeds at stormwater best management practices.

1) The most effective application method for the infestation will be used.
2) Localized infestations are controlled with small, backpack sprayers with hand held nozzles.
3) Large dense infestation shall utilize truck mounted sprayers.

3.3.6.13 Litter Collection

1) Debris and rubbish deposited on or along the highway is collected and disposed of as necessary.
2) Debris such as fallen branches and articles that have fallen from vehicles onto the traveled portion of the roadway or onto shoulders or ditches should be removed immediately.
3) Litter bags accumulated along the shoulder or ditches from Adopt-A-highway shall be removed as soon as possible.

Implementation Reference(s): Ch. 7 & 8 HRM

3.3.6.14 Adopt-A-Highway Program

1) The Washington State Department of Transportation's "Adopt-A-Highway" program is an anti-litter program intended to build civic pride, promote a litter free Washington and have the subsequent effect of removing litter and debris from surface water flows.
2) Organized groups of citizens work in partnership with the Department "adopting" a section of state highway.
3) Participating volunteer groups manually remove litter along an "adopted" section of highway for about two years.
4) The assigned sections are from 2 to 4 miles long depending on the size of the participating group and the volume of anticipated litter.

Implementation Reference(s): WSDOT Internal Directive No. 51-50

3.3.7 Highway Runoff Characterization / Water Quality Monitoring Program

40 CFR 122.26(d)2.iv.B.2
40 CFR 122.26(d)2.v
Expectations Document S7.B.4

3.3.7.1 WSDOT's Stormwater Characterization/Monitoring Plan - Purpose and Scope

The Highway Runoff Characterization/Water Quality Management Effectiveness Monitoring Program (The Monitoring Program) has been developed by WSDOT to comply with the NPDES requirements of the Part 1 and Part 2 permit application 40 CFR 122.26(d)1.iv.E., Characterization Plan and 40 CFR δ122.26(d)2.iii.D, ongoing water quality monitoring program. This monitoring program was developed for the Western Washington NPDES Permit Applications to:

1. Characterize highway storm event runoff for use in constituent loading estimates,
2. Monitor the treatment effectiveness of Highway Runoff Manual and experimental stormwater quality BMPs (detailed in section 3.2.2.4) for highway runoff, and
3. Evaluate the effectiveness of Stormwater Management Practices at long-term monitoring sites in Western Washington.

Characterization of highway storm event runoff is designed to collect information for estimating annual pollutant loadings and the mean concentration of pollutants from representative storm events. This characterization will represent range of water quality conditions associated with highway runoff. Evaluation of BMPs and SWMPs effectiveness is designed to monitor the effectiveness of existing, approved, and new technology to reduce pollutants in surface water discharges that have highway runoff as its primary source. The effectiveness of control measures will be evaluated by using statistical and trend analyses of water quality data from BMP and SWMP effectiveness monitoring, and qualitative reviews of SWMPs (e.g. trends of pesticide usage, vegetation enhancements, etc., within the highway drainage system). The Monitoring Program's priority goals are:

1. Criteria for selection of characterization and ongoing monitoring sampling locations.
2. Sampling period and frequency of representative storm events for characterization and ongoing monitoring sampling locations.
3. Sampling parameters and analytical methods for stormwater characterization.
4. Sampling equipment and procedures to conduct stormwater runoff sampling.
5. Quality assurance and quality control objectives and procedures.
6. Data evaluation methods for characterization and ongoing monitoring sampling results, and evaluation methods of stormwater management programs (e.g. vegetation management, noxious weed controls, pesticide applications, etc.

3.3.7.2 Rationale for WSDOT's Stormwater Characterization and Monitoring Locations

The purpose of highway runoff characterization is to establish baseline water quality analyses that are representative of state highway land use. Water quality for a specific site will be characterized as the runoff is directly discharged from the highway right-of-way, prior to any BMPs.

The purpose of ongoing monitoring is to evaluate the ability of new and improved control measures (i.e., BMPs and SWMPs) to reduce pollutants in highway runoff. Monitoring BMP effectiveness is the primary objective of the WSDOT sampling program. To evaluate control measures, sampling locations will be selected at specific sites where a BMP has been implemented within the state highway drainage system. The monitoring data will identify the water quality trends associated with the specific BMP or SWMP. The intent is to aid designer selection of stormwater BMPs based on specific water quality deficiencies.

The diversity of BMP designs, SWMPs and factors that affect highway runoff water quality are numerous and the degree of uncertainty (i.e. inherent statistical variability) is significant. Literature Two factors are generally considered to be significant for characterizing highway stormwater: percent impervious surface and ADT. Characterization and ongoing monitoring locations will be selected throughout Western Washington, concentrating WSDOT's efforts on characterizing and monitoring water quality associated with specific BMP designs, SWMPs, and other factors that affect water quality.

WSDOT anticipates that characterization (BMP influent) and monitoring (BMP effluent) data will be collected simultaneously within the same precipitation event. The rational for characterization and ongoing monitoring site selection is presented in the following paragraphs with a discussion of WSDOT's consideration for common state-wide programs and site specific consideration.

3.3.7.3 WSDOT's Monitoring Site Selection Criteria

Characterization sampling sites will be selected by reviewing the information collected during the outfall inventory / field screening process and the priority ranking value assigned to each outfall location (see δ3.2.5, WSDOT Outfall Inventory and BMP Prioritization System). Each sampling location will be selected to characterize one or a combination of factors that are known to affect highway runoff water quality. Studies in Washington State and nationwide have shown that highway runoff contains pollutants in highly variable concentrations. Most published studies have attempted to correlate Average Daily Traffic (ADT) count of the roadway, precipitation characteristics, and drainage mechanisms with the mean average pollutant concentration in stormwater runoff. The criteria that were used to evaluate potential sampling sites were:

- The catchment area should consist primarily (or exclusively, if possible) of WSDOT road surfaces and adjacent right-of-ways.
- Whenever possible, individual sites should sample a unique combination of ADT and/or percent impervious surface typical of WSDOT's MS4 systems.
- The catchment area should be able to produce sufficient amount of runoff for collecting samples. This is determined using the Rational or Santa Barbara Urban Hydrograph methods for determining stormwater runoff flow rates and volumes. Presence of culverts in the drainage system are definitive indicators of sufficient flow rates for characterization.
- The catchment area boundary and land uses must be well defined.
- The catchment should not have significant cross connections with other MS4 systems, or, if cross connections exist, the chemical characteristics of the runoff from the cross connections should be evaluated concurrently.
- The site must have a unique outfall structure or discharge point.
- The drainage system should not have extensive sections drained by perforated pipe systems. From a water quantity viewpoint, perforated pipes are a viable solution for flood prevention in areas with shallow water tables. From a water quality characterization or monitoring perspective, seepage into drainage systems from the perforated pipes have undesirable effects:

    1. Reduces the degree of kurtosis, i.e. "peakedness", in the runoff hydrographs. This effect makes it difficult to program the samplers to initiate water collection, since a "surge" in water flow or rainfall is generally used to trigger a sampling event.
    2. Results in a mixture of stormwater runoff and seepage from the substrate drained by the perforated pipes. Since the purpose of the program is to evaluate highway stormwater runoff quality and evaluate BMP effectiveness, introduction of seepage from adjacent land or the road prism is a complication and makes data difficult or impossible to analyze.

- The outfall structure must be structurally competent for the installation of sampling devices.
- Sites should represent the range of weather conditions in Western Washington, i.e. characteristic of the type 1A Western Washington hydrograph.
- The site must have safe and easy access with minimal traffic hazards.
- Uniform flow conditions must exist, e.g. not in pipe sections where hydraulic jumps occur.

3.3.7.4 Stormwater Characterization and Monitoring Site Descriptions

Using the rationale described above, WSDOT has developed a list of 9 primary sites for stormwater characterization and monitoring. Modifications to this list may occur because of project-related modifications or stormwater monitoring required by WSDFW using HPA permits as authority. If or when these changes occur Ecology will be notified. The majority of the BMPs included in this list are scheduled for construction during the '97-'99 biennium. BMP construction and related appurtenances, such as inlet/outlet pipes, weirs, flumes, manholes, etc. will be purchased through highway project funds. Budget for sampling equipment, staff time, and laboratory analytical costs will come through a separate fund in the I-4 (Environmental Retrofits) funding category (see δ3.2.3.1). The Water Quality Unit was allocated $234,000 for the '95-96' biennium and has requested an additional $200,000 for the '97-'99 biennium to continue with the BMP monitoring program. Funding will be requested for the '99-'01 biennium during the 1999 legislative session to continue with the monitoring program to the end of the term of the permit, July 5, 2000.

This list will be expanded or modified as new BMPs are identified or developed. The current listing (as of 1/97) of monitoring sites are detailed in Table 21. Ecology will be notified whenever new BMPs or monitoring sites are in the planning stage. Two future projects that are currently in the planning stage:

1) WSDOT received a grant from FHWA in September 1996 to develop design standards for the implementation of coagulation/flocculation/sedimentation technology in highway stormwater detention ponds. As part of this project, stormwater characterization and monitoring will be conducted at two WSDOT detention ponds and two sediment control ponds at construction sites within the Puget Sound area. The work plan for this project is included in Appendix B.

2) Washington State University researchers received National Cooperative Highways Research Program grant 25-12 to develop a expert system to optimize detention pond designs for water quality considerations. Detention pond monitoring for two locations will be included as part of this program.

There continues to be a need for low-maintenance, mechanically simple, gravity driven stormwater treatment systems, so new BMPs and modifications of existing BMPs are continuously being developed in the public and private sectors. Whenever the evidence shows that a new BMP may have applicability in treating highway stormwater runoff (low operations and maintenance requirements, high removal efficiency for solids and associated metals, gravity driven, no moving parts, space efficient) it may be incorporated into WSDOT's BMP monitoring and research programs. WSDOT will utilize the world wide web at http://wsdot.wa.gov/eesc/environmental/WQResearch.htm to inform and update municipalities, NPDES permittees, and others involved in stormwater management programs in developments in WSDOT's BMP monitoring and research programs.

Table 21 - WSDOT Stormwater Characterization and BMP Monitoring Sites 1996- 2000

Location										
SR	**MP-offset**	**Highway ADT**	**Geographic Location & Surrounding Land Uses**	**Drainage System / Area (ac)**	**Site Purpose &/or BMP Function**	**Projected Sampling Period**	**Percent Imperv. Surface**	**Sample Collection (influent, effluent)**	**Annual Precip. (inches)**	**Receiving Stream**
18	6.72-R-42	0 (construction site)	Rural, Green River Comm. College	(1a)/15 (approx.)	Construction site characterization and experimental BMP monitoring - polyacrylamides for pond flocculation	Spring '97 - '98	30 (approx.)	pipe in catch basin, pipe at outfall	45	Green River
8	15.8-L-22	16,000	Western Thurston Co. - rural, Capitol St. Forest	(1) / 0.087	BMP Monitoring - 3 vegetative filter strips w/ different soils, + catalytic pavement border	Summer '96 - '97	100	slot drain, perf. pipes	56	trib. to Kennedy Cr.
522	6.63-R-15	48,000	N. King Co. - commercial & residential btw. L. Forest & Bothell	(1a) / 0.99	experimental BMP Monitoring - Stormceptor™ vault, dual-level vault design for enhanced removal of solids, oil & grease.	Summer '97 - '99	100	weir, pipe within vault	38	Sammamish Waterway
5	18.19-L-65	52,000	N. Clark Co. - rural, agricultural	(3) / 15.75	Stormwater characterization - low impervious surface catchment	Spring '96 - '98	38	pipe within manhole	44	E.F. Lewis River
167	25.35	87,000	Auburn, King Co. - dense commercial & residential	(1) / 0.63	experimental BMP Monitoring - Ecology Embankment (underdrained terrace - sand filter)	Summer '97 - '99	100	slot drain, perf. pipes	40	Garrison Cr.
405	24.54-L-8	97,000	Bothell, N. King Co. - commercial & residential	(1a) / 28.1	experimental BMP Monitoring - Vortechs™ swirl concentrator vault	spring '97 - '99	64	pipe entering vault, pipe to wet pond	38	North Creek,
5	118.9	100,000	DuPont, S. Pierce Co.	(1a)/9.5	experimental BMP monitoring - soil additives for high transmissivity soils in infiltration BMPs.	fall '97 - '99	83	pipe entering pond, monitoring wells	38	Pierce Co. aquifer
5	2.80-R-65	101,000	Vancouver, Clark Co. dense residential & commercial	(1a) / 29.6 95% WSDOT, 5% Vancouver	Stormwater Characterization and Wet Pond Monitoring Site. Wet pond may be used by WSU researchers in NCHRP research project 25-12, developing and expert system for optimizing detention ponds for constituent removal effectiveness.	fall '97- '99	68	pipe upgrade of an energy dissipater, pipe to creek	37	Burnt Bridge Cr.
5	184.3-R-24	145,000	S. Snohomish Co. - dense residential & commercial	(2) / 4.3	BMP Monitoring - multi-cell wet pond w/ WQ wetland section.	summer '97 - '00	63 (after HOV construction)	rectangular weir, pipe to bioswale	37	County drainage to Martha Lake
5	169-M-0	200,000	Downtown Seattle - highly urbanized	(1a) / 31.5	Ultra-urban BMP Monitoring & research project - 3 filtration/sorption/ion exchange units w/ media selected from pilot tests with 3 test sites for evaluating othe stormwater treatment systems.	spring '97 - '00	72	flow splitting weir system, multiple pipes	38	Lake Union Ship Canal

Drainage Systems:
(1) - Overland flow off road surface directly to slot drains to sampling vaults.
(1a) - Overland flow off road surface to catch basins connected to lateral to main culvert to stormwater vault .
(2) - Overland flow through grassy median to catch basins connected by lateral lines to main culvert to outfall structure.
(3) - Same as (2), except upper section of catchment uses perforated pipes.

3.3.7.5 Stormwater Pollutant Parameters and Analytical Methods

Using the rationale explained in section 3.2.1 of this document and the guidance provided in 40 CFR δ122.26(d)(2), the following is a list of the parameters that will be analyzed for all highway stormwater samples for WSDOT's characterization/monitoring program.

Table 22 - Chemical Constituents For Storm Event Sampling and BMP Monitoring

Parameter	EPA Method	Minimum Sample Size	Sampling Method	Detection Limit
Conventional Pollutants / Wet Chemistry				
Total Suspended Solids	160.2	100 ml	flow-weighted composite	4 mg/l
Total Dissolved Solids	160.1	100 ml	flow-weighted composite	10 mg/l
Hardness	130.1	250 ml	flow-weighted composite	4 mg/l
Chemical Oxygen Demand	410.1	50 ml	flow-weighted composite	5 mg/l
Biochemical Oxygen Demand (5-day)	405.1	1000 ml	flow-weighted composite	2 mg/l
Nutrients				
Orthophosphate	365.2	100 ml	grab	0.05 mg/l
Phosphorous (total)	365.1	100 ml	flow-weighted composite	0.05 mg/l
Nitrate-Nitrite	300.0	100 ml	flow-weighted composite	0.05 mg/l
Hydrocarbons				
Oil & Grease	413.1/9071	1000 ml	grab	0.5 mg/l
Total Petroleum Hydrocarbons	413.1/9071	1000 ml	grab	0.5 mg/l
Metals				
Zinc (total and dissolved)	200.8/6020	500 ml	flow-weighted composite	5 µg/l
Copper (total and dissolved)	200.8/6020	500 ml	flow-weighted composite	5 µg/l
Lead (total and dissolved)	200.8/6020	500 ml	flow-weighted composite	1 µg/l
Cadmium (total and dissolved)	200.8/6020	500 ml	flow-weighted composite	0.2 µg/l

3.3.7.6 Nonconventional Constituents Testing in Lieu of Priority Pollutant Scans

Since WSDOT does not use any pesticides listed in 40 CFR 122, App.D, Table II, hazardous substances designated under section 101(14) of CERCLA, or any chemical with reporting requirements required by section 313 of title III of SARA, it makes little sense to expend WSDOT's finite budget resources on priority pollutant scans. Granted, it is entirely possible that traces of many compounds could be detected within a given precipitation event, given that many of these substances are transported using the State Highway System. Other highway stormwater sampling programs (e.g. City of Portland NPDES Part 1 Characterization Data) have shown it is highly improbable that any pervasive or indicative patterns of priority pollutants in highway stormwater runoff would be identified. As a alternative, WSDOT is proposing an alternative to priority pollutant scans which makes more sense in the context of highway stormwater runoff.

Ultimate (20-day) Biochemical Oxygen Demand (UBOD)

UBOD is a critical parameter for developing in-stream dissolved oxygen models such as QUAL2E and WASP. These models are developed in TMDL assessments for waterbodies that have been identified as having impaired beneficial uses due to low dissolved oxygen levels. Low dissolved oxygen levels in streams can result from both point and non-point source pollution, and is caused by the strains of bacteria which metabolize oxygen by decomposing organic matter, nutrients, and by high temperature. If or when a TMDL is being evaluated, having quantitative UBOD data would provide accurate evaluations of highway stormwater runoff for oxygen demand and could be indicators for the need for aeration processes as water quality BMPs. UBOD and BOD5 will be analyzed concurrently on the same samples to test for similarity.

Method:	EPA 405.1 extended
Minimum Sample Size:	1000 ml
Sampling Frequency:	2 times per year - 1 wet weather, 1 dry weather
Detection Limit:	2.0 mg/l

Bacterial Bioluminescence Toxicity Tests

The bacterial bioluminescence test (BBT), commercially known as Microtox™, is a metabolic inhibition test that uses a standardized suspension of luminescent bacteria, *photobacterium phosphoreum*, as test organisms to quickly evaluate the toxicity of a stormwater sample. Luminescent bacteria divert up to 10% of their respiratory energy into a specific metabolic pathway that converts chemical energy into visible light. This pathway is tied to respiration; any change in cellular respiration or disruption in cell structures from aquatic toxicity results in a change in respiration and a concurrent change in the rate of bioluminescence. This effect, coupled with the fact that bacterial respiration is 10 to 100 times greater than mammalian cells, proves to be a highly dynamic, quick, effective, and relatively inexpensive effluent toxicity testing method. In the BBT, the light output of test organisms is measured under standard conditions and with the test sample. Reduction in light output between the first and second measurements is essentially proportional to the toxicity of the test sample. Conducting these tests will allow WSDOT to directly evaluate:

1) Toxicity of untreated highway runoff,

2) Reductions in toxicity, if any, caused by treatment via water quality BMPs,

3) Correlations, if any, between highway parameters (ADT, impervious surface, drainage system, adjacent land uses, etc.) and toxicity.

Results from Microtox™ testing will determine whether or not more detail toxicity testing methods are necessary.

Testing Method:	ASTM Standard D 5660-96 or Standard Methods 8050
Minimum Sample Size:	100 ml
Sampling Frequency:	4 times per year - 3 wet season, 1 dry season
Detection Limit:	N/A

Polynuclear Aromatic Hydrocarbons (sediment sampling)

Polynuclear Aromatic Hydrocarbons (PAHs) are organic compounds where the carbon atoms composing the basic framework of a PAH molecule are arranged in rings. PAHs are suspected to be carcinogenic at very low levels. The presently are no surface water quality standards for PAHs, but standards exist for groundwater and marine sediments. PAHs are often the result of petroleum processing or combustion processes. Previous investigations have proposed that the types and concentrations of PAHs detected in a sample may be indicative of the source of the PAHs. These investigations suggest that lighter 2-ring PAHs are dominant in crude oil and lighter petroleum products, while heavier 3 and 4-or-more-ring PAHs are dominant in soot and combusted petroleum products. A recent study (Shepp, 1996) suggests that the *duration* of automotive exposure (the time a given impervious surface is expose to hot vehicles in a thermal expansion mode) as well as the volume of automotive exposure (the number of hot vehicles in a thermal expansion mode) is the primary factor in the generation of hydrocarbon products in

stormwater runoff. Thermal expansion and contraction of oil-bearing regions of automotive drive trains is thought to be the primary source of these hydrocarbons.

WSDOT's stormwater BMPs in the Highway Runoff Manual and currently in development (experimental) are primarily designed to remove suspended solids. Conducting analytical testing on sediment samples for PAHs will assist WSDOT in evaluating current and future BMP designs.

WSDOT will conduct sediment sampling in catch basins in two locations, one with a high (>100,000) ADT, one with a relatively low (<50,000) ADT. Sediment sampling locations, which have yet to be determined, will be selected so that highway sediments are the sole or dominant contribution. This means that highly urbanized, commercialized, or industrialized areas will be avoided in order to attempt to isolate the highway contribution to PAH and metals constituents in the collected sediments. Sampling will also be conducted continuously over several months to ensure that enough sediment is collected so that the variation in PAH and metals partitioning with respect to sediment size can be analyzed.

WSDOT would be willing to participate in a more comprehensive study of stormwater, PAHs and sediment contamination under certain conditions:

- The study would have to be a multijurisdictional, cooperative program between Ecology, WSDOT, the other NPDES permittees within Washington, and/or other jurisdictions (WDNR, WDFW, etc.) which may be stakeholders in areas with sediment quality concerns.
- PAH data must be investigated using land use and materials/fuel handling operations as the main criteria. This should include investigating various industrial, commercial, residential, streets, parks/open space, as well as state highway land uses. Facilities or sites which load and transport hazardous materials, have refueling facilities, or have degrees of automotive intensive land use (busy intersections with traffic lights, gas stations, convenience stores, etc.) should be given special attention.

  It has come to WSDOT's attention that no other NPDES permittee has been requested to perform PAH sampling by Ecology, even those jurisdictions/watersheds which contain high densities of industrial and commercial land uses. Several existing studies indicate (City of Portland Part 2 NPDES, 1992;Yamne, Nagashima, Okubo, Okada and Murakami, 1990) indicate that industrial, commercial, and urban streets have equivalent or greater PAH event mean concentrations than state highways. WSDOT sees no reason to unilaterally implicate itself as the sole source of PAHs in the environment when there is ample evidence to conclude otherwise.
- Sampling stations should not be located within non-attainment areas under the National Ambient Air Quality Standards for particulates. High atmospheric loading of particulates have the potential to exaggerate PAH concentrations in runoff and sediments.

Analytical Method:	EPA Method 610, Analysis for total organic carbon concentrations (EPA method 415.1) will be determined concurrently to provide a normalization standard.
Minimum Sample Size:	100 ml
Sampling Frequency:	Once per year. The high cost of analyzing samples for PAHs for both water and sediments will be a limiting factor for the number of samples that are feasible within WSDOT's budget constraints.
Detection Limits:	Varies from 0.013 µg/l to 2.3 µg/l by compound (Standard Methods).

3.3.7.7 Sampling Methods

Stormwater Sampling:

The standard operations will use sampling methods and procedures in accordance with EPA's NPDES Stormwater Sampling Guidance Document (July 1992) and the draft version of Ecology's Stormwater Quality Monitoring Guidance Manual (developed by Woodward-Clyde Associates, November 1995). The program will include rainfall monitoring, flow monitoring, grab sampling, flow-weighted composite sampling and sample handling procedures as required for stormwater

runoff sampling under the NPDES permit application. The types of sampling to be conducted (i.e., grab and composite) are described in the following paragraphs.

Grab sampling:

The collection of an individual sample which represents the quality of the stormwater discharge at that given time of discharge. Grab samples will be collected during the first thirty minutes of discharge or as soon as practicable, due to the variability in the sampling crews travel time to each sampling locations. Grab sampling is required for the parameters oil & grease, total petroleum hydrocarbons, and orthophosphates. Field personnel will verify during sampling that the grab sample was collected during the rising limb of the flow hydrograph and no later than two hours after the start of the storm event.

Composite sampling:

Defined as flow-weighted composite samples comprised of individual aliquots that are collected for the duration of a storm event and composites in proportion to flow volume. These samples characterize the mean quality of the stormwater discharge over the duration of the storm event. This characterization is useful for evaluating:

1. Event mean concentrations (EMC);
2. Pollutant loads of stormwater discharges; and
3. Concentration-based water quality impacts.

Flow-weighted composite sampling will be accomplished using ISCO™ automated composite samplers or by hydraulic flow splitting devices. WSDOT has purchased five automated sampling systems. The automated sampling systems are designed for flow-weighted composite sampling for NPDES permits requirements. The ISCO samplers can be engaged by either flow measurements or by rain gauge data. Engaging the automated samplers by flow readings requires detailed hydrologic analysis of the drainage basin area, impervious surface ratios, and precipitation hydrograph data. The automated sampling equipment that will be used for composite sampling consists of the following:

- 4 ISCO™ Model 674, rain gauges
- 3 ISCO™ Model 3230, bubbler flow monitoring system. Used in conjunction with model 3700 samplers.
- 2 ISCO™ Model 730 bubbler flow monitoring systems. Used in conjunction with model 6700 and 6700C samplers.
- 2 ISCO™ Model 750 bubbler flow monitoring systems. Used in conjunction with model 6700 and 6700C samplers.
- 3 ISCO™ Model 3700 automatic samplers with Teflon tubing, stainless steel probe and glass composite or individual containers.
- 2 ISCO™ Model 6700 automatic samplers with Teflon tubing, stainless steel probe and glass composite or individual containers.
- 2 ISCO™ Model 6700C compact automatic samplers with Teflon tubing, stainless steel probe and glass composite or individual containers.

The rain gauge measures on-site rainfall and signals the flow meter after every 0.01 inch of rainfall. The flow meter records the rainfall amount for isochrons that can be programmed using Flowlink™ software. At specified program parameters (continuously or at a specified time intervals), the flow meter measures the runoff water level in the pipe or channel, converts this level to flow rate and records total volume of the storm event. At a specified programmed flow volume, the flow meter activates the sampler. Then, the sampler pumps a specified sample volume into a glass sample container. Detailed flow volume, rain volume, and sample collection intervals can be downloaded after a precipitation event through the Flowlink™ software.

Hydraulic Flow Splitting:

Flow splitters are simple, relatively inexpensive mechanical devices that collect a fraction of the total flow stream based on flow velocity. Flow splitters generally consist of a box flume which has a narrow opening at the end which collects a small fraction of the total flow. This flow fraction is routed to a sample container using simple gaskets and vinyl tubing. The ratio of the opening size to the flume width is the proportion of the total flow that is sampled. 6 Flow splitters using this basic design was constructed at Washington State University from Plexiglas and were calibrated in the lab to verify accuracy. They have been installed at WSDOT's SR8-15.8-L-22 Filter Strip Monitoring site in Western Thurston County to sample surface and subsurface drainage from the three vegetative filter strips.

There are other variations of flow splitters that are currently being developed for use in pipes and culverts. A well designed flow splitter can collect accurate flow-weighted composite samples, but only total flow for the precipitation event can be back calculated. Flow splitters require detailed knowledge of expected flow volumes by using the drainage basin hydrologic analysis. For BMP monitoring, it can be expected that WSDOT will use one automated sampler (generally at the BMP inlet) and one flow splitter (outlet) in order to minimize costs.

Sediment Sampling:

A specialized system consisting of a flow splitting weir box, a "T" junction, a vinyl hose, a 5-gallon carboy, and fine mesh filter fabric, will be constructed to passively collect composite sediment samples over an extended period of time within a catch basin. The weir box will the wired to the underside of a grate inlet lid to a catch basin. The weir box will have openings sized, using the catchment hydraulic characteristics, the modified Manning's equation for curb flow, and the inlet bypass flow equation (WSDOT Hydraulics Manual, δ5-5.1) such that the flow into the will be split such that the 5 gallon carboy will be completely filled by a 0.25 inch precipitation event. The "T" junction will allow excess stormwater to bypass the carboy sampler whenever the volume capacity of the carboy is realized. The carboy will have an opening incised at its base, where the filter fabric, commonly used in catch basin insert filters, will be attached to allow stormwater to infiltrate back into the catch basin, while retaining captured sediments. Initially, the finer silt fractions <100 μm will pass through the filter fabric. Gradually, the bottom of the collection bucket will accumulate sediments and will to "clog" the fabric. After several storms, the accumulated layer of sediment, in combination with the sieve, will act to capture the progressively more complete size profiles of the sediment with each precipitation event. After many precipitation events, the residue should reasonably represent a complete sediment size profile.

Initially, WSDOT will install two sediment traps at locations where state highways are isolated from other land uses. One will be installed in a catch basin along a high ADT (>100,000 per day) highway and one along a low ADT (<50,000 per day) highway. Sampling will be conducted over several months to ensure the collection of sufficient quantities of sediment in order to facilitate analysis of pollutant partitioning by sediment size fractions.

3.3.7.8 Monitoring Frequencies, Statistical Analysis, and Number of Samples

WSDOT's monitoring program is designed to evaluate precipitation events which are representative of the 4 NPDES permit areas in Western Washington for which WSDOT will have permits. WSDOT will program its samplers to collect stormwater samples from representative events. Therefore sampling frequencies will be dependent mostly on precipitation patterns. The exception to this paradigm will be dry season, i.e. summertime monitoring. WSDOT will attempt to gather a minimum of two dry season stormwater samples to evaluate the effect that extended antecedent dry periods have on runoff water quality.

The representative storm event for the Puget Sound region (Western Washington type 1A hydrograph) is defined as meeting the following criteria:

Rainfall Volume:	0.10 inch minimum per 24 hours (generally 0.25 in. is needed for sampleable quantities of runoff). No fixed maximum.
	Typical Range: 0.2 to 0.75 inches per 24 hours
Rainfall Duration:	No fixed maximum or minimum.
	Typical Range: 6 to 24 hours
Antecedent Dry Period:	24 hours minimum
Inter-event Dry Period:	6 hours

The total number of samples that will be taken at each monitoring site will vary and will depend on the number of samples required to statistically validate the data. At all WSDOT stormwater characterization and BMP monitoring sites, the coefficient of variation (CV) for TSS will be analyzed continuously as the sampling program progresses in order to determine at what point a statistically valid number of samples has been collected. Sites which have little variability, indicated by CV's less than 0.4, will require relatively few samples. Those sites which display high CV's (>0.8) may require up to 22 samples in order to attain a statistically significant number of samples. At each WSDOT sampling location, there are three statistical parameters that will be estimated to estimate pollutant loads in each of the NPDES areas.

Stormwater quality for an individual storm is reported as an *event mean concentration (EMC)* of a particular pollutant. The EMC is therefore defined as the total mass discharge of that pollutant divided by the total runoff volume for all storm events that are sampled. When multiple storm events are monitored at a site, the EMCs generally are highly variable. The central tendency of the individual EMCs can be defined by either its mean or median. This EMC is the concentration of a sample that is collected as a flow-weighted composite throughout the duration of a storm event, and is a function of many site specific, local and regional variables.

EMC = *f*(ADT, percent impervious surface, best management practices, precipitation characteristics, surrounding land uses, ambient air quality, regional soil types, etc.)

$$EMC = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Where x_i are the individual analytical pollutant concentrations for each of the *n* precipitation events sampled and analyzed.

EMCs, along with drainage basin hydraulics, will be used to compute pollutants load using the "simple method" cited in EPA's guidance manual for completing the Part 2 NPDES MS4 permit application. In this method, the average annual pollutant load from stormwater runoff is estimated by the product of the runoff volume by the EMC. The generic equation for pollutant loading from a drainage basin assumes the form:

$$L_p = \frac{[H_r P_j R_v][EMC][A]}{98.6}$$

Where: L_p = Pollutant load during interval (kg)

H_r = Rainfall amount over the specified time internal (mm)

P_j = Percentage of rainfall during the interval which produces runoff

R_v = Runoff Coefficient = 0.05 + 0.009 x (percent impervious surface)

EMC = Event Mean Concentration (mg/l)

A = Basin area (ha)

98.6 = Unit conversion factor

The *probability distribution function (PDF)* of a pollutant parameter at a sampling site is an evaluation of the likelihood that a parameter can assume certain values. It is generally accepted that stormwater quality data exhibits log-normal probability behavior. The annual mean EMC or site mean concentration is calculated using the individual EMCs and using the assumption of log-normality. WSDOT will evaluate the probability distribution functions of pollutant parameter in detail during the course of its BMP monitoring program and this will determine the number of samples needed to evaluate BMP effectiveness.

The *coefficient of variation (CV)* is defined as the standard deviation divided by the arithmetic mean, an determines the number of samples that are necessary to estimate a pollutant parameter within a defined confidence level or desired error.

$$CV = \frac{s}{EMC} = \frac{n^2}{(n-1)}\left\{\frac{\sqrt{\sum_{i=1}^{n}(x_i - \frac{1}{n}\sum_{i=1}^{n} x_i)^2}}{\sum_{i=1}^{n} x_i}\right\}$$

The tables shown below are estimates of the number of stormwater samples required to evaluate pollutant characteristics or BMP pollutant removal effectiveness. These estimates use the CV data complied from the Portland NPDES Part 2 application and demonstrates the dependence on how the variability of a pollutant parameter affects the ability of a sampling program to measure its efficiency. Statistical computer software will be used to perform frequency analysis of the long-term output time series of hydrographs and pollutographs (plots of concentration versus time) and for identification of individual hydrologic events that may be of special interest for detailed design or other purposes.

Table 23 - Number of Samples Required to Estimate Event Mean Concentrations with an Allowable 20% Error (80% Confidence) and a Log-Normal Probability Distribution

Coefficient of Variation for a Pollutant Parameter	Degree of Precision	Number of Samples Required to Estimate the Event Mean Concentration
2.0 (Biological Testing)	0.100	170
1.5 (Dissolved Copper)	0.133	60
1.2 (Total Dissolved Solids)	0.166	50
0.8 (Total Zinc)	0.250	22
0.6 (Total Phosphorous)	0.333	13
0.4 (Total Suspended Solids)	0.500	8
0.2 (Orthophosphates)	1.000	4

Table 24 - Number of Samples Required to Measure BMP Pollutant Removal Effectiveness Ratios. (estimated using a 90% confidence interval and assuming log-normal probability distribution functions)

	BMP pollutant removal efficiency			
	30%	50%	80%	90%
Coefficient of Variation for a Pollutant Parameter	Number of Samples Required to Measure a pollutant removal efficiency			
TDS (CV=1.2)	>200	36	16	11

Zinc (CV=0.8)	>200	18	8	4
Phosphorous (CV=0.6)	40	5	3	2

Since all current HRM and proposed experimental BMPs are designed primarily to remove suspended solids, the coefficient of variation for suspended solids will be used to identify when a statistically representative number of samples have been collected and analyzed. BMPs do have the ability to remove constituents other than solids. Nutrient removal wet ponds (SR5-184.3-R-24) and polyacrylamides for pond flocculation (SR18-6.72-R-42) have the potential for removing substantial amounts of nutrients. The ultra urban/confined space BMP (SR5-169.0-M-0) has the potential to remove dissolved metals. Once a statistically representative number of samples for suspended solids are acquired and analyzed, the coefficient of variation for other constituents will also be examined for statistical viability. If it appears that sampling a few more storm event will provide valuble information on these other constituents, then the monitoring program may be continued.

Generally, most pollutant parameters prevalent in highway stormwater runoff have coefficients of variation ranging between 0.3 and 1.5. Certain constituents, primarily bacterial counts, commonly display coefficients of variation well in excess of 3.0. An extremely large number of samples (numbering in the hundreds) would have to be collected and analyzed to identify even the highest removal efficiency rates. WSDOT is excluding bacterial constituents from its monitoring program for this reason. Using this data as a general guideline, 8 to 15 stormwater samples per site should be sufficient to evaluate BMP pollutant removal effectiveness rates ranging between 50 and 90 percent (dependent on runoff volume). This correlates to the removal rates generally expected of the stormwater BMPs listed in WSDOT's Highway Runoff Manual and would be generally expected of any new or experimental BMPs that WSDOT would attempt to incorporate into the Highway Runoff Manual.

3.3.7.9 Quality Assurance / Quality Control

Project Description:

1. Sites: WSDOT's stormwater characterization and monitoring sites are located throughout Western Washington. Site selection criteria and the BMPs are described in detail in sections 3.3.7.4 and 3.2.2.4 (experimental BMPs).

2. Schedules:

   1996:

   Stormwater sampling sites were constructed and sampling commenced at 3 sites, SR8-15.8-L-22 (filter strip monitoring), SR5-18.19-L-65, and SR5-2.80-R-45, both characterization sites located in Clark County.

   1997:

   Monitoring on the detention pond located at SR18-6.72-R-42 will start in Spring 1997. Data and jar testing on the stormwater samples will be used to develop a polyacrylamide dosing system at the site.

   Construction on the SR5-168.5-L-20 site (Ultra-Urban / Confined Space BMP research and monitoring) is scheduled to commence during spring/summer of '97 and stormwater sampling starting in summer/fall 1997.

   The Stormceptor™ vault associated with the SR 522 project in Bothell will be installed in the winter of 1997 and monitoring will commence when project construction is completed, tentatively scheduled for spring 1997.

   The phase of the SR 167 project in Auburn which will install the Ecology embankment and ditch is scheduled to start in summer 1997. Stormwater sampling will commence once the BMPs are constructed.

Monitoring wells at the DuPont interchange site located at SR5-18.9 will be drilled and completed in spring 1997. Monitoring will commence whenever construction of the interchange is completed.

The SR 405 project which will install the Vortechnics™ system will commence in summer/fall 1997. Monitoring is scheduled to commence in fall or winter 1997.

1998:

Construction of the multi-cell wet pond at SR5-184.3-R-24 and associated with the I-5 HOV project in Snohomish County will commence in either late 1997 or 1998.

3. Project Objectives:

The goal of this program (other than NPDES permit compliance) is to develop a predictive model linking water quality to key state highway parameters, such as ADT, percent impervious surface, and water quality BMPs. This goal will be achieved by achieving the following objectives:

1) Characterize the physical parameters within state highway right-of-ways that have measurable, statistically significant effects on state highway stormwater runoff characteristics, as defined in section 3.3.7.4.

2) Develop and calibrate stochastic models based on existing and new state highway parameters that can be reliably used to estimate event mean concentrations and probability distribution functions of state highway stormwater runoff characteristics.

3) Develop a process for using the model by highway design engineers and transportation project planners to aid in the preparation of EIS Water Quality Discipline Reports, Design Hydraulic Reports, Hydraulic Project Approval Applications, et. al.

4) Evaluate standard HRM and experimental BMPs for their ability to remove stormwater constituents associated with highway runoff (as detailed in section 3.3.7.5).

Project Organization:

The following are responsible for the planning, budgeting, and implementation of WSDOT's Stormwater Characterization and Monitoring Program:

<u>WSDOT Water Quality Program</u>

Water Quality Program Manager - Shari Schaftlein (Administration, Budgeting)

Water Quality Specialist - Ed Molash (Planning, Budgeting, Implementation)

Water Quality Specialist - Bert Bowen (Planning, Budgeting, Implementation)

Water Quality Sampling Technician - Stacy Trussler (Sample QA/QC, Implementation)

Data Quality Objectives:

<u>Precision and Bias:</u>

Analytical Methods and lower reporting limits, as detailed in section 3.3.7.5 and 3.3.7.6, will be equivalent or lower than those used in Standard Methods for the Analysis of Water and Wastewater, 1995.

<u>Representativeness:</u>

Sampling locations, schedules, and water quality variables to be analyzed will according to the procedures outlined in sections 3.3.7.2 through 3.3.7.7. These sections address representativeness of WSDOT's stormwater sampling program and its objectives.

Samples will be collected by standard techniques and will be used to calculate mass pollutant loading estimates transported to receiving streams by state highway stormwater runoff.

Completeness:

The most critical data for achieving the monitoring program's objectives are annual and seasonal loading estimates (calculated from event mean concentrations), and an analysis of variability of those pollutant parameters discussed in section 3.3.7.7 and 3.3.7.8.

Comparability:

Data will be reported in the standard units cited in Appendix C of Ecology's Guidelines and Specifications for Preparing Quality Assurance Project Plans. Data will be filed in Excel spreadsheets and transformed to hypertext markup language for display over the internet at the URL location:

http://www.wsdot.wa.gov/eesc/environmental/WaterQuality.htm

Quality Control:

Field QC Procedures:

A randomly selected 5% of field samples will be collected in duplicate and processed according to standard operating procedures.

Laboratory Selection:

WSDOT has contracts with 13 analytical laboratories which have all been certified by Ecology's Manchester Laboratory to perform water and wastewater analyses for stormwater for the analytes listed in the section within certification guidelines. WSDOT has selected three labs to perform the majority of the analytical testing for its stormwater and sediment samples. They are:

Sound Analytical Services
4813 Pacific Highway East
Tacoma, WA 98424

Columbia Analytical Services
1317 South 13th Ave.
P.O. Box 479
Kelso, WA 98626

North Creek Analytical - Southwest Region
9405 SW Nimbus
Beaverton, OR 97005

North Creek Analytical - Northwest Region
18939 120th Ave. NE, Ste. 101
Bothell, WA 98011

Laboratory Procedures:

The analytical procedures used by the contracted labs to analyze WSDOT stormwater samples are documented in section 3.3.7.5 and 3.3.7.6.

Laboratory QC Procedures:

Check standards, duplicates, spikes, and blanks such as specified in Appendix E of Ecology's Guidelines will be analyzed for this program.

Chain-of-Custody Documentation:

Standard chain-of-custody documents will be completed, signed, and retained by WSDOT for all stormwater samples.

3.3.8 WSDOT Research Programs for Highway Stormwater Improvements

WSDOT has and will continue to initiate, fund, and implement research to develop new and improved BMP for treating highway stormwater runoff. WSDOT's MS4 system is unique amongst NPDES municipal permittees because of its wide geographic distribution, number of conveyance systems, lack of easy access, and sheer number of stormwater facilities. These limitations require WSDOTís stormwater BMPs to be low maintenance, mechanically simple, gravity driven systems. WSDOT's research problems are designed to overcome these complications using well researched, high quality science and engineering principals. The following are abstracts of WSDOT's recent, current, and future research project. In 1996, the Water Quality Unit will be proposing several more projects which will provide WSDOT design and maintenance personnel the technology to improve the quality of highway runoff from the state highway system.

In 1995, WSDOT began developing implementation plans to facilitate the use of new BMP technologies in the field. The implementation plans are intended to make the transition

between pilot scale treatment processes, which are typically evaluated during the research phase, and field scale design specifications. In order to utilize new or innovative stormwater BMPs, exact design specifications must be developed and performance monitoring in actual field conditions evaluated if they are to be included in the HRM. WSDOT will hold meetings to discuss implementation plans with the principal researchers, hydraulics engineers, water quality personnel, and designers. WSDOT will also seek opportunities through grants and project funds to bridge the gap between BMP research and practical field application of new and innovative technologies.

When research projects are completed WSDOT will hold presentations of relevant findings by the principal investigators in conjunction the monthly American Public Works Association (APWA) stormwater managers meeting. These meetings will allow researchers, NPDES permittees, and stormwater utilities to discuss the research results and their implications to stormwater management.

The following are abstracts and descriptions of each of WSDOT's recent, current, and future water quality BMP research projects.

3.3.8.1 Assessment of Relative Storm Runoff Control Advantages of Alternative Roadway Shoulder Pavements

Drs. Brian W. Mar & Richard Horner - Department of Civil Engineering, University of Washington

Abstract / Project Description: A study of the relative hydraulic, hydrologic, and surface water quality characteristics produced by conventional paved surfaces, permeable pavement material, and gravel for use as roadway shoulders is currently in its field experiment phase. King County Roads Division is the primary sponsor of this project with WSDOT contributing some funding. Gravel shoulder surfaces provide environmental benefits insofar as it increases the potential for infiltrating significant amounts of stormwater runoff, but has serious safety and maintenance liabilities. Conventional paved shoulder surfaces are durable and low maintenance, but increases net runoff volume during storm events. Porous pavements may present a suitable compromise between paved and gravel shoulder surfaces. Previous attempts to use porous pavement as a roadway was determined to be unsuccessful because of progressive clogging of the porous matrix from fine particulates. The test site, constructed in Fall '95, consists of three separate shoulder sections, paved, gravel, and porous pavement, which will be evaluated for two winters and the intermediate summer for: 1) water quality characteristics, 2) infiltration capacity over time, and 3) safety and maintenance considerations.

Sampling Methods: Flow-weighted composites of roadway surface runoff from the three sections using flow splitters and composite sample tanks.

Water Quality Parameters Evaluated: TSS, turbidity, electrical conductivity, hardness, Cu, Pb, Zn, total phosphorous, soluble reactive phosphorous

Completion: 09/15/96
Percent Completed: 100%, implementation phase taking place at a monitoring station located at SR8, MP15.8.

3.3.8.2 Cost Benefit Analysis of Stormwater Retrofits

Dr. Michael Barber Washington State Univ.

Abstract / Project Description: Develop a time dependent, cost/ benefit model which will allow the user to determine which remedial approach to stormwater mitigation will provide the optimum return on investment. The resultant cost/benefit model will be included in WSDOT's mobility project prioritization criteria in Array Tracking System budget tracking, prioritization, and allocation system. A cost benefit model used by economists has been modified to account for the risks and performance uncertainties inherent in the design, maintenance, and operation of stormwater management facilities. A BMP Cost database has been developed with the cooperation from construction projects initiated since 1995 in WSDOT's Northwest and Olympic regions. An implementation phase to this project to estimate non market benefits of protecting water courses using BMPs will be necessary to fully implement the benefit/cost estimation system. This would entail a contingency market survey of the major stormwater utilities in Washington.

Scheduled Completion: 8/97 (for the reseach phase

Percent Completed: 80% - draft final has been received and is in review.

3.3.8.3 Assessment and Application of Highway Slopes for Highway Stormwater Contaminant Removal

Dr. David Yonge - Department of Civil and Environmental Engineering, Washington State University

Abstract / Project Description: The vegetated slopes along roadways are typically the recipient of significant quantities of stormwater runoff from roadway surfaces. Additionally, connected systems of catch basins located in the grassy medians of highways are common hydraulic design configurations. These vegetated cut and fill slopes reduce the amount of suspended solids, associated sorbed metals, and petroleum products through filtration and biological uptake of the vegetation residing on the side slopes. As a first phase of evaluating the pollutant removal potential of roadside vegetative filter strips, this research project was initiated in 1994 to evaluate filter strip design parameters (length, width, slope, vegetation density, Manning's n, etc.) and their effect on pollutant removal rates. A rectangular scale model vegetative filter strip was designed and built at WSU which could be tilted to adjust the slope and effective length of the filter strip. Bromide tracer studies were used to determine residence times and estimate Manning's n for the various filter strip length/slope configurations.

Sampling Methods: Flow-weighted composites of filter strip runoff using slot drains and collection vessels. Feed solution was premixed using NURP study pollutant profile characteristics .

Water Quality Parameters Evaluated: Total Suspended Solids, Cu, Cd, Pb, Zn

Completion: June 1996

3.3.8.4 Enhancing Contaminant Removal in Stormwater Detention Basins by Coagulation

Dr. David Yonge - Department of Civil and Environmental Engineering, Washington State University & Falcon Price - Sunshine Mining Corp.

Abstract / Project Description: Four commercially available coagulants were evaluated in a 1:15 scale model of a stormwater detention basin for their ability to enhance removal of suspended solids in the 5 to 15 nm range and associated sorbed metals. A proprietary, commercially available cationic polymer coagulant, SWT 848, exhibited the best performance of the coagulants tested, based on rapid floc formation, solids settling characteristics, and a wide effective range of dosing concentrations. It was found that the coagulant facilitated sedimentation of solids in the sediment particle size range (around 4 11m) that has the greatest

sorption capacity for lead and zinc. Successful field implementation will depend on identifying wet ponds with the appropriate surface overflow rates (<300 nm./sec) and devising a simple semi-automated method for dosing the wet ponds with the SWT 848 coagulant. A second phase of this research involved the investigation of incorportating baffle walls in sedimentation basins for water quality improvements. The results of incorporating baffles in the pilot scale facilitated as much as 20% additional metals removal by reducing hydraulic short-circuiting and improving floc development. Interest in implementing coagulation techniques has been expressed by WSDOT's Olympic Region and funding mechanisms for developing design criteria are being investigated.

Sampling Methods: Flow-weighted composites of scale model basin effluent to collection vessels. Feed solution was pre-mixed using pollutant profile characteristics taken from historic Washington highway runoff studies.

Water Quality Parameters Evaluated: Total Suspended Solids, Cu, Cd, Pb, Zn

Completion: May 1995

3.3.8.5 The Assessment of Groundwater Pollution Potential Resulting From Stormwater Infiltration BMPs

Drs. Wade W. Hathorne & David Yonge - Department of Civil and Environmental Engineering, Washington State University

Abstract / Project Description: A study of infiltration characteristics of typical Washington state soils for metals removal in the presence of natural organic matter was completed in late 1995. The study examined three characteristic soil types Everett (high infiltration rate, moderate organic content), Springdale (high infiltration rate, low organic content), and Garrison (low infiltration rate, high organic content), for their ability to capture both solid phase and soluble concentrations of four metals (zinc, copper, lead, and cadmium) commonly found in highway stormwater runoff. It was found that the organic content of a soil was a better overall indicator of the soils ability to remove the full range of heavy metals in highway runoff than its cation exchange capacity. Lead (Pb) and Cadmium (Cd), metals commonly found in highway runoff, were attenuated to a very high degree (>90%) in the upper levels of all soil types, regardless of organic content or hydraulic conductivity. The percentage of natural organic material (NOM) in the feed solution had little effect (<10%) on the removal efficiency of Pb and Cd, suggesting that the cation exchange capacity of the mineral matrix was the primarily mechanism for their removal. The presence of NOM in the feed solution significantly improved the removal efficiencies for Zinc and Copper in all soils. Recommendations were given for soil characteristics which optimize soil hydraulic performance and metals attenuation capacity, which has use for siting or maintenance operations of infiltration BMPs. Overall, it was estimated that breakthrough of metals to groundwater resources would take years to decades, depending on the soil type and depth to groundwater.

Sampling Methods: Time -weighted composites of infiltration gallery effluent from 2 intermediate sampling ports and 1 terminal port, all separated by 30 cm. Feed solution was pre-mixed using pollutant profile characteristics taken from historic Washington highway runoff studies.

Water Quality Parameters Evaluated: Total Suspended Solids, Cu, Cd, Pb, Zn

Completion: February 1996 for the research phase - The implementation phase will commence in summer/fall 1997 using groundwater monitoring wells (one upgrade, two downgrade for each) adjacent to three infiltration basins built in conjunction with the SR 5 - DuPont interchange project.

3.3.8.6 Catalytic Pavement Borders

Dr. Richard J. Watts & Alexander P. Jones - Department of Civil and Environmental Engineering, Washington State University

Abstract / Project Description: Measure the effectiveness of titanium dioxide, a powerful photocatalytic oxidizer, as a pavement border in reducing the amount of hydrocarbons in highway stormwater runoff. The photocatalytic process is based on attaching titanium dioxide to roadway pavement surfaces incorporated into a fixant. The fixed TiO2 enhances rates of natural photoxidation through a semiconductor effect. Six fixants containing TiO2 were evaluated for photocatalytic activity with concrete sealant and paint base being the most effective in degrading trichlorophenol. Batch studies under controlled laboratory conditions showed degradation of TCP to beyond 99% after 72 hours of exposure. TiO2 pavement borders will be incorporated into the Filter Strip Monitoring research project to determine 1) effect of width of a TiO2 road border on hydrocarbon degradation in highway runoff, 2) rate of reapplication of TiO2 to maintain effectiveness, and 3) cost/ benefit analysis. If found to be effective, catalytic pavement borders may have use as a border to drains and catch basins on bridges and ferry terminals.

Sampling Methods: Batch grab samples. The initial dosage consisted of a 50% mass/mass ratio of contaminant to deionized water.

Water Quality Parameters Evaluated: 2,4,6 trichlorophenol (TCP), hexadecane, anthracene

Completion: September 1995 for the reseach phase, verification of research findings commenced in Winter 1997 at WSDOT monitoring site located at SR 8, MP 15.8.

3.3.8.7 BMP Evaluation for Handling and Treating Stormwater in Ultra-Urban and Confined Situations

Dr. Michael Barber - Department of Civil and Environmental Engineering, Washington State University

Abstract / Project Description: Stormwater runoff from transportation facilities such as ferry docks, bridges, shorelines, and highly urbanized areas pose a special problem for designers because of the lack of physical space. This lack of space prevents standard stormwater BMP solutions, such as those detailed in the WSDOT Highway Runoff Manual, from being implemented. For example, a properly designed constructed wet pond typically requires over an acre of land to obtain the required hydraulic detention times. The overall objective of this project is to provide unbiased, objective evaluations of filtration media for the treatment of stormwater runoff, and associated operations/ maintenance requirements that will allow WSDOT personnel to specify stormwater quality improvement projects which satisfy water quality goals with the highest cost/benefit performance.

The first phase of this project (through spring '96) will involve filtering simulated highway runoff through packed infiltration columns using media of various compositions, including sand, organic enhanced sand, leaf mulch compost, zeolites, diatomaceous earth, iron oxide coated sand, activated wood products, and/or material mixtures. The various filter media will be evaluated for their ability to remove typical road runoff constituents, their maintenance requirements, availability, and replacement costs. The three filter media which demonstrate the best performance in the lab evaluation will then be used in an full-scale field test of the media using custom designed vaults which will collect stormwater runoff from the I-5 Lake Union Ship Canal bridge located in downtown Seattle. This section on roadway is one of the most heavily traveled in the State of Washington, with an ADT of nearly 200,000 vehicles per day. Effectively treating the stormwater runoff from this source will present a significant challenge for this technology and, if successful, will have many practical applications for WSDOT facilities statewide. The BMP is described in detail in section 3.2.2.4. *Sampling Methods:*

Phase 1- Lab evaluation of filtration media: Flow weighted and time composite samples of filtration unit effluent. Simulated highway runoff will be formulated from published studies of representative pollutant concentrations and from stormwater sampling from the Kingston Ferry Terminal on the Kitsap Peninsula.< BR>

Phase 2 - Actual stormwater runoff will be collected via catch basins and directed by pipes to a central mixing chamber, from which flow-weighted composite samples will be taken to characterize the chemical constituents in the bridge runoff. The effluent from the mixing

chamber will distributed using flow splitters to sampling locations three of which will house the ultra urgban BMP.. Flow-weighted composite samples will be collected from the 3 vaults, which will contain the filter media selected form phase 1, and the oil/water separator.

Water Quality Parameters Evaluated: TSS, Zn, Cu, Pb, Cd, petroleum hydrocarbons, nitrates, kjehldahl nitrogen, total phosphorous, soluble reactive phosphorous.

Progress Report: December 1995- Modified work plan approved. February 1996- Literature search completed. Plans for the scale model infiltration galleries are being developed.

Summer 1997 - Phase 1 will be completed.

Summer 1997 - Construction will commence on WSDOT's ultra urban BMP testing site located next to Lake Union in Seattle.

Scheduled Completion: Late 1998 or early 1999.

3.3.8.8 Filter Strips and Ecology Ditch Field Monitoring and Assessment

Drs. David Yonge & Wade Hathorne - Department of Civil and Environmental Engineering, Washington State University

Abstract / Project Description: An evaluation the pollutant removal effectiveness of vegetative filter strips and ecology ditches (combination infiltration /biofiltration using re engineered highway borrow ditches) for inclusion of these BMPs into the Highway Runoff Manual. Vegetated highway The primary objective is to obtain quantitative data on the pollutant removal effectiveness of vegetative filter strip prototypes constructed on WSDOT r.o.w.'s in King County (SR 169) and Thurston Counties (SR 8, MP 16) using WSDOT's automated sampling equipment. Influent and effluent water quality will be measured simultaneously for concentrations of typical highway runoff constituents.

Sampling Methods: Flow weighted samples of overland runoff through three filter strips and two sections of roadway via slot drains.

Water Quality Parameters Evaluated: TSS, Zn, Cu, Pb, Cd, petroleum hydrocarbons, nitrates, kjehldahl nitrogen, total phosphorous, soluble reactive phosphorous

Progress Report: December 1995 - Plans for the sites revised and approved January 1996 - Filter strip site on SR 8, MP 16 was built with the assistance of WSDOT's Elma, WA maintenance personnel. Feb/March 1996 - Site will be rebuilt because of an accident that occurred during a snowstorm in January which damaged one of the filter strip sections.

Scheduled Completion: December 19 97

3.3.8.9 Wet Detention Pond Design for Highway Runoff Pollutant Control

National Cooperative Highway Research Program (NCHRP) Project 25-12

Drs. David Yonge, Mike Barber, and Wade Hathorne - Dept. of Civil and Environmental Engineering and Dr. Shulin Chen - Dept. of Biological Systems Engineering, Washington State University

Abstract / Project Description: To develop a rational, optimized design and operational protocol for wet detention ponds in highway environments. The project objectives will met by combining pertinent historical data with data collected during the course of the proposed project. The final results will be used to generate a report documenting and explaining the procedures and design criteria for constructing FHWA wet pond projects throughout the country. Design concepts will include constructed wetlands for water quality improvements. A computerized decision support ("expert") system will accompany the document which will enable engineers and scientists to select pertinent information of the design criteria. WSDOT wet detention facilities in western Washington will be used in the study. WSDOT water quality, hydraulics, and biology staff will support the WSU investigators as project deadlines and requirements dictate.

Progress Report: Work plans for the project will be developed in early 1996.

Projected Completion Date: November 1998 (tentatively)

3.3.8.10 FHWA Water Quality Research Projects

There are two current FHWA studies being conducted that have the potential for water quality improvements.

Oregon State University is conducting an FHWA study that is examining the toxicity effects of substances used in roadside maintenance activities, adjuvants, dust suppressants, toxicity, mobility, and persistence of non-listed pesticides, etc. WSDOT hopes to use the results, anticipated by Fall 1996, to guide future roadway and roadside maintenance activities and protocols. As part of the monitoring program, WSDOT will collect stormwater samples to evaluate the water quality impact of roadway and roadside activities, such as pesticide applications, roadway sweeping, drainage system maintenance, etc.

Woodward-Clyde Associates office in Portland, Oregon is in the field testing phase of FHWA-sponsored research on stormwater sampling and monitoring equipment. The study is investigating accuracy of flow metering technology, automated sampler accuracy, and low-cost flow splitting devices. The final report for this project is expected to be released by the end of 1996 and relevant guidance will be used as part of WSDOT's BMP monitoring and research programs.

3.3.8.11 Implementation of Research Project Findings

Flood control was the historic primary purpose for constructing highway stormwater detention basins, although most exhibit an ability remove suspended solids, and the pollutants associated with solids. One method for improving the removal of pollutants in existing detention basins is through the implementation of coagulation technology. WSDOT has applied for and was granted $90,000 by the FHWA through its 1996 Priority Technologies Grant Program to develop methods for implementing and establishing design criteria to use coagulation techniques in highway stormwater detention ponds. Coagulation processes have been successfully used for treating drinking water and wastewater for decades under highly controlled conditions. WSDOT will re-engineer coagulant technology for use in highway stormwater detention basins which, unlike water treatment plants, have no available electrical power, are often located in remote or inaccessible areas, and are maintained infrequently. The program, scheduled from 1996 through the end of 1998, will facilitate development of a low cost, mechanically simple system for implementing coagulation technology in highway stormwater detention basins and temporary sedimentation basins. Preliminary studies, including Dr. Yonge's work indicates a high probability for success.

WSDOT will continue to investigate ways to translate research findings to BMP design implentation through a combination of construction project funds, grants, partnerships with local governments, and combinations of financing methods.

3.3.8.12 Anticipated Future Water Quality Unit Research Projects

WSDOT will continue to aggressively pursue new and innovative technology to improve the quality of stormwater runoff from the state highway system. Internal funding for research projects is done biannually. The initial phases of WSDOT's stormwater BMP research has emphasized removal and immobilization of solids and sorbed metals. Subsequent phases will increasingly emphasize removal and immobilization of hydrocarbons, nutrients, and dissolved pollutant phases from highway stormwater runoff. Some of the potential future water quality research projects may include the following:

- Stormwater Pretreatment Systems For Discharges To Dry Wells.
- Methods For Reducing Infiltration Rates In High Transmissivity Soils and Related Water Quality Effects In Highway Runoff Infiltration Ponds.
- Life-Cycle Maintenance Requirements for Stormwater BMPs
- Phytoremediation Techniques For Stormwater BMPs

3.3.9 Public Education Programs

40 CFR 122.26(d)2.iv.B.6

Expectations Document S7.B.8.i

A number of public education efforts are ongoing in WSDOT to encourage adoption of BMPs which affect water quality. These activities are grouped in four subject areas and discussed below. A large scale public education campaign, necessitating additional FTEs and program dollars is not anticipated. If conditions mandate, existing staff will redirect staff time and available resources to gradually respond to changing priorities.

3.3.9.1 Training and Technology Transfer

WSDOT is recognized as a leader amongst state transportation agencies and our direction is sought by many local government agencies as well as groups in the private sector. Significant resources are expended on transportation research and technology transfer. Innovations are encouraged and promoted through a variety of organized meetings and multi-media learning opportunities. Outreach activities extend far beyond in-house training.

WSDOT recently held Erosion Control, Bioengineering, Wetlands, and Hydraulics courses that included attendees from the private sector and other state and local agencies. Many courses are held in response to updates in WSDOT's manuals. The Design and Environmental Offices are coordinating development of the Highway Runoff Manual. The Environmental Branch in Maintenance is preparing a Waste Management Manual for Transportation Maintenance Shops. WSDOT's manuals, standard specifications, and general contracting provisions are often adopted by municipal transportation organizations around the state.

The Northwest Technology Transfer Center (T^2), is funded by FHWA to provide technology transfer to non-urbanized cities, counties, and others. Outreach activities include workshops, road shows, newsletters, video loans, flyers, reference lists, and an electronic bulletin board. Information on water quality impacts of transportation activities is included in this education effort.

3.3.9.2 Public Affairs Office

The Public Affairs Office responds to a wide variety of information requests from the public. A number of brochures are available upon request. Topics include organizational information on the agency, annual budget , and transportation planning activities. In addition, public involvement is sought to reduce traffic congestion and maintain litter free shoulders. Some examples of available brochures include: Sign of the Times-A guide to the Diamond Lanes and how they work; The Washington State Commute Trip Reduction Law; Interstate 90 Bicycle and Pedestrian Trail; and, the Washington Bike Map and Highway Guide. Organizations and individuals concerned about litter receive the following brochures: A Guide to Reporting Highway Litter Violations and Evergreen and Everclean: Adopt-A-Highway Program.

3.3.9.3 Transportation Planning Processes

There are three significant planning processes that provide an opportunity for the public to learn and comment on transportation priorities and environmental implications (including stormwater management): the State Transportation Policy Plan; the Washington Statewide Multimodal Transportation Plan, and, the Transportation Improvement Plan prepared by the Puget Sound Regional Council, the designated metropolitan planning organization as defined in ISTEA.

1. A State Transportation Policy Plan Steering Committee annually presents the opportunity for the public to learn about transportation policies and provide input through a Public Response Survey, and regional public forums. Final recommendations are presented to the Transportation Commission for approval before being sent onto the State Legislature. The policies recommended will then be used by the state, regional, and local agencies in guiding future transportation programs.

2. The Transportation Commission has developing a Statewide Multimodal Transportation plan in response to the Growth Management Act, Clean Air Act mandates, and ISTEA. The State Transportation Systems Plan is the first step in developing the Statewide Multimodal Transportation Plan. The Systems Plan covers only state-owned facilities and services. It specifically defines service objectives and proposes strategies for maintaining, preserving, and improving state highways, the Ferry System, and state-owned airports.

3. The overall transportation program document containing transportation projects selected through the regional decision process is officially called a Regional Transportation Improvement Program (TIP). The TIP is a three year program of projects and is updated annually in this region. The Transportation Policy Board and Executive Board of the Puget Sound Regional Council publicize the draft TIP for public review through Growth Management and Countywide meetings. In addition copies of the draft TIP were made available for review at twenty-six major local libraries and copies were sent to local jurisdictions and agencies. The draft documents were also available at the Puget Sound Regional Council's Public Information Center. WSDOT plays a major role in project selection in cooperation with the Regional Council.

3.3.9.4 Maintenance Procedures Training

Maintenance personnel throughout WSDOT are trained regularly in the various aspects of roadway and roadside maintenance procedures. They include:

- Maintenance Leadership Institute - training for Lead Technicians.
- Supervisor's Leadership Institute - Training for Maintenance Supervisors.
- New BMP Maintenance training as new BMP are installed.
- Roadside "Spring training" for contractors.
- Statewide Maintenance Superintendents stormwater needs.
- Vactor™ class for truck operators

3.3.9.5 Project Review

Public input is sought during the planning and design of specific construction projects. Public meetings are held to disseminate information and obtain input on environmental, social, and economic tradeoffs associated with various design options. In addition, the public is notified of environmental documentation in order to meet reporting requirements of various environmental laws. For example, the Water Quality Discipline Reports which are part of the NEPA process are available for public review and include an alternatives analysis related to stormwater management. In addition, to comply with the NPDES General Baseline Permit for the Construction Industry, WSDOT advertises its application for a permit in local newspapers. The Public has a 30 day opportunity to review and comment on the Temporary Erosion Control Plan.

3.3.9.6 Information on WSDOT's Activities through the World Wide Web

WSDOT's Water Quality Unit will maintain a internet site at: http://www.wsdot.wa.gov/eesc/environmental/WaterQuality.htm that will be used to disseminate information to the public about its current programs. Reports, guidance documents, monitoring data, and (eventually) this document will be made available through the Water Quality Unit's web site.

3.3.10 Legal Authority

40 CFR 122.26(d) 1.ii
40 CFR 122.26(d) 2.I
Expectations Document S7.B.3

Amendments to the Clean Water Act (CWA) in 1987 established statutory requirements to manage and improve the quality of stormwater discharges from municipalities with populations greater than 100,000 Furthermore, the United States Environmental Protection Agency (USEPA) established, through a procedural rule making process in November, 1990, a definition of "municipality" to include incorporated and unincorporated areas within counties that have established a base population greater than 100,000. Through this ruling, the South Puget Sound, Cedar-Green, and Island Snohomish NPDES MS4 Permit areas were established by Ecology and are regulated by the provisions set forth in 40 CFR 122.26(d), *Application requirements for large and medium municipal separate storm sewer systems*. WSDOT is included in this class of municipalities.

Controlling and regulating storm water runoff over large scale geographic areas creates practical and administrative complexities which cannot be addressed using the standard methods of sampling and numeric effluent limitations that have been promulgated in NPDES permits for industrial facilities and publicly owned treatment works. The NPDES program for controlling municipal separate storm sewer discharges takes a different approach, and mandates the following provisions:

- Requiring the implementation of long term storm water management programs, which includes watershed-based mitigation planning strategies, structural controls, nonstructural controls, BMP design optimization, and water quality research programs.
- Issuance of general storm water permits which cover large geographic areas and can include multiple permittees,
- Prioritizing sites/outfalls which have demonstratively contributed to degrading water quality or discharge to sensitive watersheds or aquifers,
- Mandating pollution prevention programs which require control of the source(s) of storm water pollution (construction BMPs, vegetation management, integrated pest management, street cleaning, etc.) and the continuous implementation /retrofitting of BMPs which , provide control and reduction of storm water quantity and/or facilitate water quality treatment.

3.3.10.1 WSDOT Legal Responsibilities and Authority

WSDOT has not been given by the Legislature the general police power authority available to cities and counties under the state Constitution. WSDOT has only that authority necessary to carry out its enumerated purposes. It may "exercise all the powers and perform all the duties necessary, convenient, or incidental to the planning, locating, designing, constructing, improving, repairing, operating, and maintaining state highways, including bridges and other structures, culverts, and drainage facilities and channel changes necessary for the protection of state highways." RCW 47.01.260.

WSDOT may design, maintain, and operate drainage and stormwater facilities connected with its highways in accordance with environmental regulations. But WSDOT may exercise its authority over private citizens only as it relates to promoting a highway purpose. To the extent implementation of the municipal NPDES stormwater program is a general benefit to the general public independent of designing, constructing or protecting highways, it does not fall within WSDOT authority. See also RCW 47.01.300. *WSDOT, therefore, does not have authority to prohibit discharges that originate off of its right of way, or to initiate enforcement actions or impose penalties if those discharges create a problem that is not related to the safety or integrity of the state highway.*

Specific WSDOT authority over its right of way can be found in the following: title to the rights-of-way, RCW 47.04.040; authority to lease unused highway land or air space, RCW 47.12.120; an obligation to own portions of city streets that form a part of state highways, RCW 47.24.020; authority to grant utility franchises on state right-of-way, RCW 47.44.010; authority to regulate access to state highways, RCW 47.50.010; authority to remove encroachments or obstructions on state right-of-way where necessary for the convenience and safety of public travel and use of a state highway, RCW 47.32.010; and authority to prevent nuisances, natural or artificial, that threaten or endanger the state highway, RCW 47.32.130.

Obviously, WSDOT may control, through contract provisions, construction work performed on right-of-way. Most construction work on state right-of-way will be covered independent of this program by way of coverage under the provisions of either the NPDES General Stormwater Permit for Construction Activities, or individual NPDES Construction Stormwater Permits. Where WSDOT enters into contracts to perform construction activity, it may include conditions as part of the contract or in its specifications. WSDOT already requires compliance with all applicable federal, state and local regulations in its Standard Specifications, which includes the requirement for obtaining the appropriate NPDES permits. WSDOT also requires its construction contractors to submit and implement erosion and sediment control plans. WSDOT inspects its construction projects, and will stop work on a project or will impose such damages as are provided in the construction contract if, in WSDOT's best professional judgment, the conditions warrant such actions.

With respect to development that occurs outside the right-of-way, WSDOT cannot regulate that activity unless it somehow requires the use of state right-of-way, and therefore requires a utility permit or franchise (see section 3.3.10.2. Ultimately, WSDOT only has authority to regulate or condition activities which either take place on the right-of-way, or for which WSDOT is authorized to require a permit. Where WSDOT is authorized to permit an activity, such as installing a utility or connecting a new road approach, it may add conditions to its permit related to stormwater flow and quality. WSDOT will require as a condition of its utility permits that the permittee comply with all existing federal, state and local regulations and guidelines for water quality, including the Stormwater Management Manual for the Puget Sound. Other than what is described in the following section 3.3.10.2, WSDOT does not impose conditions that exceed what is required by such regulations and guidelines. WSDOT will not revoke permits for failure to meet water quality related conditions unless the violations relates to the safety or integrity of the state highway and WSDOT cannot impose penalties for failure to meet water quality related conditions or standards. WSDOT proposes that instances of failure to meet water quality standards or other water quality related legal standards will be referred for enforcement action to the local government and the Department of Ecology, whichever is the appropriate entity.

The following sections describe the manner in which WSDOT will implement its existing legal authority. WSDOT believes that these methods fully implement its existing legal authority consistent with its legislative mission except as specifically noted. As described in these sections, where WSDOT does not possess legal authority, it proposes to rely upon the existing legal authority vested in either the Department of Ecology or in local governments. WSDOT proposes a general Memorandum of Understanding with the Department of Ecology that specifies the conditions under which WSDOT will refer identified stormwater discharge problems to the Department of Ecology for enforcement actions under Ecology's authority. As described below, WSDOT proposes to enter into interjurisdictional agreements with local governments in order to refer for enforcement identified problems that lie within the legal authority of local government, such as changes in land use.

WSDOT believes it is inappropriate to request additional legal authority from the State Legislature because any additional authority would be identical to that which already is properly vested in either the Department of Ecology or local government, and such additional legal authority would infringe upon the powers granted to those other authorities.

3.3.10.2 WSDOT Property

WSDOT is obligated to perpetuate natural drainage and cannot refuse to accept or to convey surface water flows. Therefore, it cannot and does not require a utility permit unless a formal

connection is proposed to WSDOT facilities. All storm water drainage or utility connections from private and public property onto state highway ROW requires a utility permit/franchise. Permits are obtained according to the processes described in the WSDOT Utilities Manual. Some excerpts which reference flows, water quality, application data requirements are as follows:

1-19.01 [WSDOT] assumes liability for no more than that rate of flow which would flow toward and onto the highway right-of-way from the property in question in the undeveloped state....In those instances where [WSDOT] agrees to accept augmented flow into its system, the liability for the increased flow...shall remain with the Utility.....

1-19.02 The Utility...shall assume all responsibility and liability for the water quality of this runoff. This includes water quality both during and after development of the property in question.

1-19.03 The Utility...shall be responsible for compliance with all existing and future rules, regulations, ordinances and resolutions of the applicable local agency and Ecology with regard to drainage, and land use associated with drainage and water quality. All local agency permits associated with drainage in any manner shall be made part of the applications for the permit or franchise from [WSDOT] unless local agency approval is contingent upon a [WSDOT] issued permit or franchise.

1-19.07 The application.... shall be accompanied with the following information:

1. Statement of Criteria A summary of criteria that are used in the drainage design for the property in question. If storm water management principles are used in the drainage design, this criteria should be included.
2. Contour map All contributing drainage areas should be outlined on the map.
3. Plan and profile indicating:
   - Location and details of connection to highway drainage system, oil separators, flow restrictors, siltation basins, detention ponds and any other devices that may be part of the drainage system for the property in question;
   - Complete hydrological and hydraulic calculations;
   - Details of temporary erosion control measures.

It is WSDOTs intent to use the following implementation procedures for issuance of utility permits and franchises in the future within the Island-Snohomish, Cedar-Green, and South Puget Sound NPDES MS4 permit areas:

Utilities or jurisdictions which have pipes, culverts, or ditches which conveys source(s) other than stormwater or natural base flow shall not be granted a utility permit or franchise for conveyance using WSDOT storm sewer systems, including roadside ditches.

Utilities or jurisdictions using WSDOT storm sewer systems for conveyance of off right of way stormwater or natural base flow shall provide water quantity and quality controls, including conveyances, which conform to specifications in *Storm Water Management Manual for the Puget Sound* or local stormwater design guides or ordinances, if more stringent.

3.3.10.3Industrial and Commercial Facilities

Dischargers of stormwater associated with industrial activity identified under 40 CFR δ122.26(b)(4)(i) through (x), are required to apply for a NPDES stormwater permit through an individual permit, group application, or seek coverage under a promulgated stormwater general permit. The Department of Ecology has implemented these requirements for the State of Washington through the Baseline General Permit For Stormwater Discharges Associated With Industrial Activities. The regulations require specific industrial facilities, which discharge stormwater associated with industrial activity, to obtain a NPDES and State Baseline General Permit. The most significant requirement associated with these permits is the development of a Stormwater Pollution Prevention Plan (SWPPP). The purpose of the SWPPP is to reduce, eliminate, or prevent the pollution caused by stormwater through the application of best

management practices. Unless requested, submission of a SWPPP by an industrial facility to Ecology is not a requirement.

Whenever WSDOT identifies, or is informed of stormwater discharges to WSDOT's MS4 systems from an industrial facility, whether covered or required to be covered under NPDES regulations or not, field reconnaissance may be performed, if appropriate, to verify and/or delineate the problem. This investigation will focus on material storage and loading practices, vehicle fueling operations, the presence of non-stormwater (process and nonprocess wastewater) effluent, and structural control measures for controlling stormwater runoff. If a potential deleterious impact to water quality is identified, WSDOT will initiate the following action items:

1. Formally communicate directly with the owner/operators of the facility through official channels to discuss potential solutions and work cooperatively to resolve the situation,
2. If resolution is not achieved in step 1, WSDOT will contact the local authority or Ecology, if appropriate, to participate in and continue with the mediation process with the owner/operators of the facility,
3. If resolution is not achieved through steps 1 and 2, WSDOT will officially request that Ecology exercise its authority to require the submission of a SWPPP by the facility according to Special Condition S9 of the Storm Water Baseline Permit or take other enforcement actions determined to be appropriate.

Where WSDOT leases State right-of-way that is not required for highway purposes to commercial facilities, it includes as a condition of any such lease that the lessee comply with all applicable federal, state and local regulations. These would include the need to obtain any applicable NPDES permits, and other regulations related to stormwater control. WSDOT does not have the authority to impose penalties for violation of such regulations. WSDOT proposes that it will refer violations of such regulations to the appropriate enforcement authority, either the Department of Ecology or local government, in accordance with the Agreements described above. Using its best professional judgment, WSDOT proposes that it will terminate leases for such violations in egregious cases.

3.3.10.4Interagency and Interjurisdictional Cooperation and Agreements

WSDOT works to comply with a wide variety of local, state, tribal, and federal environmental regulations. Increasingly, WSDOT is taking responsibility for stormwater program implementation by developing co-operative agreements with state resource agencies and operating under general permits. The benefit of interagency cooperation is reduced delays in project development and efficient use of staff time in complying with environmental regulations. WSDOT will use interagency mediation processes and intergovernmental agreements whenever necessary to address off-site discharges and cross-connected drainage systems when a water quality or water quantity problem has been identified.

WSDOT proposes cooperation from NPDES permittes and other jurisdictions by requesting the following:

> WSDOT is requesting that jurisdictions will use their environmental review and permitting authority whenever development and redevelopment occurs. This consists of requiring stormwater controls per the minimum guidance provided in *Storm Water Management Manual for the Puget Sound* or Ecology-approved sections of a local stormwater design manual. Jurisdictions will notify WSDOT before variances are provided which will result in discharges to WSDOT's MS4 system that would 1) result in design flow rates exceeding the hydraulic capacities of stormwater BMPs and/or stormwater conveyance structures, or 2) result in water quality parameters violating Washington State standards as per WAC 173-201A-030. Jurisdictions will consider the cumulative impacts of storm water loading for both quantity and quality from existing and projected land use changes. In addition, Ecology or the jurisdictions will notify WSDOT whenever Industrial Storm Water or Construction Baseline Permits are issued or when dischargers are involved in an environmental regulatory compliance or enforcement activity within areas that would affect WSDOT's MS4 drainage

system. This will serve as notice to WSDOT personnel to be aware of potential illicit discharges and alert WSDOT to situations which may require additional conditions in regards to issuing utility permits/franchise. WSDOT shall notify the jurisdictions or Ecology for purposes of initiating enforcement actions when it discovers violations of water quality related regulations by an individual or entity permitted by WSDOT.

3.3.10.5WSDOT - Ecology Proposed MOU

The Washington State Department of Ecology (Ecology), the delegated agency responsible for enacting the provisions of the CWA within Washington State, and WSDOT propose a memorandum of understanding concerning program / permitting requirements, jurisdictional boundaries, and enforcement actions with regard to the NPDES stormwater discharge program requirements. WSDOT does not currently have jurisdiction over flows which originate outside of the WSDOT right-of-way; instead it will negotiate the terms of enforcement with Ecology or the local jurisdiction which posseses enforcement authority.

With regard to storm water discharges that are discharged directly to ground water (via water quantity BMPs) or indirectly by surface water/phreatic zone interactions, Ecology has authority under RCW 90.48.030 to control pollution from stormwater discharges to groundwater through this permit. All field characterizations, management program developments, and future program implementation will address discharges to groundwater in the same context and format as discharges to surface waters.

3.3.10.6Summary

This section details implementation procedures that will be used by WSDOT to acheive the objectives listed in the MS4 permit with regard to legal authority:

Permit Condition S.7.B.3.a.i - WSDOT will implement the procedure outlined in section 3.3.10.3 to control discharges associated with industrial activities.

Permit Condition S.7.B.3.a.ii - WSDOT will negotiate with Ecology or the local jurisdiction(s) to utilize their existing legal authority to prohibit illicit discharges.

Permit Condition S.7.B.3.a.iii - WSDOT will negotiate with local enforcement authorities, enter into agreements with local jurisdictions, as in section 3.3.10.4, use its utility permitting/franchise authority and associated implementation procedures, as in 3.3.10.2, to control the discharge of spills or disposal of material other than stormwater into WSDOT's MS4.

Permit Condition S.7.B.3.a.iv - The proposed interagency agreement among permittees is detailed in section 3.3.10.4.

Permit Condition S.7.B.3.a.v - WSDOT will utilize use its utility permitting/franchise authority and associated implementation procedures, as in 3.3.10.2, and interjurisdiction agreements to require compliance with conditions in ordinances, permits, contracts, or orders.

Permit Condition S.7.B.3.a.vi - Same as in Condition S.7.B.3.a.v.

3.4 Fiscal Analysis

40 CFR 122.26(d)2.vi

Expectations Document S7.B.5

WSDOT, under the direction of the Transportation Commission, works closely with the public, the state Legislature, the Governor, and the Federal Highway Administration to prioritize projects, budget its resources, and set policy direction.

The accounting and budget methods used at WSDOT are not conducive to tracking stormwater management on a watershed basis. Significant administrative effort is needed to evaluate options for tracking base level activities in relation to new responsibilities mandated by the NPDES permit.

Environmental staff and budget personnel have used professional judgment to identify costs and funding sources for purposes of developing the permit application.

Below is a summary of revenue sources available to WSDOT and a discussion of the trends in revenue projections and biennium budgets. This information will provide some context for understanding WSDOT's ability to meet environmental responsibilities, and the tradeoffs that may occur. Seven major budget line items have been identified and will serve as an indicator of program expenditures. The rationale used for developing projected expenditures for New Construction, Retrofits, Sampling, Research, Training, Maintenance, and Administration is included along with a five-year proposed budget. Specific budget information is included in the Management Program and Sampling Sections.

3.4.1 WSDOT's Revenue Sources

Revenues from state motor vehicle fund taxes and fees provide about 40 percent of the total funds in supporting WSDOT's budget. The state gas tax and motor vehicle license fees are the major sources of funds that support the state's highway construction and maintenance programs, as well as planning and administrative costs.

Bonds provided about two percent of the budget. They are issued to supplement other revenues for the highway construction and rehabilitation program. Historically, federal funds have paid for almost 45 percent of the WSDOT's total transportation budget. Two percent of WSDOT's budget is funded by payments received from local governments, primarily cities and counties. These funds are provided mainly to reimburse WSDOT for construction projects on city and county roads undertaken in conjunction with state highway projects and other work done on behalf of cities and counties by WSDOT.

1. ISTEA - The Intermodal Surface Transportation and Efficiency Act of 1991 provides Federal funds for a variety of transportation systems and directs Regional Transportation Planning Organizations to evaluate and rank transportation improvement projects. One category that is eligible for this source of federal funding is stormwater management. The Puget Sound Regional Council has published the Transportation Improvement Program. This consists of a two volume set of transportation projects proposed for three years (1994-1996). As part of 2SHB-2031, passed during the 1996 legislative session, $700,000 in redirected ISTEA funds will be allocated through a committee to local governments to address water quality and quantity problems associated with highway stormwater runoff. The committee will consist of members from WSDOT, cities, counties, Ecology, and environmental groups.

2. Decision Packages - A decision package is a request to the State Legislature that identifies additional money and FTE needs above the current spending level to meet performance requirements. Program Offices submit decision packages for consideration during every odd year legislative session. Decision packages lend themselves to specific projects that do not fit in the standard budget categories and are new, short term expenditures. Nine decision packages were approved for the 1993-1995 Budget, one of which funded the $650,000 Outfall Inventory and Field Screening Project. The 1995-1997 biennial budget allocated WSDOT's Water Quality Unit a total of $234,000 to comply with NPDES provisions, including $48,000 in NPDES permit fees. This amount for future biennia is considered the current law funding level to support NPDES program compliance activities and will be maintained. The Water Quality Unit is in the process of requesting additional funding for the 1997-1999 biennium to fund additional NPDES program activities, and they are listed below.

3. Grants - The Federal Government via agencies such as EPA and DOT-FHWA, occasionally for innovative projects that combine transportation and water quality benefits. Also Ecology through the Water Quality Grants program, occasionally makes available to local government agencies, (or state agencies that are co-applicants) funds to implement innovative water quality projects. WSDOT will accelerate its efforts to acquire grant funding for innovative programs, particularly water quality research.

4. Highway Disaster Funding - Under the Federal Highway Disaster Fund Program (FHWA, Title 23), if a stormwater outfall, culvert, or appurtence is damaged during a flood event, federal funding may be available to replace the structure to current standards. Through this program a “betterment” of a BMP, i.e. upgrading an older BMP with one built to HRM standards, may be possible. WSDOT will examine the possibility of using disaster funds for BMP improvements whenever a flood event occurs.

5. Public/Private Partnerships - Given the shrinking state budget for transportation needs, WSDOT is trying to facilitate the use of private capital for partnership projects. Where economic development is placing demands on the transportation system, the local developers or government jurisdictions may organize a funding package that includes a variety of contracts and agreements in order to construct a needed project in a timely manner.

3.4.2 WSDOT Budget Analysis for the 1995 - 2000 Term of the Island-Snohomish, Cedar-Green and South Puget Sound NPDES Permits

WSDOT is budgeted on a bienniel basis during odd-numbered years. WSDOT is currently positioning itself to request funding for the 1997-1999 budget period. All budgetary elements must be approved through the LTC and the State Legislature. It must be noted that all decision packages denoted as "agency request" are highly dependent on an increase in the Washington State Motor Vehicle Fund through a gas tax increase for the 1997-2000 period.

3.4.2.1 1995-2000 Expenditure Estimates For Non-Maintenance WSDOT Stormwater Management Activities

1. Decision Packages

(A) 1995-1997 Biennium		
NPDES Permit Fees	$46K	
Stormwater Monitoring	$188K	
(B) 1997-1999 Biennium Requests		
Snohomish Basin Pilot Project	$200K	Current Law, Essenial Requirement
ESSHB 2031 Stormwater Admin	$200K	Current Law, Essential Requirement
Stormwater Monitoring	$200K	Current Law, Essential Requirement
Stormwater Technology Transfer	$275K	Current Law, Agency Request
ESSHB 2031 Stormwater Grants	$2M	Agency Request
Stormwater Retrofits	$11.1M	Agency Request
Revolving Loan	$10M	Agency Request
Project Scoping-Advanced	$17M	Agency Request
(C) Year 2000 Estimates		
Snohomish Basin Pilot Project	$100K	(speculative - assuming 0% increase)
ESSHB 2031 Stormwater Admin	$100K	(speculative - assuming 0% increase)
Stormwater Monitoring	$100K	(speculative - assuming 0% increase)
Stormwater Research	$137.5K	(speculative - assuming 0% increase)
SSHB 2031 Stormwater Grants	$1M	(speculative - assuming 0% increase)
Stormwater Retrofits	$6.65	(speculative - assuming 0% increase)
Revolving Loan	$5M	(speculative - assuming 0% increase)
Project Scoping-Advanced	$8.5M	(speculative - assuming 0% increase)

2. Environmental Research Budget

(A) 1995-1997 Biennium **$285K** on environmental research benefiting Puget Sound NPDES areas

(B) 1995-1997 Biennium	I-5/Lk Union Brdg. BMP testing facility	$100K
	DuPont I/C grndwater monitoring wells	$56K
	Hydromodification of stormwater ponds	$35K
	ESC test sites	$30K
	SR 205 enhanced biofiltration swales	$10K
	Total	**$231K**

(C) Current Projects — Water Quality (*) — $330K (filter strip 90K,conf. BMP 75K, C/B 75K,Coag. 90K)

(*) Washington State University has **$450K** NCHRP grant for wetpond research, directly related to WSDOT projects. WSDOT research on confined space BMPs and Coagulants will continue into the 97/99 biennium.

(D) 1997-1999 Biennium — $75K soil additives (high probability)
$75K C/B for bioengineering (high probability)
$150K total

(E) 2000 — $370,000 (estimated assuming 0% increase in funding)

3. Local Jurisdiction - Stormwater Utility Fees (Total = $1.2 million, plus)

- In 1995, WSDOT paid over **$886K** in stormwater jurisdictions within the Puget Sound Basin, $**983K** statewide. Payments will are assumed to remain the same during the 97-00 period.
- **(2) FTEs** are dedicated to developing and maintaining NPDES permits **(110K).**

4. Stormwater System and BMP Expenditures (93/95 Total = $81 million)

1995-1997

Statewide		Puget Sound NPDES (60%)
(*) Stormwater Mgt. (New impervious)	$66.8 million	$40.0 million

1997-2000

Statewide		Puget Sound NPDES (60%)
(*) Stormwater Mgt. (New impervious)	$100.2 million	$60.0 million

(*) 95/97 estimates total **$60 million** statewide, **$36.4 million** for Puget Sound NPDES areas. Excluded from this amount is **$37K** left over from construction funds to be used for 2SHB2031.

5. Environmental Permits Coordination (Total = $256K)

1996 Expenditures	Statewide	Puget Sound (60%)
Permit Liaison EAO	$106K	$64K
Permit Liaison ECY	$150K	$90K
Total	**$256K**	**$154K**

6. Additional Grant Funded Activities (Total = $994K)

EPA	Assessment of Mitigation Alternatives/Sno Basin	$25K
EPA	Statewide Sensitive Area Groundwater Map	$69K
EPA	Wetland Mit/Decision-Making Guidance - Proposed	$200K
ISTEA	2SHB2031 Implementation	$700K
Total		**$994K**

7. Roadside Maintenance of WQ BMPs (Total = $6.5 million, *Puget Sound Only*)

7/95-6/96	$3,403,590
7/96-6/97	$3,186,952
Biennial Total	**$6,590,542**

8. GIS Decision Packages (Total = $2.433 million)

GIS Admin & Development Support (2 FTE)	$289K	Current Law
GIS Base Map Maintenance & Enhancement (1FTE)	$189K	Current Law
GIS Infrastructure Base (3FTE)	$837K	Agency Request
• Infrastructure Base (1FTE)		
• Development of GIS DB application (consultant)		
• Support to Regions (2FTE)		
• GIS Admin & Dev Support - Extended(8FTE)	$1.118M	Agency Request
• Infrastructure-Extended (adds a test server)		
• GIS Support to Regions - Extended (5FTE)		

Table 25 - WSDOT Stormwater Management Plan Budget Estimates for Stormwater Activities 1995-2000 (in thousands)

Program Element	'95-'96	'96-'97	'97-'98*	'98-'99*	'99-'00**
Stormwater BMP Construction in Highway Improvement Projects	$20,000 (1)	$20,000 (1)	$20,000 (1)	$20,000 (1)	$20,000 (1)
Snohomish Basin Project	0	0	$100	$100	$100
2SHB 2031 Program - Administration	0	0	$100	$100	$100
2SHB 2031 Grants	$700	($1,000)	($1,000)	($1,000)	($1,000)
Stormwater Characterization and BMP Monitoring	$94	$94	$100	$100	$100
NPDES Permit Fees	$46	$46	$46	$46	$46
Stormwater and BMP Research Programs	$142.5	$142.5	$82.5	$82.5	($100)
I-4 Stormwater BMP Retrofit Projects	0	0	($5,550)	($5,550)	($6,600)
Stormwater Research Implementation	0	0	($137.5)	($137.5)	($137.5)
Stormwater Utility Fees	$886	$886	$886	$886	$886
Stormwater Systems Maintenance & Operations	$2,587.3	$2,587.3	($2,815.2)	($2,815.2)	($2,815.2)

Those budget elements listed in (parentheses) are agency request decision packages and are dependent on on increase in the Motor Vehicle Fund through a gas tax increase.
(1) - Estimated at 5% of total project costs.
* Speculative estimate based on developed budgets
** Highly speculative estimate based on 0% increase from 1997 levels

3.4.2.1 Maintenance and Operations Budget Estimates and Future Commitments to Stormwater-Related Service Objectives

The 1997-1999 budget request includes increases to the 1995-97 base to accommodate system additions and service delivery increases. These requested increases will provide necessary resources to maintain the current level of service, i.e., the 1995-97 level of expenditure.

WSDOT Maintenance and Operations will request the first of three increases for the identified activities over the next three biennia. The requests will ultimately result in an overall

maintenance level of service to strive toward fulfillment of the identified un-met program needs.

The Legislature has directed WSDOT that the additional funds granted in 1997 will be applied to Washington's transportation infrastructure, and will lower life-cycle costs for some high-priority roadside maintenance activities. If the legislature grants any additional funds to maintenance of the highway system, such funds will be applied to maintenance activities that will improve safety for the traveling public and will increase the protection of taxpayer's investment in Washington's transportation infrastructure.

Specific maintenance activities targeted for increases - selected because of their identified priority and current less-than-desirable performance levels - include: snow and ice control, pavement patching and repair, pavement striping, grading and cleaning ditches and maintenance of culverts.

If the requests are granted WSDOT's stormwater management program will be enhanced over current levels 19% for grading and cleaning of ditches and 108% for maintenance of culverts.

ACTIVITY	CURRENT $ /YR	1997-99 $	% Increase
Grade and Clean Ditches	305,516	363,000	19%
Maintain Culverts	157,636	328,000	108%

WSDOT will request funding adequate to maintain the current level of all other stormwater maintenance components for the 1997-1999 biennium. Any further increases to the curent funding will be based on direction from the Legislature.

3.5 Assessment of Controls

40 CFR 122.26(d)2.v

3.5.1 Accidental Discharges - Spill Prevention and Containment

Current and Proposed Program:
Emergencies that Maintenance Crews encounter most frequently are associated with transportation accidents and less frequently with natural disasters (slides, floods, fires, wash-outs). The goal of WSDOT incident/emergency response program is to facilitate traffic control under the coordination of the Washington State Patrol (WSP). Although hazardous materials control activities by the Department are limited, certain environmental benefits are attained. For example, emergency response vehicles are equipped to pump diesel from saddle tanks on diesel trucks that have been in an accident.

WSDOT staff are to take only the emergency actions required to protect human life and property until the WSP has gained control of the situation. The WSP has the responsibility for safety measures and coordination of the clean-up of spilled substances.

WSDOT maintenance crews are instructed to perform the following upon encountering a hazardous condition on the roadway:

1. Advise WSP and the WSDOT Maintenance Area Superintendent.
2. Take sufficient precautions for protection from continued exposure to the hazardous condition.
3. Physically close the highway or restrain traffic from entering the hazardous area.
4. If the spilled substance is identified and is spreading toward additional traffic lanes or is likely to cause groundwater damage, take limited actions to absorb or confine the spill, using careful judgment. Avoid contact with any substance known or unknown.

5. Remain in the area to assist traffic control until traffic control devices have been installed or the crew member is relieved by a maintenance foreman, maintenance lead technician or a WSP trooper.
6. Report all hazardous materials incidents occurring on the highway to the Washington Department of Ecology. When reporting, provide as much information as possible, including:
   a. Caller name and call back number;
   b. On-scene contact person;
   c. Location and description of event;
   d. Name of material released or any identifying information;
   e. Status of the spill event;
   f. Any life threatening situation, and container type, labels, truck/rail car number, shipping papers, or other identifying information.

A number of emergency spill tracking systems are available to WSDOT to assist the Water Quality Program with identifying high risk spill sites along state routes. Both the WSP and Department of Community Development (DCD) receive complaints or reports regarding spills that have occurred statewide. The DCD forwards spill records to Ecology, which maintains a database for tracking spills. Ecology's Environmental Report Tracking System (ERTS) contains 42 field of information, which includes not only incidence information but also information obtained from spill investigations. Ecology forwards information related to highway accidents to WSDOT's Transit Research and Intermodal Planning Section (TRIPS) for their comprehensive database on accidents. this information is evaluated when prioritizing outfalls for retrofits. In addition, safety improvements can be made at sites where frequent accidents occur.

Evaluation: Success of this program will be measured by continuing funding levels and providing control measures at the base annual level.

A hazardous materials database, which documents the SR, milepost, hazardous material, spill volume, damage estimates, and injuries related to each incident involving hazardous materials is maintained in WSDOT's Transportation Information and Planning Support system. Results from this database will be listed in WSDOT's annual NPDES report.

Schedule: FY 1996-2000 - No funding increases in the current programs are expected.

3.5.2 Maintenance of Structural Controls and BMPs

Current and Proposed Program:
The proposed program will consist of efforts directed toward a continuation of the current levels of service and funding. Adjustment in service levels and priorities will be made where additional (new) highway facilities must be maintained and where additional funding is made available.

A limited allocation of dollars and labor hours are made available to the Regions each biennium and are based on previous biennium expenditures plus funds needed for additions to the system. Future biennium levels may be reduced if projected revenue does not equal past years' revenue.

SWMP effectiveness of maintenance activities for structural stormwater controls (i.e., catch basins, oil/water separators, and channel conveyance systems) can be measured both qualitatively and quantitatively . Each of these measures is discussed in the following paragraphs.

Catch basins and oil/water separators are inspected and cleaned annually or on an as needed basis (see Maintenance Program). Qualitative SWMP effectiveness monitoring for catch basins and oil/water separators include the following activities:

a. Reporting needed repairs or unusual visual observations (i.e., antifreeze, excessive oil, odor, illicit dumping), and;

b. Tracking corrective actions for problems identified in these reports.

Quantitative SWMP effectiveness monitoring for catch basins and oil/water separators include sampling to identify effects of changes in operation/maintenance practices on water/sediment quality.

Channel conveyance systems are inspected twice a year and, if needed, maintained annually for adequate channel conveyance and function. SWMP effectiveness monitoring for channel conveyance systems includes the following activities:

a. Reporting needed repairs (i.e., structural, erosion, vegetation repair, etc.) or unusual visual observations (i.e., excessive sediment buildup, odors, illicit dumping or discharge)

b. Tracking corrective actions for problems identified in these reports

c. Sampling to identify effects of operation/maintenance practices or changes in these practices on water/sediment quality.

Activities for operating/maintaining highways include roadway sweeping, snow and ice control, and application of pesticides, herbicides and fertilizers. SWMP effectiveness monitoring for these activities include the following:

a. Reporting the status of research activities that explore development of environmentally safe and cost-effective chemicals used in ice control activities.

b. Development of a data base system to track the amounts of pesticides used in correspondence to the acres applied.

c. Sampling to identify effects of changes in practices (i.e., application) on water quality.

Maintenance crews report any sites that require repairs or where unusual water or sediment characteristics have been observed. Documenting and improving the reporting procedures will aid in increasing SWMP effectiveness. Tracking the action taken to correct the reported problems will aid in monitoring WSDOT effectiveness in water quality improvement from the highway system (see Maintenance Program).

As changes in operation/maintenance practices are identified, a sampling program can be developed to monitor the effects on water/sediment quality. This program can be developed and implemented by WSDOT Water Quality Unit with assistance and input from Operations Highway Maintenance on identifying changes in operation/maintenance practices.

Evaluation of Controls:
The effectiveness of the program is dependent on funding. Current or increased funding will maintain a roadway drainage system that is adequate and protective of the environment. Monitoring of certain BMPs will measure the effectiveness of the structure design and effectiveness of maintenance activities.

WSDOT's Northwest Region, which covers the Cedar-Green and Island-Snohomish permit areas, is conducting an inventory of vaults, catch basins, and other drainage features throughout the Seattle area. This inventory includes locating each drainage feature using geographic positioning system technology and has been compiled into a database. This database will be reformatted for inclusion in WSDOT's ArcView GIS system.

Data on numbers of catch basins cleaned, highway lane miles swept, and numbers of drainage facilities (including BMPs) maintained will be tabulated and listed in WSDOT's annual NPDES report.

Schedule:

FY 96-97 - Continuation of current service levels.

FY 97-99 - To Be Determined by Legislative Policy and Funding. Funding for maintenance activities and equipment is allocated based on the previous year's expenditures. Adjustment in service levels and priorities will be made where additional (new) highway facilities must be

maintained. A limited allocation of dollars and labor hours are distributed each biennium and are based on the previous biennium plus additions to the highway system. Future biennium levels may be reduced if projected revenue does not equal past years. Expenditures for specific tasks are tracked within each Region maintenance area. Funding requests are approved and awarded by the Region Administrator based on general needs as indicated by the Maintenance area superintendents.

3.5.3 Construction Site Controls

WSDOT has developed an ongoing Erosion Control Education and Training Program to implement the Highway Runoff Manual guidance. The goal is to prevent discharge of contaminated stormwater from construction sites. The Olympia Service Center Hydraulic and Water Quality Unit will continue to coordinate the Program.

1. **Highway Runoff Manual** - Temporary Erosion and Sediment Controls: Continue to update and improve the Highway Runoff Manual as BMP designs develop to increase effectiveness and new BMPs are added. Promote use of HRM design protocol statewide. It serves to streamline the permitting process by documenting operating procedures so that WSDOT can provide "self-enforcement". Updates will be added in order to stay consistent with the Stormwater Management Manual for the Puget Sound Basin and Ecology's Stormwater Management Manual. To facilitate cross-referencing among WSDOT Manuals, updates will be recommend for the following manuals: 1994 Standard Specification for Road, Bridge, and Municipal Construction; Hydraulics Manual; Design Manual; and Construction Manual.

   Schedule: Completed in January 1995. Will provide annual updates as necessary

   Evaluation of Controls: The quality and applicability of TESC plans included in the SSP will indicate whether the plan preparers are correctly implementing the HRM guidelines. Reviewers of SSPs can be queried to determine trends in compliance with the Minimum Requirements listed in the HRM.

2. **Erosion Control Program**: Develop an annual training program on Erosion Control which meets the needs of Designers, Plan Reviewers, Inspectors, and Contractors. Feedback received from participants in the previous training workshops will be evaluated and used to guide development of future training efforts.

   Evaluation of Controls: Determine total number of personnel involved in implementing the Erosion Control Program and assess level of training they have previously received. Determine if the training program is meeting the identified needs by comparing participant list with needs list. Furthermore, course evaluations forms will be evaluated to determine if teaching style and course material was suitable for participants.

   Schedule: FY 95-99 Implement Annual Training Event for Highway Designers and Construction Contractors.

3. **Participate and Initiate Research Efforts to Identify Effective Temporary Erosion Control Methods and Practices**. WSDOT will apply for grant money through federal and state agencies to initiate research projects to determine the effectiveness of TESC controls and to evaluate new and innovative TESC products.

   a. An Internal Materials Review Committee in cooperation with WSDOT's Materials Lab evaluates new products submitted by Manufacturers. Priority items to be reviewed include filter fences and erosion control matting.

   b. Develop communications through the world wide web to distribute new information in a timely manner. Given the remote office locations for WSDOT personnel involved in Erosion Control, communication can be facilitated by utilizing a wide area network server.

   Schedule: Continuing. Will be incorporated into future research programs and grant proposals.

Evaluation of Controls: The efficiency with which new products or methods can be evaluated, approved, publicized, and used determines the success of an applied research program. Case histories should be maintained to determine improvements in WSDOT's technology transfer system. The number of special provisions developed to accommodate new products serves to document trends in construction practices.

4. **On-Site Technical Assistance**: Develop ability to provide on-site technical assistance to Project Inspectors. The Water Quality Unit will establish an FTE position in 1996 to facilitate Erosion and Sediment control inspections on a continuing basis. This staff member will make field visits to construction sites to evaluate implementation of the TESC plan and the effectiveness of TESC construction and maintenance. This will provide the Dept. the opportunity to share successful experiences and develop consistency in program implementation.

   Schedule: Continuing

   Evaluation of Controls: A log book and database which documents field observations, experiences, and questions to be resolved shall be maintained by the Water Quality Unit. Trends in implementing the TESC plans will become evident and will help in determining deficiencies the Erosion Control Program. In addition, statistics on enforcement actions taken against WSDOT will be maintained.

5. **Construction Site Monitoring**: Evaluate the results of Construction Site Stormwater Monitoring Plan to be implemented at the SR 18 Auburn Black Diamond to SE 312th Construction Project by the Cedar River. Turbidity and Total Settleable solids has been monitored to determine effectiveness of the erosion control measures. Because of the sensitive nature of the receiving body of water in this area, the monitoring activity was required as a special provision of a King County Grading Permit.

   Schedule: Completed in FY95. Will continue the program and modify to incorporate changes to the program.

   Evaluation of Controls: A final report will be developed to summarize the experience gained in implementing the Sampling Plan and how the results influenced site management. Estimates of total TESC BMPs and evaluations of their effectiveness will be listed in WSDOT's annual NPDES report.

3.5.4 Illicit Connection Identification and Removal

Proposed Program:
Enhance Utility Permitting Activities to support WSDOT's Stormwater Management Program. The goal of the proposed program is to reduce the Department's liability for off-site pollution contributions, and encourage users of WSDOT's drainage system to use and maintain stormwater best management practices through a self-policing program.

1. Evaluate the Stormwater Drainage component of the Utility Manual and determine if edits are needed to reduce stormwater liability related to quantity and quality issues. Issues to evaluate include: a) cancellation and re-issuance of permits; and b) adding Special Provisions to document quantity and quality data.
2. Evaluate Utility Permit data bases, and Olympia Service Center Utility Franchise Inventory database, and determine how to access information to support the Stormwater Program.
3. Evaluate the resources needed to identify un-recorded stormwater connections and bring discharges into the Utility Permit program.
4. Evaluate the efforts of local jurisdictions to notify WSDOT of potential discharges during local review of construction projects when grading and building permits are issued.
5. Evaluate efforts needed to obtain drainage information on local roads that are relinquished to the State for operation and maintenance.

Schedule:

FY 94-96: Develop recommendations related to utility program.

FY 96-99: Implement recommendations.

Evaluation of Controls:
Success with this program can be evaluated by reporting: 1) statistics on new and re-issued drainage Utility Permits; 2) efficiencies gained by better data base management; and, 3) case history reports of regulatory responses to suspected illicit connections.

Numbers of newly discovered illicit connections and corrective actions will be listed in WSDOT's annual NPDES report.

3.5.5 Maintenance Practices for Operating Highways

Proposed Program:
The proposed program will consist of efforts focused toward a continuation of the current levels of service. Adjustment in service levels and priorities will be made where additional (new) highway facilities must be maintained or additional funds are made available.

Evaluation of Controls:
The primary purpose of the application of road abrasives and deicing chemicals is to provide for safe passage on the highway system. Fewer accidents and less driver inconvenience are the main measure of the effectiveness of the program. Minimization of system user complaints on damage to vehicles through abrasive application is a goal of the Department. Improvements related to environmental consequences through snow and ice control activities are measured qualitatively in the field by maintenance personnel and through the development of new and improved deicing chemicals.

Volumes of abrasives and deicing materials by road mile for the permit areas will be listed in WSDOT's annual NPDES report.

Schedule:

FY 95-97: 10% reduction previous program funding.

FY 97-99: Pervious year's level of expenditure and activity.

3.5.6 Integrated Vegetation Management

Proposed Program:
The overall direction of WSDOT's vegetation management program adopts an integrated approach by:

1. Defining the long term goals and objectives in Roadside Management Plans (RMPs);
2. Documenting of the rationale behind management decisions;
3. Tracking the efficacy and cost of chosen control methods;
4. Identifying environmentally sensitive areas;
5. Commitment to reduce the use of chemicals because of potential or perceived environmental impacts; and
6. Establishing stable, native vegetation in roadside management zones thus reducing the amount of active management necessary to control the area.

Evaluation of Controls:

Success of this program can be evaluated by reduction in the area requiring annual treatment after five years, once stable, beneficial vegetation is established. Inventories of the volumes and types of pesticides used in maintenance operations will be documented in WSDOT's annual NPDES report.

Schedule:

FY 95-97: Estimated 72.3 percent or less of the treatable roadside acreage will be treated using pesticides annually through establishment of long term vegetation and management strategies based upon prevention.

FY 97-2000: The goal is to achieve a stable plant community on 38.5 percent of the total treatable roadside acreage.

3.5.7 BMP Monitoring and Research

Proposed Program:
WSDOT's Water Quality Unit will be evaluating the effectiveness of stormwater controls through its BMP monitoring and research programs. The probability distribution functions, including central tendencies and performance ranges, of the pollutant removal effectiveness of BMPs will be determined. Evaluating BMP performance quantitatively will allow WSDOT to modify BMP designs to optimize performance. The factors which will be examined to enhance pollutant removal effectiveness include:

- Detention time effects. Modifying BMP dimensions to increase effective treatment or contact times for all hydraulic loading rates.
- Vegetation type and density factors. Identify the effects that vegetation types (e.g. metal accumulators vs. excluders, wetland vs. terrestrial plant types) and vegetation density have on pollutant removal rates. These factors may be critical factors for the effectiveness of vegetative filter strips, biofiltration swales, and constructed wetlands.
- Hydraulic distribution. Structural modifications designed to impede hydraulic short circuiting through stormwater BMPs.
- Chemical and matrix composition enhancements. Research chemical reactions within BMPs and devising methods to enhance pollutant removal and retention rates. Some examples include: the use of chemical coagulants to enhance particulate removal, soil amendments to infiltration BMPs to improve metals encapsulation, high sorption filtration media compositions, etc.
- Operations and maintenance factors. BMPs that require extensive maintenance to be effective will not be constructed on a system-wide basis.

Evaluation of Controls:
Statistical databases of removal efficiencies for the operational range of precipitation events. Conclusions and decisions will be detailed on those design factors which enhance pollutant removal efficiencies in structural BMPs. The initial phases of BMP monitoring will focus primarily on the removal of particulate matter in stormwater runoff, since most of the pollutants of concern in highway stormwater runoff are conservative and sorbed to suspended solids, such as heavy metals and PAHs. The second phase of BMP monitoring and research program (still in the planning stages) will concentrate on BMPs that reduce dissolved and non-conservative pollutants in highway runoff, such as nutrients, temperature and oxygen demand.

Numbers and types of BMPs constructed and their net affects on pollutant loading will be tabulated and reported in WSDOT's annual NPDES report.

Schedule:

FY 95-98: BMP monitoring and research for solids removal BMPs, including: vegetative filter strips, ecology ditch, ecology embankment, Stormceptor™ vault, confined space filtration unit, enhanced water quality wet pond, et. al.

FY 98-2000: BMP monitoring and research will continue and emphasis will be placed on removal of dissolved and non-conservative pollutants.

3.6 Personnel, Equipment, and Resources to Implement WSDOT's Stormwater Management Plan

Expectations Document S7.B.5

CFR 122.26(d)2.iv

3.6.1 Personnel, Equipment, and Resources - NPDES Programs, Design, and Hydraulics

The Water Quality Unit of WSDOT's Olympia Service Center will coordinate the development, tracking, documentation, and implementing the elements of WSDOT's Stormwater Management Plan. From the start of WSDOT's NPDES program 1992 until 1996, the Water Quality Unit had two full time employees (FTEs), a Water Quality Program Manager and a Water Quality Specialist that facilitated program development. During this period many of the field operations, databasing, background research, and documentation tasks were performed by temporary employees and interns, whose terms of employment were generally fixed in 9 month increments. WSDOT's NPDES program was often impeded by the lack of continuity in the staffing. In 1996, the Water Quality Unit will be establishing positions for 3 FTEs for those positions that were staffed by temporary employees from 1992 to 1996. Additionally, the Environmental Affairs Office will be staffing another FTE to administer the Geographic Information Systems that have been purchased and developed. These change will dramatically increase the level of consistency and continuity to implement WSDOT's SWMP and other water quality programs. The Water Quality Unit Staff and their duties will be as follows:

Table 26 - Water Quality Unit: FTEs involved in WSDOT's SWMP Implementation

Position	Duties
Olympia Service Center - Water Quality Program Administers State-Wide NPDES and Water Quality Programs	
Water Quality Unit Manager	Administration, budgeting, project development
Water Quality Specialist	Project tech. assistance, groundwater projects, BMP monitoring, NPDES program
Water Quality Specialist	NPDES program, WQ & BMP research, BMP monitoring and stormwater sampling, HB 2031
Water Quality Specialist	SSP/TESC plans, EIS - Water Quality Discipline reports, Ferry System, Snohomish Basin Project
Erosion Control Specialist	Erosion & Sediment Control Inspections, SSP / TESC plans, Erosion Control training
Water Quality Specialist	HPAs, Shoreline permits, NEPA/SEPA/404, short-term mods, NPDES, EISs, GMA
Geographic Information Systems Specialist	GIS data acquisition, analysis, spatial analysis
WSDOT Olympic Service Center - Hydraulics Unit State-Wide Stormwater Design and Technical Assistance	
Hydraulics Manager	Administration of Hydraulics Program
Hydraulics Engineers (4)	Stormwater conveyance and facility design, Project-specific technical assistance
WSDOT Northwest Region- Hydraulics Unit Stormwater System Design and Technical Assistance in the Island-Snohomish and Cedar-Green NPDES MS4 Permit Areas	
Hydraulics Manager	Administration of Hydraulics Program
Hydraulics Engineers (4)	Stormwater conveyance and facility design, Project-specific technical assistance
WSDOT Olympic Region - Environmental and Hydraulics Services Stormwater System Design, Technical Assistance, and Environmental Compliance for the South Puget Sound MS4 NPDES Permit Area	
Environmental Manager	Administration of Hydraulics Program
Assistant Environmental Manager	Assists Environ. Manager
Hydraulics Engineers (3)	Stormwater conveyance and facility design, Project-specific technical assistance

Table 27 - Water Quality Unit: Temporary Personnel and Technicians

Position	Duties
Stormwater Sampling Technician	stormwater and groundwater sampling, sample preservation, data analysis
Outfall Inventory / Field Survey Technicians (1 or 2, depending on budget and season)	Field surveying and GPSing WSDOT stormwater outfalls, drainage features, wetlands, etc.
GPS / GIS Processing Technician	GPS to database and GIS data conversion. Mapping and GIS system operations.

Planning, funding, design, construction, operation, and maintenance of WSDOT's drainage systems are accomplished by a wide variety of personnel throughout WSDOT, both in the Olympia Service Center and the Regional Offices. Hundreds of staff located in all of WSDOT's regions will be involved in implementing the various provisions of WSDOT's SWMP program. Those Olympia Service Center sections in the Program Development Division include the staff of the Environmental Affairs Office and the Hydraulics Staff of the Design Office. Additionally, highway maintenance staff in the Environmental Support and Landscape Offices will have coordinating responsibility for the Operations Division's activities, such as roadway and roadside maintenance, vegetation management, etc.

Olympia Service Center will work closely with Environmental and Hydraulics staff in WSDOT's regional offices to implement and comply with permit conditions. The increasing demands for expertise in the water quality field has resulted in the establishment of the FTEs as noted above.

The following is the list of specialized equipment that has been purchased by WSDOT to carry out its NPDES program. More equipment, such as automated samplers, may be purchased as need and funding dictates.

Equipment

Outfall Inventory / Field Survey:
(2) Trimble Pro Excel MVI™ portable Geographic Positioning System Data Logging Systems
(2) Trimble Pro Excel™ antennas
(2) range finders
Trimble Pfinder™ - GPS mapping & GIS interface processing software

Stormwater Sampling Equipment:
(6) LaMotte Model 880K™ Storm Drain kits
(3) LaMotte Model DA-1™ conductivity meters
(3) LaMotte Model DHA3000™ pH meters
(3) LaMotte Model 200B™ turbidity meters
(3) ISCO™ Model 4230 bubbler flow meters
(2) ISCO™ Model 730 bubbler flow meters
(2) ISCO™ Model 750 area-velocity flow meters
(3) ISCO™ Model 3700 automated stormwater samplers
(2) ISCO™ Model 6700 automated stormwater samplers
(2) ISCO™ Model 6700C automated stormwater samplers
(5) complete sets of sample bottles, bubbler tubes, sampler hoses for ISCO™ automated samplers
(4) ISCO™ high capacity AC power packs
(5) ISCO™ DC power packs
(8) Deep-cycle marine 12V DC batteries (for powering samplers)
(4) battery chargers (for marine batteries)

Geographic Information Systems:
(3) Gateway P5-133™ GIS computer workstations
(3) ESRI ArcView™ Version 2.1b GIS software

Computer Software for Stormwater Management
USEPA Stormwater Management Model (SWMM) for Windows
Flowlink™ PC interface to ISCO™ flow meters
Waterworks™ hydraulics water quantity model using the Santa Barbara Urban Hydrograph method

3.6.2 Personnel, Equipment, and Resources - WSDOT Operations and Maintenance Systems to Implement WSDOT's SWMP

WSDOT Regional Maintenance is divided into *Maintenance Areas.* The three NPDES permits in the Puget Sound region affect five WSDOT maintenance areas. The NPDES coverage effects each of the maintenance areas in a "patchwork" coverage, applying to separate segments of state and interstate highways. It is not possible WSDOT staff to track SWMP activities conducted within the fractional segments of roadways covered under the permit.

For example: Manual tracking of a SWMP activity for the 1.33 mile sections out of the 13.56 miles of Interstate 5 in Northwest Region Maintenance Area 4 would require additional record keeping and utilize time and effort better invested toward the identified action strategies.

In the Northwest Region: WSDOT Maintenance Area 2 has 10.11%, Maintenance Area 3 has 68.89%, WSDOT Maintenance Area 4 has 53.31% and WSDOT Maintenance Area 5 has 47.71% of the total roadway miles within the Island-Snohomish, Cedar-Green, and South Puget Sound NPDES MS4 permit coverage. The Olympic Region has 53.20% of the total roadway miles of Maintenance Area 3 within the NPDES Municipal Permit coverage.

Personnel

WSDOT had identified in previous sections of the permit the activities of the maintenance portion of the SWMP. Resource levels are defined in dollars for staff activity and equipment for all roadways within each of the WSDOT Maintenance Areas for each activity identified as the SWMP.

WSDOT has identified statewide funding levels necessary to fulfill all maintenance to the level established by the Commission. A comparison of the ideal funding level to the current funding levels provides a percentage difference estimate identifying unmet needs in dollars for each activity.

Activities are listed by order of priority identified in the Priority Matrix. Staffing levels are shown in full time equivalent (FTE) hours per activity per year.

Current Maintenance Expenditures for Stormwater-Related Service Objectives

ACTIVITY	CURRENT $ /YR		FTE Hours
Noxious Weed Control	143,356		3,582
Maintain Storm Drainage Systems	234,864	7,092	
Grade and Clean Ditches	305,516	7,182	
Maintain Culverts	157,636	4,878	
Sweeping and Cleaning	735,818	1,916	
Nuisance Weed Control	126,223	5,364	
Mowing	186,922	4,212	
Maintain Silt Basins	375,924	8,874	
Misc. Drainage Maintenance	3,193		103
Litter Pickup	306,509	13,968	
Integrated Veg. Management	9,375		225

Roadway Maintenance Equipment
For all three NPDES permit areas WSDOT has the following equipment for use in participating in the SWMP.

Equipment	
Catch basin/drainage maintenance vehicles	5
Pick up and non-pick up roadway sweepers	19
Mowers	17
Truck mounted herbicide spray vehicles	6

Equipment Description	Northwest Region Cedar-Green and Island-Snohomish permit areas	Olympic Region South Puget Sound permit area
Street Sweeping Trucks	6	1
Catch Basin Vacuum Trucks	3	1

Note: roadway maintenance work is often contracted to the private sector when necessary and when permitted by the individual contract.

3.7 References

NPDES Permit and Document Guidance

Code of Federal Regulations, Section 40, Part 122.26 (d)2.iv, *Application Requirements for large and medium municipal separate storm sewer systems. Proposed management program*. 7/93.

Washington Department of Ecology, *National Pollutant Region Elimination System (NPDES), Municipal Stormwater Permit for Cedar - Green, Island - Snohomish, & South Puget Sound Water Quality Management Areas*, 1995.

WSDOT, *NPDES Part 1 Permit Applications for Multiple Separate Storm Sewer Systems in the Cedar - Green, Island - Snohomish, & South Puget Sound Water Quality Management Areas*, 1995.

Washington Department of Ecology, *NPDES Municipal Permit Clarification of Permit Conditions*, WSDOT, 1995.

Washington Department of Ecology, City of Seattle, King County, Snohomish County, City of Tacoma, Pierce County, Washington State Department of Transportation, and City of Bellevue. *National Pollutant Discharge Elimination System Municipal Permit Clarification of Permit Conditions*. 3/95.

City of Portland, Multnomah County, Port of Portland, Oregon Department of Transportation, *Multnomah Drainage Region #1, Peninsula Drainage Region #1, Peninsula Drainage Region #2, Part 2 NPDES Municipal Stormwater Permit Application.* 5/93.

WSDOT, *NPDES Part 1 Permit Application - Columbia Gorge Water Quality Management Area*, 1996.

Puget Sound Water Quality Authority, *1994 Puget Sound Water Quality Management Plan*, 5/94.

Highway Stormwater Systems Management

Camp, Dresser and McKee, Inc., *California Best Management Practices - Municipal*, California State Water Resources Council Board, 1993.

Colorado Department of Transportation, *Erosion Control and Stormwater Quality Guide*, 1992.

Driscoll, E., and Mangarella, P., *Urban Targeting and BMP Selection*, USEPA Contract No. 68-C8-0034, Woodward Clyde Associates, 1990.

Driscoll, E., Shelley, P.E., and Strecker, E.W., *Pollutant Loadings and Impacts From Highway Stormwater Runoff, Volumes I-IV*, Federal Highways Administration, FHWA/RD-88-006-9, 1988.

Entranco. *WSDOT Stormwater Runoff Management Overview.* 1992.

Ficklin Environmental Services, et al. *Environmental Cost Savings and Permit Coordination Study*. WA State Legislative Transportation Committee. 1994.

Horner, R.R., *Biofiltration for Storm Runoff Water Quality Control*, University of Washington Center For Urban Water Resources Management, 1993.

Horner, R.R., and Mar, B.W., *Assessing the Impacts of Operating Highways on Aquatic Ecosystems*, Transportation Research Record 1017, 1985.

Irish, L.B. and Lesso, W.G., *An Evaluation of the Factors Affecting the Quality of Highway Runoff in the Austin, Texas Area*, Technical Report CRWR 264, Center For Research in Water Resources, University of Texas at Austin, 1995.

Northern Virginia Planning District and Engineers Surveyors Institute, *Northern Virginia BMP Handbook, A Guide to Planning and Designing Best Management Practices in Northern Virginia*, 1992.

Shueler, T.R., *Controlling Urban Runoff:: A Practical Manual for Planning and Designing Urban BMPs*, Metropolitan Washington Council of Governments, 1987.

Shueler, T.R., *Developing Effective BMP Systems for Urban Watersheds*, Washington D.C. Coucil of Governments, 1991.

Transportation Research Board / National Research Council, Yu, S.L., *Stormwater Management For Transportation Facilities*, 1993.

USEPA, *Final Report of the Nationwide Urban Runoff Program*, 1993.

Washington Department of Ecology. *Stormwater Management Manual for the Puget Sound Basin*. 1992.

Washington Department of Ecology. *1995 Statewide Water Quality Assessment 305(B) Report*

Washington State Department of Transportation (WSDOT). *Highway Runoff Manual*. 1995.

WSDOT, *Standard Specifications for Road, Bridge, and Municipal Construction*. 1994.

WSDOT, *Maintenance Manual.* 1986

WSDOT, *Hydraulics Manual*. 5/89.

Outfall Inventory / Field Screening

WSDOT, Water Quality Unit. *Draft Final Report Outfall Inventory and Field Screening Project*. 1995.

WSDOT, Water Quality Unit. *Outfall Inventory/Field Screening Form*. 1995.

WSDOT, Water Quality Unit. *Manual for Outfall Inventory and Field Screening Project*. 1993.

WSDOT, Water Quality Unit. *Manual For Research - Outfall Inventory and Field Screening Project*. 1994.

WSDOT, Water Quality Unit, Hobbins, M. *Global Positioning System Protocol (Draft)*. June 1995.

WSDOT, Water Quality Unit. *Prioritization Index for Retrofitting Highways with Stormwater BMPs*. 1994.

Planning and Program Development

WSDOT, *State Highway System Plan, 1997-2017,* April, 1996.

WSDOT, *Capital Construction Program, 1995-1997 Biennium,* September, 1995.

WSDOT, *Key Facts: A Summary of Useful Transportation Data*. January 1996.

WSDOT, Water Quality Unit. *Environmental Performance Elements, Construction Phase of WSDOT Projects,* November 5, 1995.

WSDOT, *Integrated Vegetation Management Program*, Communications between L Rus. and E. Molash, February 1996. (Will be incorporated into WSDOT's IVM planning document in late 1996)

WSDOT, *Maintenance Program Service Object Prioritization Plan*. Communications between N. Thompson and E. Molash. March, 1996.

Lynch, Patty, WSDOT, Water Quality Unit. *Water Quality Protection Measures for Highway Construction in Washington State,* (Paper approved for presentation at International Erosion Control Association's 1996 conference). 1995.

Highway Stormwater Monitoring and Characterization

Federal Highway Administration. *Constituents of Highway Runoff, Vol. 1*. Report No. FHWA/RD-81/042. 1981

Federal Highways Administration, *Highway Maintenance Impacts to Water Quality, Executive Summary*, FHWA/RD-85/057, 1985.

Malinga, Charbeneau, Ward, Barrett, Zuber, and Collins. *A Review and Evaluation of Literature Pertaining to the Quantity and Control of Pollution from Highway Runoff and Construction,* Technical Report CRWR 239, Center For Research in Water Resources, University of Texas at Austin, March 1993.

Chui, T.W.D., Mar, B.W., and Horner, R.R.. *Pollutant Loading Model for Highway Runoff*. Journal of the Environmental Engineering Division of ASCE. Vol. 108, pp. 1193-1210. 1982

Chui, T.W.D., Mar, B.W., and Horner, R.R. *Highway Runoff in Washington State: Model Validation And Statistical Analysis,* WSDOT Report No. WA-RD-39.12. 1981

Farris, G., Dalseg, R., and Machno, P. *Freeway Runoff form the I-90 Corridor.* Study Prepared for the Washington State Highway Commission Department of Highway by the Municipality of Metropolitan Seattle. 1973.

Gilbert, R.O. *Statistical Methods for Environmental Pollution Monitoring*. Van Nostrand Reinhold, New York. 1987.

Horner, R.R., University of Washington - Center for Urban Water Resources Management. *Storm and Surface Water Monitoring - Course Manual*. October, 1995.

Pitt R., *Demonstration of Nonpoint Pollution Abatement Through Improved Street Cleaning Practices*, EPA-600/2-79-161, 1979.

Sartor, J.D. and Boyd, G.B., *Water Pollution Aspects of Street Surface Contaminants,* USEPA Document EPA-R2-72-081, 1972.

Shepp, D.L., *Petroleum Hydrocarbon Concentrations Observed in Runoff From Discrete, Urbanized Automotive-Intensive Land Uses,* Metropolitan Washington Council of Governments, 1996.

Sheu, H.L., Le, W.J., Su, C.C, Chao, H.R., and Fan, Y.C., *Dry Deposition of Polycyclic Aromatic Hydrocarbons in Ambient Air*, Journal of Environmental Engineering, December 1996.

Standard Methods for the Examination of Water and Wastewater. Edited by Greenberg, A.E., Clesceri, L.S., and Eaton, A.D. American Public Health Association. 1992

Washington Department of Ecology (prepared by Woodward-Clyde Associates*). Stormwater Quality Monitoring Guidance Manual (draft report).* December, 1995.

Woodward-Clyde Consultants. *Oregon Department of Transportation Stormwater Monitoring Plan.* April, 1995.

Yamane, A., Nagashima, I., Okubo, T., Okada, M., and Murakame, A., *Stormwater Runoff of Hydrocarbons in te Tama River Basin in Tokyo Japan and their Fate in the River*, Wat Sci. Tech, Vol. 22, No. 10/11, pp.119-126, 1990.

Polyacrylamides For Construction Site Erosion Control and Detention Pond Treatment

Azzam, R.A.I., *Agrucultural Polymers, Polyacrylamide Preparation, Application and Prospects In Soil Conditioning*, Comm. Soil Sci. Plant Anal.11:235-243, 1980.

Barvenik, F.W., *Polyacrylamide Characteristics Related to Soil Applications*, Soil Science 158:235-243, 1994.

Barvenik, F.W., *Fate of Acrylamide Monomer Following Application of Polyacrylamide to Cropland*, University of Idaho Publication No. 101-96, pp. 103-110, 1996

Buchholz, F.L., Polyacrylamides and Poly(acrylic acids) in *Ullmann's Encyclopedia of Industrial Chemistry*, Vol. A21, pp. 143-156, 1992.

Deskin, R., Product Stewardship Considerations in the Use of Polyacrylamides in Soil Erosion, University of Idaho Publication No. 101-96, pp. 31-33, 1996.

Goodrich, et.al, *Acute And Longterm Toxicity Of Water-Soluble Cationic Polymers To Rainbow Trout And The Modification Of Toxicity By Humic Acid*, Environ Toxicol. Chem. 10:509-551, 1991.

Kay-Shoemake, J.L., and Watwood, M.E., *Microbial Ecology of Polyacrylamide Application in Agricultural Soils*, University of Idaho Publication No. 101-96, pp. 33-41, 1996.

Malik, M., and Letey, J., *Pore-Size-Dependent Apparent Viscosity For Organic Solutes in Saturated Porous Media*, Soil Sci. Soc. Am. J., 56:1032-1035, 1992.

Mace, G.R., *Specifier's Guide To Polymer Feed Systems*, Pollution Engineering, pp. 75-79, May 1990.

MacWilliams, D.C., Acrylamide and Other Alpha, Beta Unsaturated Amines, In: Functional Monomers: Their Preparation, Polymerization, and Application, Vol. 1, ed. by R.R. Yocum and E.B. Nyquist; Marcel Dekker, N.Y., 1973.

Mallevialle, J., Bruchet, A., and Fiessinger, F., *How Safe Are Organic Polymers in Water Treatment?*, Journal of the American Water Works Association, pp. 87-93, June 1984.

McElhiney, M., and Osterli, P., *An Integrated Approach for Water Quality: The PAM Connection - West Stanislaus HUA, CA*, University of Idaho Publication No. 101-96, pp.27-30, 1996.

Mortimer, D.A., *Synthetic Polyelectrolytes - A Review*, Polymer Internat., 25:29-41, 1985.

Natural Resource Conservation Service, *Interim Conservation Practice Standard 201 - Irrigation Erosion Control (Polyacrylamide)*, January 1995.

Roa, A., *Screening of Polymers to Determine Their Potential Use in Erosion Control on Construction Sites*, University of Idaho Publication No. 101-96, pp.77-83, 1996.

Roa, A., Bubenzer, G.D, and Han, J.S., *Use of Polymers to Control Erosion and Runoff at Construction Sites*, currently in preparation for publication, March 1997.

Seybold, C.A., *Polyacrylamide Review: Soil Conditioning and Environmental Fate*, Comm. Soil Sci. Plant. Anal., 25:2171-2185, 1994.

Sojka, R.E. and Lentz, R.D., *A PAM Primer: A Brief History of PAM and PAM-Related Issues*, University of Idaho Publication No. 101-96, pp. 11-20, 1996.

Sojka, R.E. and Lentz, R.D., *Improving Water Quality of Return Flows in Furrow-Irrigated Systems Using Polymer-Amended Inflows*, Proceedings of the SWCS Conference on Agricultural Research to Protect Water Quality, pp. 395-397, Minneapolis, MN, 1993.

Sojka, R.E. and Lentz, R.D., *Polyacrylamide (PAM): A New Weapon in the Fight Against Irrigation Induced Erosion*, USDA-ARS Soil and Water Management Research Unit Station Note #01-94, 1994.

Stephens, S.H., *Final Report on the Safety Assessment of Polyacrylimides*, J. Am. Coll. Toxicol., 10:193-202, 1991.

WSDOT Stormwater Runoff Research Programs

Washington State Transportation Center (TRAC) / Washington State University (WSU), Yonge, D., Principal Investigator, *Contaminant Removal in Runoff, Draft Report*. August, 1995.

TRAC / WSU, Hathorne, W. and Yonge, D., *Enhancing Contaminant Removal in Stormwater Detention Basins by Coagulation*, Draft final report. August, 1995.

TRAC / WSU, Hathorne, W. and Yonge, D., *Assessment of Groundwater Pollution Potential Resulting from Stormwater Infiltration BMPs*, Draft final report, August, 1995.

TRAC / WSU, Jones, A. and Watts, R., *Catalytic Pavement Borders*, Draft final report. November, 1995.

David Evans and Assoc., *Ecology Ditch Water Quality Monitoring*, WSDOT. November, 1994.

TRAC / WSU, Horner, R. and Mar, B., *Assessment of Relative Storm Runoff Control Advantages of Alternative Roadway Shoulder Pavements*, Interim report. May, 1995.

TRAC / WSU, Hathorne, W. and Yonge, D., *Filter Strips and Ecology Ditch Monitoring and Assessment*, Project work plan, November, 1995.

TRAC / WSU, Barber, M., *BMP Evaluation For Handling and Treating Stormwater in Confined Situations.* Project work plan. December, 1995.

TRAC / WSU, Barber, M., *Stormwater Runoff Cost/Benefit Project Prioritizing Outfalls*, Draft Final Report. April, 1996.

TRAC / WSU, Newberry, G.P. and Yonge, D., *The Retardation of Heavy Metals in Stormwater Runoff By Highway Grass Strips*, Draft Final Report. February, 1996.

Yonge, D., Barber, M., Hathorne, W., and Chen, S., *Wet Detention Pond Design for Highway Runoff Pollutant Control*, NCHRP Grant Project 25-12 proposal. November, 1995.

WSDOT, Research Office. *WSDOT Research Implementation Strategy*, 1995.

WSDOT, Water Quality Unit. *WSDOT Watershed Demonstration Project - The Snohomish Basin*, (Wetland protection grant proposal submitted to Environmental Protection Agency - Region 10), 1995.

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