Year 4, Runoff Water Quality, August 1980 - August 1981

WA-RD-39.13

Interim

August 1981

Washington State Department of Transportation
Public Transportation and Planning
In Cooperation with
United States Department of Transportation
Federal Highway Administration

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. WA-RD-39.13	3. Recipient's Catalog No.
4. Title and Subtitle YEAR 4, RUNOFF WATER QUALITY, AUGUST 1980 - AUGUST 1981	5. Report Date August, 1981
	6. Performing Organization Code
7. Author(s) Brian W. Mar, John F. Ferguson, Dimitris E. Spyridakis, Eugene B. Welch and Richard R. Horner	8. Performing Organization Report No. WA-RD-39.13
9. Performing Organization Name and Address Environmental Engineering and Science Program, Department of Civil Engineering, FX-10, University of Washington, Seattle, Wa 98195	10. Work Unit No.
	11. Contract or Grant No. Y-1804
12. Sponsoring Agency Name and Address Washington State Department of Transportation, Highway Administration Building, Olympia, WA 98504	13. Type of Report and Period Covered Interim 8/80 - 8/81
	14. Sponsoring Agency Code

15. Supplementary Notes

The study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration, under the title Runoff Water Quality.

16. Abstract

This report sumarizes findings presented in Report Nos. 10 - 12. Included are the results of studies aimed at improving and extending Asplund's solids loading model, increasing data on the ratios of various pollutants to TSS in the runoff, investigating the fate of heavy metals in drainage systems, and conducting bioassays on sensitive organisms exposed to highway runoff.

17. Key Words Highways, Runoff, Water Pollutants, Washington State, Monitoring, Models, Heavy metals, Bioassays, Tosicity	18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	23	

Form DOT F 1700.7 (8-69)
HWY FORM 341-004 6/72

Introduction

This report focuses on the results of four research thrusts that resulted in dissertations and condensed research reports during this reporting period. There are now 14 project reports either completed or close to completion, as shown in Table 1; this report summarizes the results reported in numbers 10 - 12. Also summarized in Table 1 are the reports planned for the remainder of the project.

Table 1

Highway Runoff Water Quality Reports

Report No. 1. Horner, R.R. and E.B. Welch, "Effects of Velocity and Nutrient Alterations on Stream Primary Producers and Associated Organisms," Nov., 1978.

Velocity and nutrient studies at 12 sites in Western Washington streams indicated that 50 cm/sec is the critical average current velocity where the productive base of the food web is impacted. Swift flowing streams rich in nutrients should not be slowed to this value, and slow flowing streams should not be altered to have velocities greater than this value.

Report No. 2. Horner, R.R., S.J. Burges, J.F. Ferguson, B.W. Mar and E.B. Welch, "Highway Runoff Monitoring: The Initial Year," Jan., 1979.

This report covers the initial 15 months of effort to review the literature, select a prototype site, and compare the performance of several automatic sampling devices, and install a prototype sampling site on I-5 north of Seattle.

Report No. 3. Clark, D.L. and B.W. Mar, "Composite Sampling of Highway Runoff: Year 2," Jan., 1980.

A composite sampling device was developed that can be installed at less than ten percent of the cost of automatic sampling systems currently used in Federal highway runoff studies. This device was operated for one year, side-by-side the I-5 site, to demonstrate that the composite system provides identical results to the automated system.

Report No. 4. Vause, K.H., J.F. Ferguson and B.W. Mar, "Water Quality Impacts Associated with Leachates from Highway Woodwastes Embankments."

Laboratory and field studies of a woodchip fill on SR 302 demonstrated that the ultimate amounts of COD, TOC and BOD per ton of woodchips can be defined and that this material is leached exponentially by water. After a year the majority of the pollutant has been removed, suggesting that pre-treating of the woodchips prior to use in the fill can reduce the pollutant release from a fill. This chips should be protected from rainfall and groundwater intrusion to avoid the release of leachate. Release of leachate onto tidal lands can cause beach discoloration and an underground deep outfall may be required.

Report No. 5. Aye, R.C., "Criteria and Requirements for Statewide Highway Runoff Monitoring Sites."

Criteria for selecting statewide monitoring sites for highway runoff are established to provide representative combinations of climate, traffic, highway, land use, geographic and topographic characteristics. Using these criteria, a minimum of six sites are recommended for use in this research.

Report No. 6. Asplund, R., J.F. Ferguson and B.W. Mar, "Characterization of Highway Runoff in Washington State," Dec., 1980.

A total of 241 storm events were sampled at ten sites during the first full year of statewide monitoring of highway runoff. Analyses of these data indicate that more than half of the observed solids in this runoff is traced to sanding operations. The total solids loading at each site was correlated with traffic during the storm. The ratio of other pollutants to solids was linear when there were sufficient traffic generated pollutants to saturate the available solids.

Report No. 7. Mar, B.W., J.F. Ferguson, and E.B. Welch, "Year 3 - Runoff Water Quality, August 1979 - August 1980."

This report summarizes findings detailed in Report Nos. 4 and 6 plus the yet-to-be-published work of Karen Zawlocki on trace organics in highway runoff. Several hundred compounds tentatively identified by GC-MS were grouped into nine categories, which were not mutually exclusive, by Zawlocki. Major components of these categories were petroleum products used by vehicles and incompletely combusted hydrocarbons. The concentrations of these trace organics groups were low compared to criteria proposed for protection of aquatic life.

Report No. 8. Eagon, P.D., "Views of Risk and Highway Transportation of Hazardous Materials - a Case Study in Gasoline."

While gasoline represents one-third of all hazardous materials transported in the country by trucks, the risk associated with gas transportation, as viewed by the private sector, is small. Public perceptions of risk are much greater due to lack of knowledge on probabilities and consequences of spills. Methods to improve knowledge available to the public on gasoline spills and methods to improve estimate of environmental damages from gasoline spills are presented. Generalization of methodologies to hazardous materials in general are discussed.

Report No. 9. Zawlocki, K.R., J.F. Ferguson and B.W. Mar, "A Survey of Trace Organics in Highway Runoff in Seattle, Washington." (To be issued Fall, 1981).

Trace organics were surveyed using gas chromotography coupled to mass spectrometry for highway runoff samples from two Seattle sites. The characterization of the organics exhibited concentrations of aliphatic, aromatic and complex oxygenated compounds. Vehicles, including exhaust emissions, were concluded to be the source of many of the organics.

Report No. 10. Wang, T.S., D.E. Spyridakis, R.R. Horner and B.W. Mar, "Transport, Deposition and Control of Heavy Metals in Highway Runoff," (To be issued Fall, 1981).

Mass balances conducted on soils adjacent to highways indicated low mobility of metals deposited on well-vegetated surfaces. Grassy drainage channels were shown to effectively capture and retain metals (e.g. a 40 m channel removed 80 percent of the original Pb concentration).

Mud or paved channels, however, demonstrated little or no ability to remove metals from runoff. Metal release studies suggested that acid precipitation could release metals bound in the soil, especially where low buffering capacity exists.

Report No. 11. Portele, G.J., B.W. Mar, R.R. Horner and E.B. Welch, "Effects of Highway Stormwater Runoff on Aquatic Biota in the Metropolitan Seattle Area," (to be issued Fall, 1981).

The impacts of stormwater runoff from Washington State freeways on aquatic ecosystems was investigated through a series of bioassays utilizing algae, zooplankton and fish. Algae and zooplankton were adversely affected by the soluble fraction of the runoff, while suspended solids caused high mortalities of rainbow trout fry. In addition, BOD_5 values similar to those reported in the stormwater literature were measured; however there were indications that results were influenced by toxicity to microbial populations.

Report No. 12. Chui, T.W., B.W. Mar and R.R. Horner, "Highway Runoff in Washington State: Model Validation and Statistical Analysis," (to be issued Fall, 1981).

Results of the second year of full-time operation of nine monitoring sites in the State of Washington produced 260 observations of highway storm runoff. A predictive model was developed based on the data from two years of observation for total suspended solid loads. A high correlation was demonstrated between total suspended solids and COD, metals and nutrients. The major factor controlling pollution loads from highways in Washington State is the number of vehicles passing during each storm, not those preceding storms.

Report No. 13. Mar, B.W., J.F. Ferguson, D.E. Spyridakis, E.B. Welch and R.R. Horner, "Year 4 - Runoff Water Quality, August 1980 - August 1981."

This report summarizes findings presented in Report Nos. 10 - 12. Included are the results of studies aimed at improving and extending Asplund's solids loading model, increasing data on the ratios of various pollutants to TSS in the runoff, investigating the fate of heavy metals in drainage systems, and conducting bioassays on sensitive organisms exposed to highway runoff.

Report No. 14. Horner, R.R., and B.W. Mar, "Guide for Water Quality Impact Assessment of Highway Operations and Maintenance." (To be issued Fall, 1981.)

Procedures particularly applicable to Washington State have been developed to assist the highway designer in evaluating and minimizing the impacts of highway runoff on receiving waters. The guide provides computation procedures to estimate pollutant concentrations and annual loadings for three levels of analysis which depend on the watershed, the discharge system and traffic. It further provides means to judge the potential impacts of the runoff on receiving waters.

Report No. 15. Horner, R.R., L.M. Little, and E.B. Welch, "Impacts of Channel Reconstruction in the Pilchuck River." (To be issued Winter, 1982.)

Report No. 16. Report on dissertation project during Year 5. (To be issued Summer, 1982.)

Report No. 17. Final report. (To be issued Summer, 1982.)

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Return to: B.W. Mar, FX-10
Dept. of Civil Engineering
University of Washington
Seattle, WA 98195

History

This project was initiated in May 1977 as a five-year field study to collect adequate data to establish the impacts of highway operation and maintenance practices on receiving water quality and aquatic ecosystems in the State of Washington. During the first year of the project, Horner, et al. (1977) conducted an extensive literature survey of this problem and found that most data are reported for high-intensity, short-duration storms which are not common in the State of Washington. The maritime climate of Western Washington creates long, low-intensity storms which are not reported in the literature. The site on SR 520 employed by Sylvester and DeWalle (1972) to initially explore the highway runoff problem was reactivated as the first field station for this project. Next, a prototype station was established to evaluate sampling equipment and test sampling protocols (Horner et al., 1979). Aquatic monitoring was initiated in order to evaluate the impact of nutrient additions and velocity changes in the rivers of Western Washington (Horner and Welch, 1978). A five year study encompassing before, during, and after a major channel change on the Pilchuck River for highway construction was also initiated.

During the second year criteria and requirements for the selection of a statewide highway runoff monitoring network were established (Aye, 1979), and an inexpensive composite sampling device was developed and tested. This sampler permitted the operation of ten sites across the state rather than the originally planned two sites (Clark, 1980; Clark and Mar, 1980).

During the third year all ten sites were operational and approximately 250 storm events were observed. Asplund (1980) and Asplund et al. (1980) described the operation of these sites and proposed a model to estimate total suspended solids present in highway runoff. The model was based on the hypothesis that solids present in runoff are strongly correlated with vehicles during a storm. Solids that are associated with dry weather periods were found to be removed from the highway surface by traffic-generated winds. Asplund (1980) also observed a strong linear correlation between other pollutants and TSS that is also reported in the literature. Two special topics were also researched during the third year, a study of trace organics present in highway runoff (Zawlocki, 1981) and a study of leachate from wood waste fills (Vause, 1980; Vause et al., 1980). The high cost of analysis of trace organics in runoff limited that study to six observations, but the results did not reveal types or levels of compounds that would justify further study at this time. The woodwaste research found that the majority of COD and BOD in woodwaste is released after one year of soaking. The problem can be minimized by pre-soaking the woodwaste prior to use as fill or, alternatively, by keeping the fill dry.

Fourth Year Program

The objectives of the fourth year of the research program were: (1) to validate the runoff water quality model proposed by Asplund (1980); (2) to observe the fate of pollutants found in highway runoff in various types of drainage systems; (3) to evaluate the response of aquatic indicator organisms to highway runoff; (4) to continue the channel change studies; and (5) to prepare an Environmental Impact Statement guide for highway water quality.

Model Development and Validation Studies

Asplund (1980) developed a model for total suspended solids in highway runoff based on the data obtained during the first three years of this project. The model is:

TSS = (K) (VDS) (RC)

where: TSS = lb of total suspended solids/curb mile from runoff

K = loading constant (lbs/1000 VDS/curb mile)

VDS = vehicles during the storm

RC = runoff coefficient

Asplund suggested that the loading constant for Western Washington was 6.4 lbs/1000 VDS/curb mile, excluding sanding for icy conditions, volcano fall-out, and construction-related solids. This model was proposed to describe cumulative TSS at a specific site; it had little precision in predicting individual storm TSS values.

During the 1980-81 period 260 more storm events were obtained at the ten sites. Table 2 summarizes these storm data. Close agreement with the Asplund model is shown in Figure 1, where urban Western Washington sites were observed to have a loading constant of 6 lbs TSS/1000 VDS/curb mile, excluding sanding applications or volcanic ashfall. Eastern Washington sites appeared to have a K value of about 25 - 30 (Chui, in preparation). The difference is traced to lower traffic volumes (less traffic - generated winds to transport dust and debris) and to high dust load contributions from surrounding land uses in Eastern Washington. Based on over 500 samples, the validity of the model to estimate cumulative TSS loadings is well-established.

While the coefficient for Eastern Washington and rural areas appears to be several times higher, there are insufficient data to define the value well at this time; and one more year of data acquisition is planned. In particular, the atypical point at Pullman - Control will be further investigated.

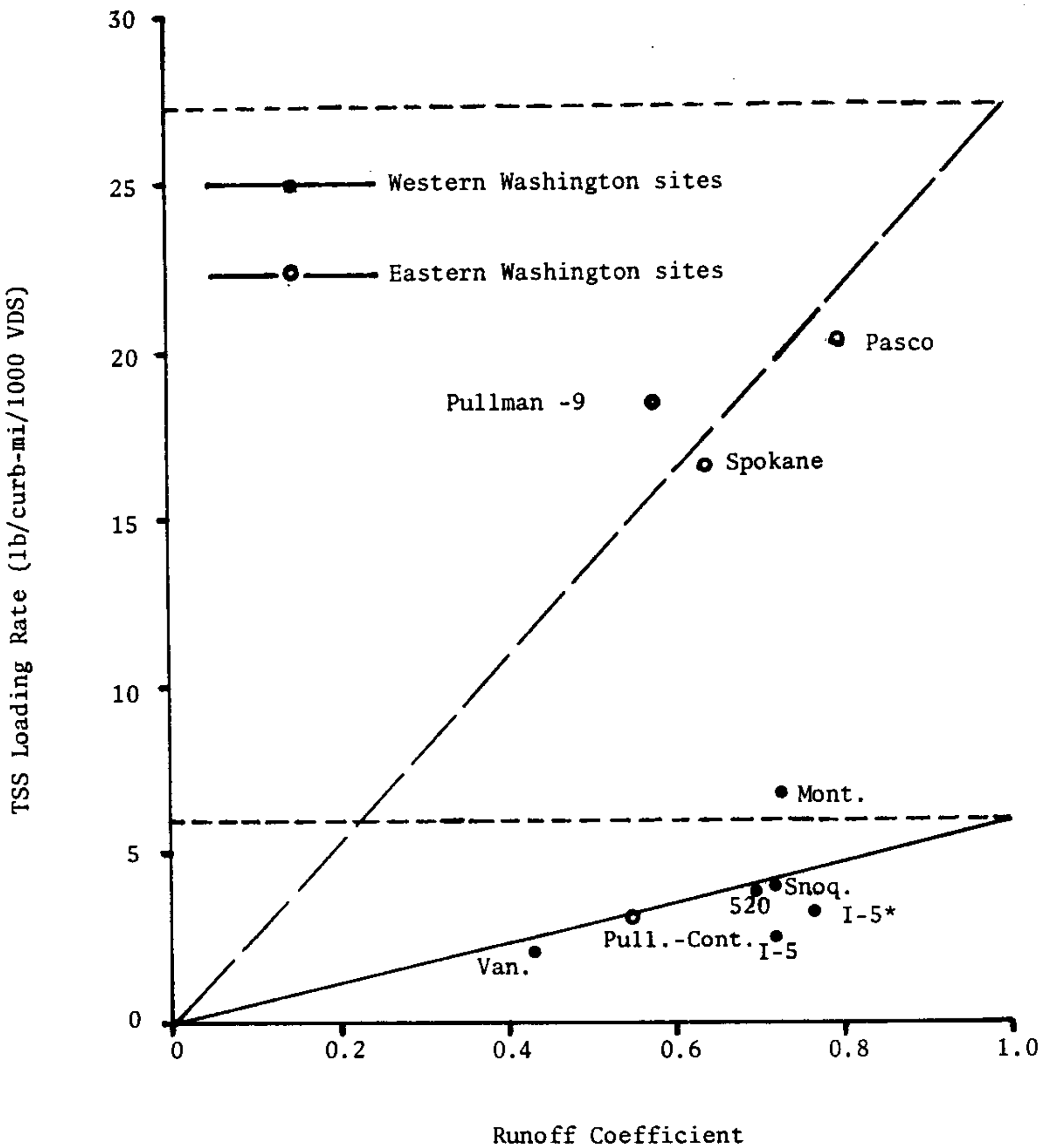

Figure 1. TSS Loading Rate vs Runoff Coefficient for Full Data Set, Excluding Samples Containing Deicing Sand or Volcanic Ash

Table 2: Summary of 1980-81 Runoff Data

Site	No. of Events	Total Rainfall (inches)	Total VDS (thousands)	Total TSS (lb) [1]
I-5	56	35.21	2,227.8	841.7
I-5*	25	16.88	859.0	69.7
Vancouver	37	29.45	1,118.1	59.2
Snoqualmie Pass	32	75.92	1,029.3	156.9
Montesano	44	75.91	609.1	1,343.1
Pasco	22	7.27	108.0	388.9
Spokane	6	14.64	2,223.7	292.2
Pullman - 9	20	13.76	162.1	251.5
Pullman - Control	18	12.46	142.3	111.6

Note: (1) Including sanding and volcanic ashfall.

The ratios of pollutants to TSS at all sites are shown in Table 3 (Chui, in preparation; Portele, in preparation). The relative magnitudes of the observed ratios for each pollutant at all sites suggest that these pollutants are traffic-related and that they can be estimated from TSS data:

$$P_i = (K_i)\ (TSS)$$

where: P_i = cumulative loading of pollutant P_i from highway runoff

TSS = total suspending solids cumulative loading

K_i = pollutant i/TSS ratio (Table 3)

The linear relationship between the pollutants listed and TSS agrees with the general consensus of the literature. In most of the reported cases the pollutant-TSS correlation is statistically significant. Being primarily in the dissolved state, No_3 + No_2 - N and SO_4 did not correlate well with TSS and are not reported. There is still sufficient storm-to-storm and site-to-site variation to warrant additional studdy of this question, particularly for Eastern Washington sites.

No significant differences between runoff from a sulfur asphalt and a control section near Pullman were observed for either loading rates or pollutant ratios. Further comparisons will be made during the final year of the project.

Table 3: Ratios of Pollutants to TSS (1)

Site	Pollutant/TSS Ratio								
	VSS $(X10^{-1})$	BOD $(X10^{-1})$	COD $(X10^{-1})$	TOC $(X10^{-2})$	Pb $(X10^{-3})$	Zn $(X10^{-3})$	Cu $(X10^{-4})$	TKN $(X10^{-3})$	TP (X10-
I-5	1.7	2.2	4.1	3.9	4.6	1.7	2.0	3.3	2.3
I-5*	2.6	N/A	7.0	N/A	4.9	2.3	3.0	1.8	1.9
SR 520	2.0	N/A	4.9	6.1	4.2	1.0	1.6	2.3	1.8
Vancouver	1.9	N/A	5.9	7.6	0.6	0.6	1.3	18	1.9
Snoqualmie Pass	1.1	N/A	2.0	2.1	0.6	0.4	1.2	2.0	2.1
Montesano	3.6	N/A	19	6.1	1.1	0.4	0.9	2.1	1.6
Pasco	2.4	N/A	5.0	6.7	1.7	1.0	0.7	5.2	1.2
Spokane	1.9	N/A	4.9	1.0	1.0	5.7	0.8	10.5	2.2
Pullman - 9	1.3	N/A	4.1	N/A	0.5	0.3	0.8	7.1	2.7
Pullman - Control	0.5	N/A	1.2	N/A	0.4	0.3	0.8	2.2	2.4

Note: (1) Includes samples containing deicing sand but excludes those containing volcanic ash (except Pullman - Control, where insufficient data points necessitated including those with ashfall).

Samples of solids adhering to the bottoms of vehicles were obtained by installing plastic-coated magnetic strips on 12 vehicles. While wide variations were observed in the buildup on and losses from these samplers, the contribution that solids adhering to vehicles makes to the TSS loads on highways is minor in urban areas (approximately 10 - 20 percent of TSS). In rural areas the vehicular contribution may increase to 45 - 70 percent. Data for solids loadings on vehicles are presented in Table 4.

Table 4: Solids Accumulation Rates on Vehicles

	Solids Accumulation Rate (g/mi X 10^{-6})	
Vehicle	Mean	Standard Deviation
1	6.5	6.5
2	15	12
3	1.9	0.8
4	1.1	0.2
5	8.0	2.7
6	2.7	1.7
7	4.8	5.6
8	2.2	1.2
9	4.4	3.6
10	1.5	0.6
11	5.2	6.9
12	7.2	9.8
Overall	5.1	3.9

Pollutant Transport

The runoff water quality model suggests that neither the wind-borne solids from adjacent lands nor the traffic-generated solids remain on the highway in large proportions. A survey of the air pollution literature indicated that heavy metals are deposited within a short distance of the highway, and tests were performed to estimate the ability of soils and vegetation to permanently retain these pollutants. Table 5 summarizes the results of soil core samples taken adjacent to the I-5 site (Wang, in preparation). Deposition of the three metals of most concern in highway runoff (Pb, Zn and Cu) was demonstrated, while several metals not generally associated with automotive traffic declined in the surface soil layers. The observed deposition rates agreed well with those quoted in the literature and those calculated from dustfall experiments. Integration of lead values on transects perpendicular to the highway yielded loading equivalent to estimates of total lead deposition from the highway since it was constructed.

Table 5: Total Metal Content of a Soil Core from I-5 Site at N.E. 158th Street

Depth (cm)	Areal Concentration (mg/m^2 X10^3)							
	Ca	Co	Cu	Fe	Mg	Mn	Pb	Zn
Top organic layer	8.15	0.01	0.03	10.3	3.48	0.26	0.98	0.12
0 - 2	301	0.48	0.68	404	145	11.1	11.3	5.49
2 - 4	21.9	0.40	0.60	379	138	11.0	2.27	1.23
4 - 6	311	0.46	0.46	440	157	11.7	3.34	1.22
6 - 8	406	0.51	0.45	502	196	12.8	2.81	0.77
8 - 10	342	0.45	0.42	469	174	10.7	3.31	0.53
10 - 12	494	0.65	0.82	622	239	13.7	1.51	0.58
Total in top 2 cm	309	0.49	0.71	414	148	11.4	12.3	5.61
Background quantity (1)	388	0.52	0.54	508	192	12.2	2.68	0.76
Total deposited since 1962 (2)	Neg.	Neg.	0.17	Neg.	Neg.	Neg.	9.57	4.85
Annual deposition rate (3)	Neg.	Neg.	0.01	Neg.	Neg.	Neg.	0.48	0.24

Notes: (1) The backround quantity was considered to be the average metal concentration in the depth interval 4 - 12 cm.

(2) Difference between previous two lines.

(3) Twenty year basis.

Laboratory exposure of these core samples to waters of varying pH revealed that waters lower than pH 4 could dissolve lead from these samples. The implication of these experiments is that, if acidic precipitation becomes more common, much of the heavy metals deposited along highways could be released in storm runoff.

The results of observations of pollutant transport in drainage systems were subjected to statistical analysis to derive polynomial regression equations relating metal concentrations remaining in runoff vs distance traveled in the channel. The equations were employed to predict the percentage of initial concentrations removed by grassy channels of various lengths. Table 6 summarizes the predictions resulting from the use of nine different equations for Pb which were derived from the data and explain a high proportion of the variance. Generalizing the predictions, it is expected that grassy channels of 20, 40 and 60 m lengths can be relied upon to remove 40 - 60 percent, 60 - 80 percent and 80 - 100 percent of the initial lead concentration, respectively. Results for Zn, TSS and COD demonstrated similar tendencies. Mud channels and paved conduits, however, permitted most of the solids and solids-related pollutants to pass through to the discharge point. These results strongly suggest that the use of grassy channels at least 60 m in length for draining highway runoff would provide an order of magnitude reduction in pollutant concentrations.

Table 6: Polynomial Regression Equation Predictions of Percentage of Initial Lead Concentration Removed from Highway Runoff After Passage Through Grassy Channels of Various Lengths

	Percent Pb Remaining		
Channel length (m):	20	40	60
Equation			
1	59.2	81.6	100
2	32.9	60.7	87.5
3	75.5	100	100
4	44.3	68.1	72.9
5	44.0	68.0	75.2
6	46.4	77.4	90.8
7	40.5	69.1	86.3
8	100	100	100
9	91.8	100	100

Bioassay Studies

The biological response to complex waste waters is difficult to predict, and exposure of sensitive organisms to highway runoff may be the only realistic measure of biological response. Bioassay studies were conducted on algae, zooplankton, and trout as indicator organisms. The studies were initiated after BOD tests revealed classic toxicity response as the runoff samples were diluted.

Tables 7 - 9 summarize the bioassay results (Portele, in preparation). Algal growth was clearly inversely related to traffic during storms. Highway runoff was toxic to *Daphnia magna* in 48, 72 and 96 hr bioassays, but the association with VDS could not be established with the data available. Dissolved substances, likely among the heavy metal contaminants, were responsible for the demonstrated toxicity. Rainbow trout mortality was apparently caused by particulates in the runoff; one test with a filtered sample yielded greater than 90 percent survival at all dilutions. The effectiveness of draining runoff through a grassy channel was further

Table 7: Summary of Algal Growth Inhibition Bioassays Conducted with I-5 Stormwater Runoff

Date of Storm	VDS	Percent Stormwater Used	Dry Weight Produced (percent of control)	IC_{50} (1) (percent)	95% Confidence Interval (1) (percent)
01/19/81	40,650	0 (Control)	---		
		25	27.8		
		50	8.3	13.5	3.0 - 60.8
		75	4.8		
		100	1.2		
02/13/81	112,950	0 (Control)	---		
		25	76.1		
		50	28.4	44.5	41.1 - 48.2
		75	34.9		
		100	15.5		
03/16/81	51,150	0 (Control)	---		
		25	94.5		
		50	45.8	50.2	30.0 - 84.0
		75	20.9		
		100	6.1		
04/06/81	12,250	0 (Control)	---		
		50	96.5	72.5	52.8 - 99.6
		75	58.9		
		100	7.5		

Note: (1) IC_{50} represents the dilution (percent stormwater) that would be estimated to produce dry weight equal to 50 percent of that produced in the control.

Table 8: Summary of Bioassays Exposing *Daphnia magna* to Stormwater Runoff from Various Freeways

Sampling Site	Date of Storm	VDS	Test Length (hr)	Sample Treatment	Percent Stormwater Used	Percent Survival
I-5	05/10/81	14,650	96	Filtered	0 (Control)	90.0
					50	0
					100	0
I-5	05/10/81	14,650	96	Unfiltered	0 (Control)	80.0
					50	10.0
					100	6.7
SR 520	05/18/81	N/A	72	Filtered	0 (Control)	100
					50	96.7
					100	56.7
I-5	05/21/81	62,200	72	Filtered	0 (Control)	100
					50	13.3
					100	0
I-90	04/17/81	4,980	48	Filtered	0 (Control)	96.7
					50	100
					100	100
SR 520	04/17/81	N/A	48	Filtered	0 (Control)	96.7
					50	98.7
					100	100
I-5	05/10/81	14,650	48	Filtered	0 (Control)	96.7
					50	68.3
					100	16.7

Table 9: Summary of 96 Hr Bioassays Exposing Rainbow Trout (*Salmo gairdneri*) to I-5 Stormwater Runoff

Date of Storm	VDS	Sample Treatment	Percent Stormwater Used	Percent Survival
04/06/81	12,250	Filtered sample	0 (Control)	100
		Filtered dilution water	30	100
			70	93.3
			100	93.3
05/10/81	14,650	Unfiltered sample	0 (Control)	100
		Unfiltered dilution water	50	30.0
			100	0
05/21/81	62,200	Unfiltered sample	0 (Control)	100
		Unfiltered dilution water	50	60.0
			100	0
05/21/81	62,200	Sampled from end of 200 m grassy channel	0 (Control)	100
		Unfiltered sample	50	100
		Unfiltered dilution water	100	93.3

demonstrated by a test run using unfiltered samples collected from the end of such a channel; survivals exceeding 90 percent resulted with all dilutions.

Other Results

The sediments, macroinvertebrates and fish in the reconstructed Pilchuck River channel were sampled several months after water was diverted into the new channel. Over the past year the winter flows have cleaned the channel of silt, and pools and riffles with stony bottoms have formed. One last series of observations will be obtained to quantify the rate of recovery of the river.

The EIS guide is designed to collate data and methodology to describe water quality impacts of operating highways. This guidebook will be presented to maintenance and design staffs in each district. Based on the results of this project and a comprehensive analysis of the literature, the following guidelines are proposed;

1. Water quality impacts from highway runoff can be minimized if the runoff drainage system contains at least 100 meter of grassy channel prior to discharge to receiving waters if no erosion of the streambed or banks occurs.
2. Use or curbs and storm drains will introduce sediment retention areas that will contribute to "first flush" concentrations which may be unacceptable; therefore, these designs should be avoided.
3. If storm waters cannot be exposed to grass-lined channels, then receivings waters that can dilute the storm waters a hundred-fold are required to avoid significant impact.
4. The quality of highway runoff can be correlated directly with traffic during the storm. Runoff from low traffic-volume highways are of acceptable quantity, while runoff from high-volume highways will require dilution or treatment prior to discharge.

Proposed Activities

During the last year of this project several key issues must be explored: (1) the cause of the zinc at the I-5 site ; (2) improvement of the TSS loading constant for Eastern Washington sites; (3) confirmation of the hypothesized low-traffic/low toxicity association; (4) capacity of nutrients in highway runoff to stimulate algal growth and the effect of grassy channel treatment on this capability; (5) summarizing the five years of observations on the rechanneled Pilchuck River and drawing conclusions; and (6) implementation of the results of the project. The zinc question will be examined by performing a mass balance to determine the contribution of rainfall, dustfall, vehicular sources, and the drainage system to the zinc loadings. The TSS loading factor will be improved by operating the sites in Eastern Washington for one more season and increasing the data base by one-third. The questions concerning toxicity and algal stimulation will be investigated by means of additional bioassays. A district-by-district series of workshops is planned to discuss and refine the utility of the EIS guidelines and the practicality of best management practices to minimize the degradation of water quality by highway runoff.

LITERATURE CITED

Asplund, R.L. "Characterization of Highway Stormwater Runoff in Washington State," M.S. Dissertation, Department of Civil Engineering, University of Washington (1980).

Asplund, R.L., J.F. Ferguson, B.W. Mar. "Characterization of Highway Stormwater Runoff in Washington State," Department of Civil Engineering, University of Washington (1980).

Aye, R.D. "Criteria and Requirements for Statewide Highway Runoff Monitoring Site," Department of Civil Engineering, University of Washington (1979).

Chui, T.W. "Highway Runoff in Washington State: Model Validation and Statistical Analysis," M.S. Dissertation, Department of Civil Engineering, University of Washington (in preparation).

Clark, D.L. "Composite Sampling of Highway Runoff," M.S. Dissertation, Department of Civil Engineering, University of Washington (1980).

Clark, D.L. and B.W. Mar. "Composite Sampling of Highway Runoff," Department of Civil Engineering, University of Washington (1980).

Horner, R.R., T.J. Waddle, and S.J. Burges. "Review of the Literature on Water Quality Impacts of Highway Operations and Maintenance," Department of Civil Engineering, University of Washington (1977).

Horner, R.R., and E.B. Welch. "Effects of Velocity and Nutrient Alterations on Stream Primary Producers and Associated Organisms," Department of Civil Engineering, University of Washington (1978).

Horner, R.R., S.J. Burges, J.F. Ferguson, B.W. Mar, and E.B. Welch. "Highway Runoff Monitoring: The Initial Year," Department of Civil Engineering, University of Washington (1979).

Portele, G.J. "Effects of Highway Stormwater Runoff on Aquatic Biota in the Metropolitan Seattle Area," M.S. Dissertation, Department of Civil Engineering, University of Washington (1981).

Sylvester, R.O. and F.B. DeWalle. "Character and Significance of Highway Runoff Waters," Report to Washington State Highway Commission (1972).

Vause, K.H. "Water Quality Impacts Associated with Leachates from Highway Woodwaste Embankments," M.S. Dissertation, Department of Civil Engineering, University of Washington (1980).

Vause, K.H., J.F. Ferguson, and B.W. Mar. "Water Quality Impacts Associated with Leachate from Highway Woodwaste Embankments," Department of Civil Engineering, University of Washington (1980).

Wang, T.S. "Transport, Deposition and Control of Heavy Metals in Highway Runoff," M.S. Dissertation, Department of Civil Engineering, University of Washington (in preparation).

Zawlocki, K. "Trace Organic Compounds in Highway Runoff," M.S.E. Dissertation, Department of Civil Engineering, University of Washington (1981).