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EVALUATION OF THE EFFECTIVENESS OF OIL-GRIT SEPARATORS IN SOUTH CENTRAL ALASKA. PHASE I

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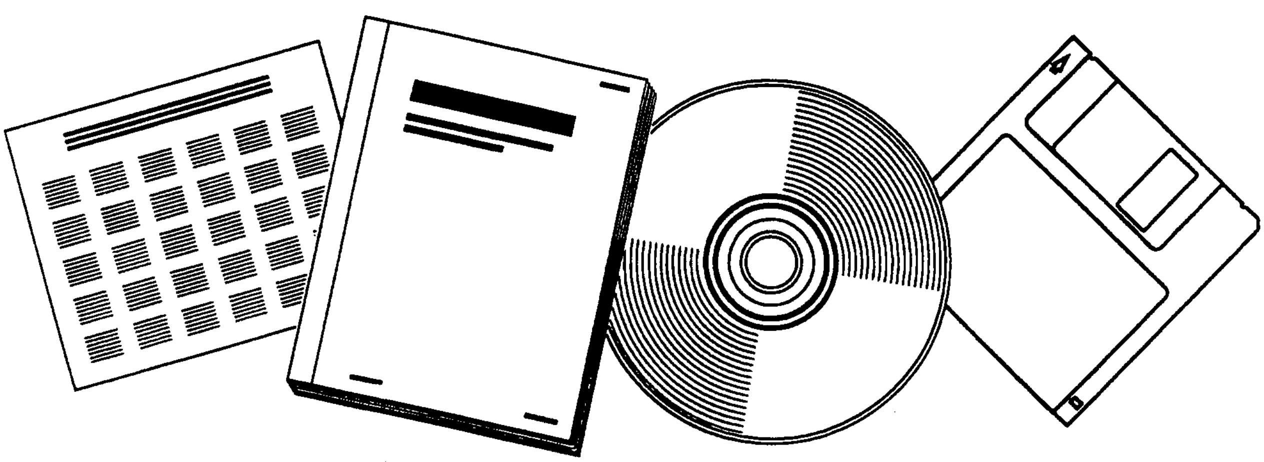

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Evaluation of the Effectiveness of Oil-Grit Separators in South Central Alaska Phase I

by

Robert F. Carlson
Charlotte I. Barker
Gary W. Scarbrough

November 1997

FINAL REPORT

Report No. INE/TRC 96.01
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INSTITUTE OF NORTHERN ENGINEERING
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16. Abstract

In response to an increasing national concern for the environmental impact of highway runoff, the Federal Highway Administration (FHWA) allocated funds for the study of the mitigation of pollutants found in highway runoff. For certain circumstances oil-grit separators (OGS) may be appropriate Best Management Practice for stream crossing sites with restricted space. However, the FHWA questions their effectiveness. They have indicated that runoff from roads such as the Sterling Highway, with a predicted Average Daily Traffic of 6,350 vehicles for the year 2,000, may not contain significant amount of pollutants and that OGS technology is not effective as an overall treatment strategy. The Alaska DOT&PF, with guidance from the Alaska Dept. Of Environmental Conservation Regulations, designed and constructed an OGS system at the Moose River. The project was funded by FHWA in response to strong environmental concern at the Moose River crossing of the Sterling Highway. The FHWA has asked for an evaluation of this facility that will include a determination as to whether significant pollutants are discharging from the roadway and whether the OGS technology is effective at removing those pollutants. A literature survey of the subject shows that OGS systems are widely specified for urban roadway BMP systems and that they have been shown to be effective is some circumstances. However, their performance is sometimes erratic and they are often difficult to maintain and evaluate. Fortunately, the Alaska Central Region has several OGS prototypes in the Municipality of Anchorage (MOA) that are currently monitored. Since the scope of MOA's research is much broader than the funds available for this project will allow the information on the applicability and efficiency of MOA's OGS systems may be useful in evaluating the Moose River facilities. This Moose River OGS study is scheduled for the Spring and Summer seasons of 1996. The evaluation will include an attempt to determine the level of pollutant discharge from the roadway drainage area into the Moose River OGS and an evaluation of the effectiveness of pollutant removal of the system.

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EVALUATION OF THE EFFECTIVENESS OF OIL-GRIT SEPARATORS IN SOUTH CENTRAL ALASKA, PHASE I

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INSTITUTE OF NORTHERN ENGINEERING
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ABSTRACT

In response to an increasing national concern for the environmental impact of highway runoff, the Federal Highway Administration (FHWA) allocated funds for the study of the mitigation of pollutants found in highway runoff. For certain circumstances oil-grit separators (OGS) may be an appropriate Best Management Practice (BMP) for stream crossing sites with restricted space. However, the FHWA questions their effectiveness (Driscoll, et al., 1990). They have indicated that runoff from roads such as the Sterling Highway, with a predicted Average Daily Traffic (ADT) of 6,350 vehicles for the year 2000 (ADOT&PF, 1992), may not contain significant amount of pollutants and that OGS technology is not effective as a overall treatment strategy (Ruby, 1994). The ADOT&PF, with the guidance of Alaska Department of Environmental Conservation (ADEC) regulations, designed and constructed an OGS system at the Moose River. The project was funded by FHWA in response to strong environmental concern at the Moose River crossing of the Sterling Highway. The FHWA has asked for an evaluation of this facility that will include a determination as to whether significant pollutants are discharging from the roadway and whether the OGS technology is effective at removing those pollutants. A literature survey of the subject shows that OGS systems are widely specified for urban roadway BMP systems and that they have been shown to be effective in some circumstances. However, their performance is sometimes erratic and they are often difficult to maintain and evaluate. Fortunately, the Alaska Central Region has several OGS prototypes in the Municipality of Anchorage (MOA) that are currently being monitored. Since the scope of MOA's ongoing research is much broader than our budget will allow, the information on the applicability and efficiency of MOA's OGS systems may be useful in evaluation of the Moose River OGS facilities. This Moose River OGS study is scheduled for the Spring and Summer seasons of 1996. The evaluation will include an attempt to determine the level of pollutant discharge from the roadway drainage area into the Moose River OGS and an evaluation of the effectiveness of pollutant removal of the system.

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I. INTRODUCTION

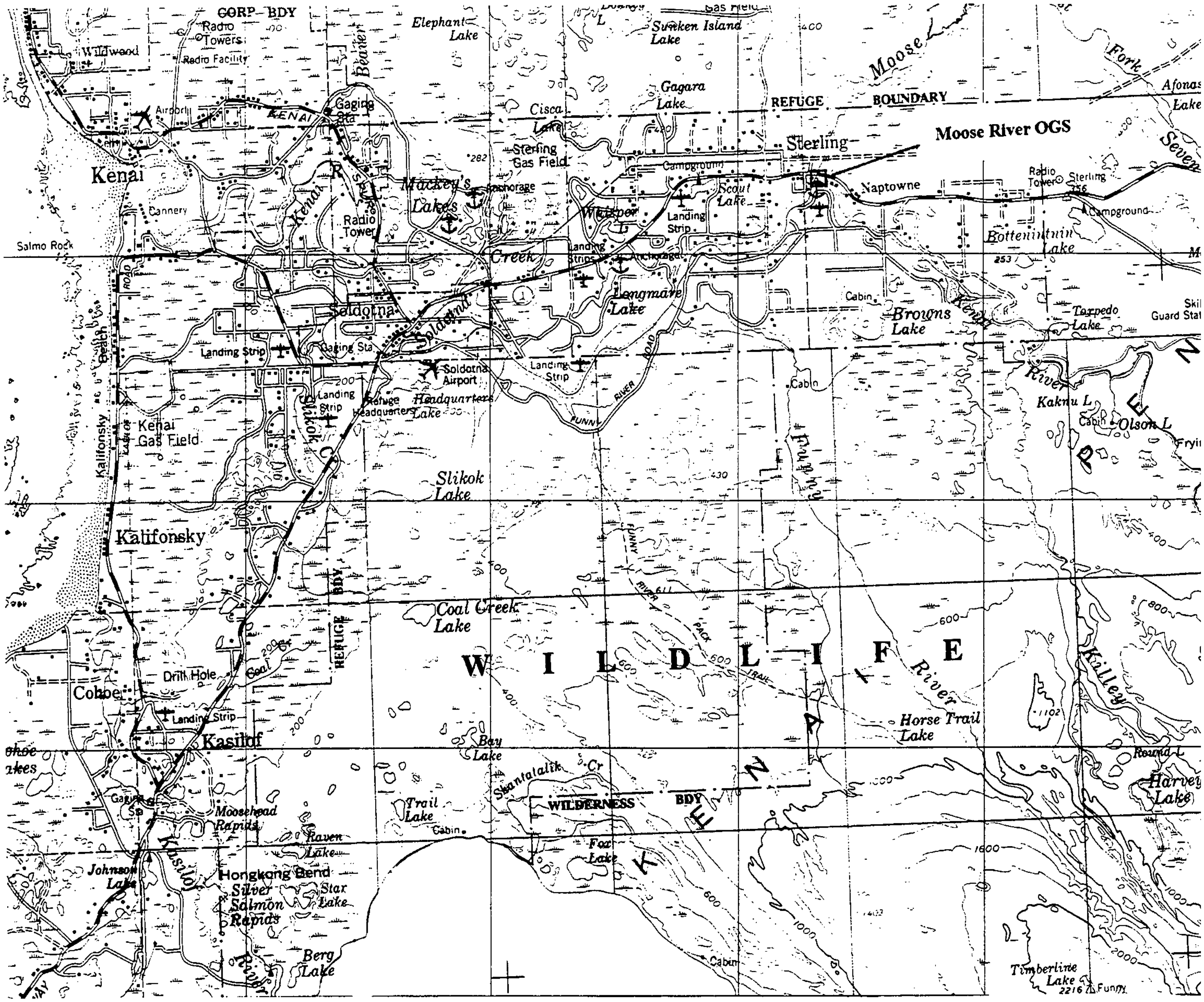
A. Purpose and Need

In 1994, the Central Region of ADOT&PF submitted a research need statement asking for a study of the Moose River OGS installation. This two-phase project was developed in response to that expression of need. The tasks for the initial phase of the project include:

1) Conduct a comprehensive literature survey of OGS systems, and
2) Summarize known information about the operation of oil and grit separators in the Anchorage and Soldotna areas.

Using this information, a means to evaluate contaminants and summarize the performance of the Moose River OGS will be presented. The work is to be delivered as two task products, a draft final report and a final report.

The Moose River OGS was initially funded by FHWA due to the sensitivity of the receiving waters. Figure 1 shows the locations of the OGS systems. The Moose and Kenai Rivers are categorized as important for the spawning, rearing, and migration of Anadromous fish (sockeye, chinook, coho, pink salmon, as well as Rainbow and Dolly Varden trout). The Alaska Department of Fish and Game (ADF&G) administers regulations promulgated to enforce the Anadromous Fish Act (AS 16.05.870) and has review authority for Project Consistency with the Alaska Coastal Management Program (6 AAC 50). One of the preparatory steps for construction over the Moose River was ADF&G issuance of a Fish Habitat Permit. The Moose River OGS units will be considered experimental until a determination of their efficiency is made. This determination will occur after they have been monitored for five years. If the facility is found to be ineffective, the FHWA will fully fund a replacement (Dunn, 1995).



Scale 1:250,000

5 0 5 10 15 20 25 30 Kilometers

Figure 1- Location of the Moose River OGS systems.

The City of Soldotna has requested installation of an additional OGS at Marydale Street (in Soldotna). Mr. Robert Ruby, Division Administrator, expressed the FHWA position on future participation in OGS projects in a letter dated Feb. 1994 to Mr. Steve Horn, Environmental Coordinator, ADOT&PF. Ruby writes, "research has shown that stormwater from roadways with less than 30,000 ADT contains very few pollutants...and unless the Moose River facility can demonstrate that significant pollutants are being removed that would otherwise enter the stream FHWA will maintain that position" (1994).

B. Background

Highway stormwater runoff has become a nationally recognized environmental issue. As mandated by the Clean Water Act (PL 95-217, CWA), the FHWA has allocated monies through the Intermodal Surface Transportation Efficiency Act (ISTEA) specifically for Amitigation of water pollution due to highway runoff' (FHWA, 1992). Studies at the federal level have been conducted to identify the constituents and their quantities, with the caveat that transportation agencies need to establish limits of responsibility: They cannot take responsibility for pollutants entering highway stormwater runoff upstream of the transportation system; i.e., even if a contaminant is present in highway stormwater runoff, if it did not originate in, on or from the transportation system, transportation agencies are not responsible for treating it (Morgan, 1988). With this statement as a guideline, various "Best Management Practices" (BMPs), such as those requiring constructed wetlands, sand filters, detention/retention basins, vegetated filter strips and oil/grit or oil/water separators, have been developed to treat runoff. A recent extensive literature search on the topic was performed by the consulting firm of Montgomery Watson as part of a contract with MOA. It is included with the permission of Tom Bacon, MOA Public Works, as Appendix A in this report.

Accumulating data seems to support the growing consensus that techniques mimicking "nature's way", that is, constructed wetland and vegetated filter strips, are more successful and cost effective. Yet these methods also have disadvantages. They require large amounts of land that are not always available. Nutrients are biodegraded within the system, but heavy metals are concentrated at the site unless the biota or material that assimilates them is removed and treated. Due to these constraints, treatment facilities using OGS systems are still considered viable options.

At the Moose River crossing on the Sterling Highway, researchers determined that OGS technology was the available best option for protecting this sensitive location. During an upgrade project on the Sterling Highway, ADOT&PF was required to design a BMP for runoff that would enter the Moose River. The Moose River is a tributary of the Kenai River, a well known and extremely environmentally and politically sensitive salmon stream. After due consideration an oil/grit separator was designed based on the experience of the MOA, as set out in their design manual. (Section 2.130, Erosion and Sediment Control, is excerpted as Appendix B1. This can be compared to information used by the State of California, Appendix B2.) The FHWA allowed federal funding for its design and installation as an experimental project. The basic intent of the program is that federal monies pay for the initial project. The State is then obligated to monitor the facility for five years, after which a determination is made whether or not the experiment has been successful. If it is not, the federal government then fully funds a replacement (Dunn, 1995). The FHWA research to date, however, indicates that stormwater runoff from roads such as the Sterling Highway, with an average daily traffic (ADT) less than 30,000 vehicles (Driscoll et al., 1990), does not contain significant amounts of pollutant, and that current OGS technology does not effectively remove them (Ruby, 1994).

C. Highway Stormwater Runoff Quality

FHWA policy decisions regarding remediation techniques are formulated on the basis of the CWA and previous studies, a primary one being the National Urban Runoff Program (NURP), which documented the constituents and their relative amounts in highway stormwater runoff. The study predated some significant changes with pollutant control, especially the national move to unleaded fuel, and the FHWA is preparing a Request for Proposals for an updated study (Banks, 1995). Banks and others expect the new data to reflect the changes, and they expect that the information will be significantly different than the data base currently referenced.

The highway contaminants directly associated with a similar traffic volume are heavy metals, hydrocarbon components and particulates. Common heavy metals that make up highway pollution include copper, lead, chromium, zinc, calcium, iron, magnesium, nickel, cadmium, potassium, and arsenic. Petroleum products, such as motor oil and fuel, are the source of many of the hydrocarbon components that contaminate highway runoff. Soil particles are either blown or washed onto the surface of highways. These particles, combined with sand from winter maintenance and soil transported by vehicles driving through wet soils, are the major sources of particulate contaminants. Other pollutants found on the highways are usually induced by maintenance activities or adjacent land use.

II. DESCRIPTION OF OIL AND GRIT SEPARATORS

A. General

Oil-grit separators (OGS) are essentially, concrete boxes in the ground. They can be either directly in line with the stormwater runoff channel or off line. They can be restricted to stormwater runoff, or they can be utilized in conjunction with sewage lines; for instance, some systems route stormwater to treatment plants. They can be designed with simple baffles (low concrete walls) to impede flow, a strategy that causes contaminants to settle out, or with both floor-based baffles for sediment and ceiling-based baffles for petroleum skimming. Off-line OGSs may have a bank of separators parallel to the flow, essentially a stack of corrugated fiberglass sheets, to enhance reduction of turbulent flow and, therefore, sediment settling (again, the sediment is the potentially problematic heavy metal pollutant load) (FHWA, 1988). Engineering parameters include the magnitude of the design storm, location, and site space available. Design factors include inlet size and location; baffle height, location, and number; floor design (e.g., flat, grooved, centrally concave); number and location of clean-outs; outlet size and location; and routing of excessive flow.

B. Municipality of Anchorage, Soldotna, and Moose River OGS Facilities

MOA is currently using OGS technology to remove particulate contaminants and free phase oil from highway runoff. In the past, efforts to assess these systems have yielded varying results. During a 1992 study of the Meadow Street OGS facility, data was recorded at the inflow and outflow of the OGS. Using this data, researchers ascertained, that total petroleum hydrocarbon and suspended solids removal efficiencies averaged 17.2% and 33.5%, respectively. Various factors, including first flush, groundwater flow, pollutant load, flow characteristics, and quantity of flow, can affect the performance of OGS. Data also suggested that contaminants initially removed may be reintroduced into the system at higher flows (Cooley, 1993), even though MOA maintenance tries to clean out the systems twice per year. MOA is presently funding a $250K study of their OGS systems. MOA's current approach is to estimate the sediment loading on local roads, determine removal efficiency, then monitor the sediment for other contaminants. The final product of this research was not available as of March 1996 (Wheaton, 1996).

Prior to 1986 the city of Soldotna, Alaska gave little consideration to stormwater effluent. During 1986, Soldotna, working with Alaska Department of Fish and Game (ADFG) and ADEC, worked to improve the quality of stormwater by increasing catchment capabilities on every newly installed storm drain manhole and catch basin. With the help of MOA, the first OGS was installed at the end of Knight Drive, and it was followed by a second OGS at the Soldotna Airport. The city has applied for a third OGS at Marydale Street, but the request was denied by FHWA, again, due to their contention that roadways with fewer than 30,000 ADT do not yield sufficient pollutants to warrant an OGS system. The effectiveness of the two installations is somewhat relative. No water flows from the Knight Drive installation because everything flowing into the system seeps away. The

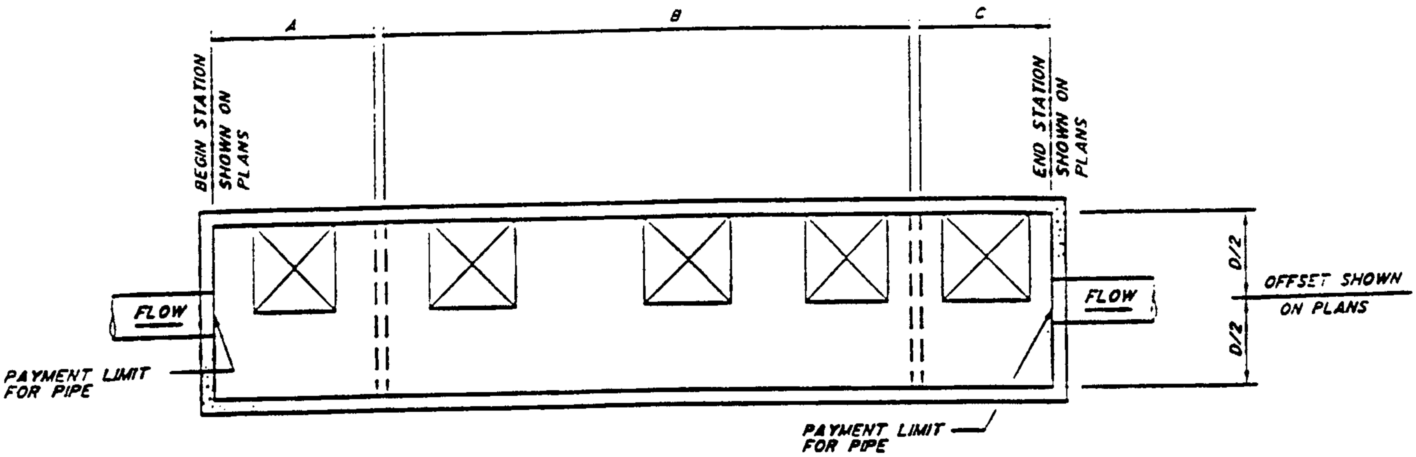
Airport installation has never been analyzed, so it is impossible to know if it is meeting the removal goals set by ADEC.

The two Moose River OGSs were designed with upstream bypass manholes. These allow flow during normal conditions to pass into the basins, and at higher stages overflow will be diverted into the river. This design is typical of an in-line system with a high flow bypass. Advantages of this type of system are simpler piping design, use of only one splitter, and less reintroduction of removed contaminants due to mixing in basins at extreme high flow conditions (Stahre, Urbonas,1990).

Both units were designed for a 2-year, 6-hour storm event as recommended in the 1988 MOA Department of Public Works Design Criteria Manual (McMillan, 1988). ADOT&PF hydrologist "Skip" Barber (Barber, 1995) calculated that a 2-year 6-hour event would generate 13.3 and 9.9 cfs for the east and west units, respectively. The east unit, designed to handle the larger flow, has a total volume of approximately 250 cubic yards, a sediment storage capacity of 43.3 cu yds, and floatables storage capacity of 5,660 gallons. The west unit has a total volume of approximately 210 cu yds, with 32.6 cu yds of sediment storage and 4,070 gals of floatables storage (See Figures 2 & 3).

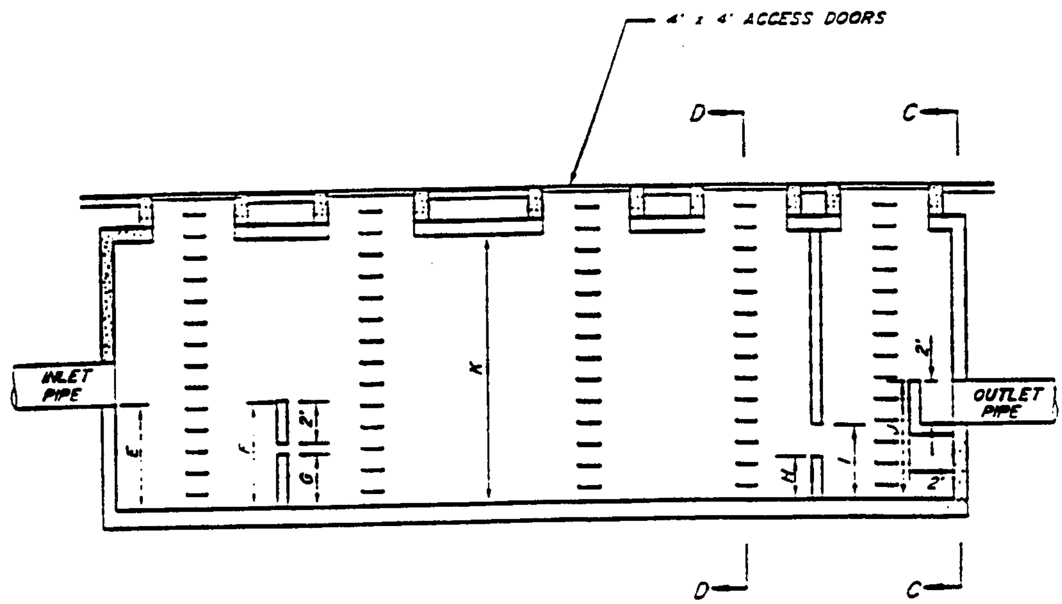
The design for the units was done in-house by Eric Miyashiro, ADOT&PF Design Engineer, using MOA guidelines and in consultation with MOA Department of Public Works personnel. MOA design criteria included efficient removal of particles 130µ or larger, with 20µ being the target size for the sedimentation basins. Tests done by MOA show 8-10% removal of 20-30µ particles (Bacon, 1992).

Maintenance of the Moose River facilities is scheduled on a yearly basis according to ADOT&PF, but the schedule is not clearly defined. A contractor cleaned the system during 1994, but as of May 1996 the system had not been cleaned a second time (Church, 1994; Lacey, 1996). According to ADOT&PF maintenance personnel in Soldotna, they



PLAN VIEW

DETAIL A



PROFILE VIEW

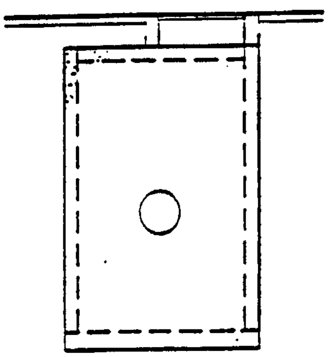
DETAIL B

SEPARATOR UNIT DIMENSIONS													
UNIT NUMBER	INLET SIZE / INVERT	OUTLET SIZE / INVERT	A	B	C	D	E	F	G	H	I	J	K
S-58	35" x 24" ARCH / 163.00	24" / 161.00	10'	24'	10'	8'	6'-6"	5'-6"	2'-6"	2'-6"	4'-6"	6'-6"	4'-6"
S-72	35" x 24" ARCH / [illegible]	24" / 157.00	10'	32'	10'	9'	7'	6'	2'-6"	2'-6"	5'	7'	4'-6"

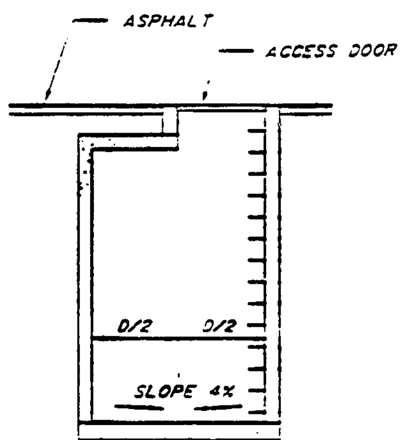
Figure 2.

GENERAL NOTES:

1. THE FLOOR OF EACH SEPARATOR UNIT SHALL SLOPE AT 4% CROSS WIDTH TOWARD THE CENTER OF THE UNIT. THE BOTTOMS OF EACH SEPARATOR UNIT SHALL BE HORIZONTAL.
2. THE CORNERS OF ALL WEIRS SHALL BE CONSTRUCTED WITH A 3/4-INCH CHAMFER OR 2-INCH RADIUS.



SECTION C-C
TYPICAL END



SECTION D-D

DESIGN DATA			
UNIT NUMBER	2-YEAR FLOOD (CFS)	SEDIMENT STORAGE VOLUME (CY)	FLOATABLE POLLUTION STORAGE (GA)
S-58	9.9	32.6	4070
S-72	13.3	43.3	5660

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

STERLING HIGHWAY
M.P. 79 TO M.P. 82

PETROLEUM
SEPARATOR DETAILS

Figure 3.

have never cleaned the Moose River OGS. If sediment removal were necessary, maintenance would call a vacuum truck from Anchorage to dispose of the sediment (Lacey, 1996). This sediment is a concern to ADEC personnel because of the possibility of contamination. If contaminants are found in the sediment it must be treated and disposed according to Solid Waste regulations.

A two-year, multi-agency water quality investigation was initiated on the Kenai River in the fall of 1989. This investigation established a baseline from which future impacts could be gaged. The parameters examined included general water quality (conductivity, pH, alkalinity, turbidity, color), nutrients (total, total filterable, and filterable reactive phosphorus, total Kjeldahl nitrogen, ammonia, nitrate, nitrite), metals (70 element scan), BOD, temperature, dissolved oxygen, coliform (total, fecal, fecal streptococcus), hydrocarbons (total petroleum, volatile organics), and benthic invertebrates. Since the Moose River OGS system is located just a short distance upstream from the confluence of the Moose and the Kenai, future impact of the OGS units should be noted in any reassessment.

Initial sampling of the Moose River OGS units was completed on June 1, 1994 at a cost of $1,770. The water samples (no sediments were found in either unit) were taken by Quality Asphalt Paving, Inc. and analyzed by Commercial Testing and Engineering Co. The following tests were performed on the samples: TCLP Extraction Test with Waste Management Profile (SW 846, EPA 1331), Extractable Petroleum Hydrocarbons (EPA 3510/3550/81), Volatile Petroleum Hydrocarbons (EPA 5031/801), and Total Volatiles (EPA 8240). The results indicated that the samples were under the limits of the point source pollution provisions of the Clean Water Act (CWA, 33 U.S.C. 1251-1387).

Four grab water samples taken from the Moose River OGS by Dr. Robert Carlson on July 3, 1995 were analyzed for oil and grease, chloride, nitrate, sodium, calcium, magnesium, iron, copper and barium. Analysis was performed at UAF laboratories by Research

Chemist Jean Marie Merli. All parameters were found below CWA minimums, but there was a detectable amount of barium noted.

C. Washington State OGS Systems

The Washington State Department of Transportation (WSDOT) has accepted a 6-month return period, 24-hour duration design storm based on studies showing that more than 50% of total runoff volume occurs during storms with a return frequency of six months or less (WADOT, 1995). They maintain that little additional water quality improvement is achieved at a substantially increased cost if BMPs are designed for storms with longer return periods.

WSDOT defines the potential pollutant load as a two-part problem, "conventional pollutants" (particle-associated pollutants--sediment and heavy metals) and "nutrients", both suspended and dissolved (phosphorous, nitrogen, etc.). The issue of highways as a source of nutrient pollution versus highways as a "receiving body" for nutrients that have been entrained upflow of the road system is overtly acknowledged. Because they accept that highways are not a major source of nutrient loadings, their BMP designs will specifically target the sediment and heavy metals fraction only, unless directed to do otherwise by other political administrative agencies.

With this background, WSDOT's preferred BMPs are grass filtration strips, biofiltration swales, wet ponds, and infiltration ponds. They overtly discourage the use of "wet vaults" (OGS's), and only projects that have limited space are considered for them. Vaults, which rely solely on sedimentation, do not perform well as a water quality treatment design, and their on-going maintenance is problematic in two senses, physical access and determination of when maintenance is necessary. Construction costs are greater as well, so WSDOT requires that any project with a wet vault design included receive prior approval from their Hydraulics Section.

As yet another approach to the basic vault concept within Washington, consider the example of the City of Redmond, Washington. They designed and installed an oil-water separator as a unit in their stormwater treatment. The controlling criteria were avoidance of developmentally sensitive areas (lake shoreline/park), minimal right-of-way, and high groundwater table. Their system is off-line and has 3 consecutive vaults. The first reduces flow velocity and evenly distributes the stream to the second, the coalescing vault. Velocity is further reduced by routing flow through parallel corrugated fiberglass plates; the effect is to increase surface area, which promotes coalescing of oil and grease and sedimentation of suspended solids. The stream passes through an oil skimmer as it is directed to the third vault, from which it is routed to a catch basin, then back into the storm drain trunk line (Cohen, 1995; Odegard, et al., 1994; Entranco, 1994.)

III. ON-GOING RESEARCH

Various locations are engaged in stormwater research. A Maryland study (Berg, 1991) recommends that OGS facilities be discouraged due to lack of information on effectiveness and high maintenance costs. They imply that OGS facilities should be used only in urban areas where other methods of treatment (such as swales, constructed wetlands, or sand filters) are not feasible due to land constraints.

Another study (Shepp, 1994) found that OGS units do trap priority pollutants temporarily. But the system will reintroduce removed contaminants when the next large flow passes through the system. This effect is due to the turbulence and eddies created within the chambers at higher flows.

In Lakewood, Colorado an OGS unit has been designed for a 2-year peak storm with an average flow velocity of less than 0.5 fps. Automatic samplers are triggered by rainfall events in excess of 0.1 inch and a mass balance is produced for the unit. The OGS has a sand filter down stream, which is the primary unit being tested. The sand filter was tested for a year prior to the installation of the OGS with negative results. Data from this ongoing study is not available yet.

MOA has been conducting research into the effectiveness of OGS for many years. A 1993 study, "Performance Analysis of the Meadow Street Oil and Grease Separator", used a mass balance approach to determine the effectiveness of the Meadow Street OGS. The study involved many hours in the field and the laboratory. To duplicate this study at Moose River would require a much larger budget than is allotted for this project.

MOA is presently engaged in a study targeting particulates that accumulate on roadways. The study is preliminary with an estimated budget approaching $250,000. Final results of this project were not available as of May 1996. Duplicating this project at Moose River would require several years and a much larger budget than allocated for this project.

Presently FHWA does not feel that roads with ADT less than 30,000 vehicles produce enough contaminants to warrant installation of an OGS. FHWA also feels that OGS units are ineffective at removing contaminants from highway runoff; the agency is researching other treatment systems. Many studies, including several mentioned in this report, are attempting to evaluate the need and effectiveness of OGS units. To address the Moose River study, two essential questions must be addressed:

1) Does stormwater runoff from the Sterling Highway contain sufficient contaminants to effect water quality, and
2) How effective are the Moose River OGS facilities at removing those contaminants?

IV. CONCLUSIONS AND RESEARCH RECOMMENDATIONS

The Alaska Department of Transportation and Public Facilities (ADOT&PF), in response to state and local concerns for the water quality of highway runoff, has designed and constructed two oil-grit separators at the Moose River bridge on the Sterling Highway east of Soldotna. The FHWA, although realizing the importance of highway runoff quality control, is not convinced that oil-grit separators are the most economical and effective control measure. The FHWA has indicated they are not willing to participate in further funding of oil-grit separators applied in similar situations, unless there are significant contaminants at site and the OGS is proven effective at their removal.

In response to this stipulation, ADOT&PF asked for a research project that would consider the effectiveness of the OGS units at Moose River and elsewhere throughout Central Alaska. This study summarizes the current literature and the state-of-the-art knowledge of designers in Alaska and other locations. The information forms the basis for the design of the Phase II study to evaluate the effectiveness of the Moose River and similar units in Central Alaska.

The following conclusions are drawn from the material collected for the Phase I study and from the basis for the design of the Phase II study:

1) The research indicates that experience with OGS for the treatment of highway runoff has been varied, ranging from no-use recommendations to reports of a favorable experience in some situations.

2) Because of the highly variable nature of the precipitation input, which can only be described in a statistical sense, the load on the OGS system is also highly variable. As a result, the evaluation of the removal and retention efficiency is difficult and expensive to characterize. In northern climates, the evaluation is made more difficult by a low temperature season and an abrupt spring snowmelt runoff.

3) The conditions for funding of the Moose River OGS require a five year evaluation period beginning from the construction in 1993 (Dunn, 1995). Thus, the

evaluation period should last until 1998. Several FHWA decisions for funding of similar units await the results of the Moose River evaluation.

4) OGS systems, when used for highway runoff pollution control, should be viewed as a BMP. This includes physical, structural and management practices that prevent or reduce pollution of water and attenuate peak flow and volumes. Highway runoff BMP include source control, water quality treatment and control of water quantities.

5) Several recently completed or ongoing references may be applicable to the Moose River evaluation. Examples include: a) Highway Runoff Manual, Washington State Department of Transportation, February, 1995; b) Survey of Urban Runoff Control Literature, Municipality of Anchorage (MOA), Conducted by Montgomery Watson, Anchorage, July, 1995; and c) Evaluation of Urban Runoff Processes and Treatment, Municipality of Anchorage, Ongoing study, 1995-96.

   The Moose River evaluation will address questions raised in the above research to assess the effectiveness of those facilities. The two questions that this research indicates must be addressed are:

   1) Are there significant contaminants in the stormwater runoff, and
   2) Do the OGS units effectively remove them?

6) The Moose River OGS units were designed with suggestions from the standard design principles used by MOA. They were cleaned once in 1994 by a contractor, but have not been cleaned since. There are no records to indicate if sediments from the by-pass manholes have ever been removed. To produce an accurate study, a clearly defined and implemented maintenance schedule must be carried out by ADOT&PF personnel.

7) Many uncertainties must be addressed when evaluating the OGS units. The precipitation regime, contributing watershed, ADT, VDS, and pollutant load for each OGS is very site specific, difficult to characterize, and subject to change. The OGS units will perform differently under different loading conditions; this makes assessing their efficiency difficult.

Objectives of a Phase II study

The primary objectives of the Phase II study remain the same as those of the original proposal:

1) Develop a method to determine if significant pollutants are contained in the stormwater runoff at the site, and

2) Evaluate the removal effectiveness of the Moose River OGS units and similar units. Attention will also be given to helping ADOT&PF meet FHWA's request for a 5-year study of the Moose River OGS units and on developing practical tools for design engineers who are faced with highway runoff pollution problems.

The methodology of the Phase II study might include:[1]

1. <u>Evaluation of the performance level of the Moose River OGS system</u>.

The effectiveness of the Moose River OGS facility is presently unknown. Yet the FHWA requires an evaluation of the site as a condition for future funding of additional OGSs. Although much can be learned by observing the results of MOA tests, each OGS is unique

[1]Since this report was written, an interim Phase IIA study report has been completed. A more detailed strategy for what now has become the Phase IIB study is given the Phase IIA final report.

and for accurate information some sampling activity must be carried out at the Moose River site.
The Phase II-A project will conduct a sampling effort that will supply a general indication of what contaminants are in the OGS basins. This data will provide a guide to a more intensive sampling program if one becomes necessary. Each sampling event will include the water column and bottom sediments, if available, within each of the two chambers.

The samples will be collected and handled according to appropriate protocols. They will be taken to Northern Testing Laboratories, Inc for contaminant analysis or analyzed at UAF laboratories. The laboratory analysis will test for heavy metals, oil and grease, anion, and other constituents as necessary. The results will be a valuable guide in indicating whether the Moose River OGS units contain contaminants and will help in the design of a more intensive future sampling plan, if one becomes necessary.

2. Developing a method to evaluate the pollutant load on the Sterling Highway and nearby surfaces.

Each OGS installation is uniquely situated with respect to such factors as the contributing area, the imposed pollution constituents from both vehicles and right-of-way surfaces, and changes to each over time. These conditions, when added to the inherent unpredictability of precipitation and runoff processes, make the task of determining pollutant load very difficult. A method that may have merit would be the simulation of a rainfall event on the Sterling Highway. Sampling stations could be set up at various locations so that initial and subsequent contaminant loadings could be monitored. Prior conditions, such as VDS, cleaning of roadway, and time since last rainfall event could be monitored. This procedure could give a reasonable answer to FHWA's question, AIs there a significant amount of pollutants on the Sterling Highway, even though its ADT is less than 30,000"?

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---

[2]Additional information about the references are given in appropriate Appendix.

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APPENDIX A

Part I- Abstracts from Update of Literature Search for Review of Potential Best Management Practices, WMP-CPg-94001, March, 1994, 83pp.

Prepared for: Watershed Management Section
Project Management and Engineering
Department of Public Works
Municipality of Anchorage

Prepared by: Montgomery Watson
400 Credit Union Drive, Suite 600
Anchorage, Alaska 99503

Part 2- Storm Water BMP Literature Search from Dialog Information Services, July 21, 1992, approximately 350 pp.

Prepared by: JMM Minnesota Water Quality Laboratory
Montgomery Watson
400 Credit Union Drive, Suite 600
Anchorage, Alaska 99503

APPENDIX B

Part 1: Annotated Bibliography- Vault Type Oil-Grit Separators

American Petroleum Institute. 1969. "Oil-Water Separator Process Design", Chapters 5 & 6, Manual on Disposal of Refinery Wastes, Volume on Liquid Wastes, 1st Edition.

Asplund, R.L., J.F. Ferguson, and B.W. Mar. 1982. Characterization of Highway Runoff in Washington State. Journal of the Environmental Engineering Division, ASCE 108(2):391-404.

> Cited by Horner and Mar (1985) as one of the several studies that underlay the development of their protocol: "The research effort was comprehensive, involving investigation of highway runoff pollutant sources, transport, fate, effects, and control."

Dorman, M.E., J. Hartigan, F. Johnson, and B. Maestri. 1988. Retention, Detention and Overland Flow for Pollutant Removal from Highway Storm water Runoff: Interim Guidelines for Management Measures. Federal Highway Administration Report FHWA/RD-87/056. 189 pp.

Dupuis, T.V., N.P. Kobriger, W.K. Kreutzberger, and V. Trippi. 1985. Effects of Highway Runoff on Receiving Waters - Vol. III. Resource Document for Environmental Assessments. Federal Highway Administration Report No. FHWA/RD-84/064. 144 pp.

Horner, R.R., and B.W. Mar. 1985. Assessing the Impacts of Operating Highways on Aquatic Ecosystems. IN: Surface Drainage and Highway Runoff Pollutants, Transportation Research Record 1017. Transportation Research Board, National Research Council. Washington, DC. pp. 47-55.

> The purpose of the article is to organize a conceptual approach to the problem of determining whether or not highway operation and maintenance cause deterioration of runoff water quality to such a degree that mitigation should take

place and, if it does, whether or not the chosen plan is likely to solve the problem. Among the mitigation techniques they identify is an oil and grease trap, but there is no further discussion of it, although there is some discussion of other techniques.

Because FHWA representatives seem to be cautious about the performance of the Moose River oil-grit separator largely because of the low ADT, Horner and Mar's identification of traffic as a factor in generation of runoff contaminants justifies a full summary of the article even though there is no further discussion of "oil and grease traps".

They credit the Municipality of Metropolitan Seattle (1972, two different studies) for introducing traffic as a variable, using it to normalize freeway runoff pollutant loading (i.e., amount of load/number of vehicles). Shaheen (1975) found traffic to be a primary variable. He derived linear regression equations to estimate pollutant loadings on the basis of traffic counts, vehicle deposition rates, and background pollutant levels.

Horner and Mar incorporate ADT into the first, "screening", level of their protocol as one of three criteria that should be assessed. If it less than 10,000, they skip the more detailed analysis involved in their second level: "With a high dilution ratio of ordinary runoff and either low traffic volume or drainage over a vegetated drainage course, it can be stated with some assurance that impact of routine operations would be insignificant."

"Vehicles during storms" (VDS) is also identified as an important factor because of the pollutant loading that results from the spray washing that loosens contaminants deposited on vehicle undersides during dry weather. California DOT (Racin, et al., 1982) found VDS to be a statistically significant variable in the analysis of their data set. Horner and Mar use VDS in the second level ("annual assessment") of their protocol, basing their cumulative loading model on data from more than 500 storms monitored at nine locations in WA:

TSS loading = (K) (VDS) (RC)

where TSS loading = annual mass flux

K = proportionality constant (varies regionally); units: kg TSS/hwy km/1,000 VDS

VDS = vehicles traveling during storm periods on an annual basis

RC = average site runoff coefficient

TSS loading is the major factor in estimation of other pollutant loadings: "other pollutant loadings can be predicted from TSS because the majority of these pollutants are associated with the solids in runoff." Horner and Mar use specific multipliers for individual pollutants, based on their accumulated field research, to estimate the loads.

ADT appears again in the interpretation of pollutant loading calculations. The authors found it necessary to define high and low ADTs on a regional basis:

Western WA:	high traffic:	42,000 to 53,000
	low traffic:	7,700 to 8,600
Eastern WA:	high traffic:	17,300
	low traffic:	2,000 to 2,500

By grouping estimates into these four categories, probability distributions plotted linearly on log-probability graphs, and the effect of mitigation methods could be estimated.

One of the conditions discussed as a periodic phenomenon is winter sanding and deicing. Asplund (1980) was not able to model the proportion of applied sand that entered the runoff, but he was able to demonstrate that the multipliers to estimate other pollutant loadings from TSS data were still valid in high traffic sites. Low traffic site data, however, showed that "pollutant deposition failed to saturate the sand particles, and the ratios were substantially lower on a cumulative basis". Horner and Mar suggest a 10,000 ADT delineation below which the seasonally increased TSS from sanding is acknowledged but other pollutant loadings are not estimated to increase as a result of it. This will be of direct interest to the evaluation of the Moose River unit.

Schueler, T., and D. Shepp. 1993. The Quality of Trapped Sediments and Pool Water Within Oil Grit Separators in Suburban Maryland--Interim Report, Revised April. MDE Urban Hydrocarbon Study Prepared for Maryland Department of the Environment.

Based on this interim report, many Maryland local governments reversed their positions regarding OGSs from requiring them for certain situations to not allowing their installation.

EXECUTIVE SUMMARY

"This interim report describes one phase of the MDE hydrocarbon study that investigated the quality of sediments and water contained within oil-grit separators in Maryland. A three-tiered sampling technique was employed to (a) determine hydrocarbon and priority pollutant levels in storm water runoff produced from different automotive related land uses, (b) characterize the effectiveness of Oil-Grit Separators (OGS) as an urban best management practice, and © assesses the possible toxicity of trapped residuals within OGS. Some of the more significant results from this phase of the study include the following:

"1. The quality of the water and sediments from 17 OGS sites was assessed, based on five broad land use categories: streets, all-day parking lots, townhouses, convenience stores, and gas stations. A sump pit and storm water pond were also monitored. Sampling was conducted at two levels: characterization of nutrient, hydrocarbon and metal concentrations within the sediment and water column of each OGS chamber, and six composite priority pollutant scans of the water column and sediments.

"2. Existing designs of OGS systems were demonstrated to have poor retention characteristics. The average wet volume of trapped sediments in over 100 OGS surveyed was slightly less than 12 cubic feet, within an average depth of only 2 inches. The mass of the trapped sediments with OGS did not increase from year to year, suggesting frequent scour and resuspension occurs. The depth of the trapped sediments fluctuated sharply from month to month; up to 50% reductions in the monthly depth of OGS sediments were observed. Dye tests indicated pool water residence times of less than ½ hour. Based on these observations of short retention, it was concluded that current design of OGS systems are not effective in trapping pollutants, and that the pollutant mass within them is largely the product of recent storm events.

"3. The mean hydrocarbon concentration in the water column of OGS was 10.9 mg/l. Mean hydrocarbon concentrations were greatest at the gas station, all day parking and convenience store sites, with lower concentrations reported at the residential and street sites. Gas stations had significantly higher pool HC, TOC, Zn and Cu levels than any of the four land uses. While the concentration of conventional pollutants (such as TP, TN, and TSS) were similar to those commonly sampled in urban runoff; the pool concentration of organic carbon, hydrocarbons and trace metals was sharply higher. In addition, substantial fractions of several trace metals such as cadmium, copper, chromium and zinc were present in soluble form.

"4. Sediments trapped within the OGS were oily, organic and relatively coarse-grained. Concentrations of hydrocarbons and TOC in OGS sediments averaged 8,150 and 53,900 mg/kg, respectively. Hydrocarbon levels were significantly higher at gas station sites; whereas, convenience store sites had significantly greater nutrient concentrations. The sediments of gas station OGS sites also had much higher levels of trace metals than the non-gas station sites.

"5. Compared with sump pits and pond sediments, OGS tended to have much greater concentrations of HC, TOC and trace metals in the sediment. Both sediment and water column concentrations did not vary appreciably between the first and second chamber of OGS, for most parameters.

"6. Priority pollutant scans indicated the presence of numerous potential toxicants in OGS sediments at all sites, particularly at gas station sites. 26 priority pollutants were positively identified at gas station sites, along with 11 others that were suspected, but below detection limits. These primarily included polyaromatic hydrocarbons and trace metals, but also included pthalates, phenol, toluene and possibly methylene chloride. Non-gas station sites recorded fewer PAHs at generally lower levels, but also exhibited the presence of two pesticides.

"7. The water column within gas station OGS had fewer positively identified priority pollutants (19), but possessed six volatile organics, including benzene, toluene, acetone, and ethyl benzene. In addition, the levels of total PAH's was estimated to exceed 250 ug/l. The water column of non-gas station OGS sites had many fewer priority pollutants, most of which were the ubiquitous trace metals.

"8. Surprisingly, the sediment PAH profile of the OGS sites was quite similar to that reported in the sediments of the tidal Anacostia river. The OGS sediment HC data provides some of the first evidence that might link upstream urban runoff to this chronic sediment contamination problem. At any rate, the study has established that higher hydrocarbon and priority pollutants can be expected from small sites with high automotive related use. Previous monitoring that had concentrated on larger more residential land uses failed to detect these priority pollutants (COG, 1983).

"9. The implications of the data on disposal of the rapped residuals and the overlying water is currently being evaluated, and will be reported in the next phase of the study. Of equal concern is the impact of the PAHs, trace metals, and hydrocarbons on downstream aquatic life, when trapped sediments are resuspended, or the overlying water is displaced. In particular, automotive land use hot spots might exert a possible toxic effect on headwater streams, where dilution is relatively low and exposure is chronic. However, actual toxicity testing will be needed to demonstrate such a link.

"10. The study confirms for the first time in the Washington region that automotive areas (such as gas-stations, all-day parking lots and convenience stores) can have elevated concentrations of hydrocarbons and other priority pollutants.

"11. Effective controls for the pollutants generated by the 2500 gas stations and vehicle maintenance operations in the Washington metropolitan area are not currently available. Some interesting new technologies may hold some promise, such as sand filters, or off-line oil-grit separators. Non-structural practices that improve the handling, storage and disposal of automotive fluids to prevent spills and leaks, may also be an effective strategy to prevent pollution."

Sthare, P., and B. Urbonas. 1990. Storm water Detention For Drainage, Water Quality, and CSO Management. Prentice Hall. Englewood Cliffs, NJ. 338 pp.

This is a design text and therefore presents limited and general commentaries about effectiveness. Chapter 5, titled "Concrete Basins", is based primarily on work that's been done in Germany. The authors maintain that of all storm water storage facilities, concrete basins offer the greatest flexibility. Their advantages are that they "can be configured into almost any geometric shape. Their main advantage is that their sides can be made near-vertical or vertical, which means that right-of-way can be minimized." The listed disadvantages are "poor aesthetics, high construction cost, and safety."

Design objectives determine whether the concrete basin is built in-line or off-line relative to the drainage conveyance system. They can be built open-topped or, more usually, as buried vaults. Their greatest use in Europe has been for the control of combined sewer overflows (CSOs), although some designs are for separate storm water runoff systems. "Some treatment of separate storm water runoff can be achieved...without additional downstream treatment facilities if an in-line system is employed. When storage is the only source of treatment, the operation and maintenance activities will increase, consistent with the treatment levels."

At this time permission has been requested of the publisher to include a complete photocopy of the chapter as Appendix A of the final report. The chapter's major subheadings are

(1) General,
(2) Systematization of Storage Basins,
(3) Technical Configuration,

(4) Supplemental Provisions, and
(5) Operation and Maintenance.

Citing Munz (1977), Stare and Urbonas state that in some situations "the accumulation of pollutants in storm sewers may be the prime reason for the observed first flush". This observation is the same as the hypothesis formulated by MOA's Tom Bacon and Scott Wheaton to explain the inconsistent results in previous "front-end back-end" sampling studies of MOA oil-grit separators.

Chapter 8 of the text is devoted to tunnel storage, a different but related technology. In the example that was given, all storm water from a subdivision in Stockholm, Sweden was routed through a 7-mile tunnel that emptied into a river. Storage, which is maintained at capacity, is almost 10 million cubic feet; inflow displaces water in storage. Stockholm Water and Sewage Works (1978) studied the efficiency of two other tunnels in their system and found that suspended solids showed 73-80% removal and that most of the clarification occurred during the first 24 hours. Analyses of the bottom sediments found 8,000 and 21,000 mg/kg (dry weight) hydrocarbons.

Kobriger, N.K., and A. Geinopolos. 1984. Sources and Migration of Highway Runoff Pollutants, Volume III: Research Report. Prepared by Rexnord Inc. for FHWA Office of Research and Development. Report No. FHWA/RD-84/059. 338 pp.

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Asplund, R.L. 1980. Characterization of Highway Storm water Runoff in Washington State. M.S.E. Thesis. Department of Civil Engineering, University of Washington, Seattle, WA. 186 pp.

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Leitao, A., and C.M.P. Rangel. 1988. Analysis of the Copsul water-oil separation system. Water Science Technology 20(10): 91-100.

Little, L.M., R.R. Horner, and B.W. Mar. 1983. Assessment of Pollutant Loadings and Concentrations in Highway Stormwater Runoff. Report FHWA WA-RD-39.12.1. Department of Civil Engineering, University of Washington, Seattle, WA. 41 pp.

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Mar, B.W., R.R. Horner, J.F. Ferguson, D.E. Spyridakis, and E.B. Welch. 1982. Summary--Washington State Highway Runoff Water Quality Study, 1977-1982. Report FHWA WA-RD-39.17. Department of Civil Engineering, University of Washington, Seattle, WA. 118 pp.

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Shaheen, D.G. 1975. Contributions of Urban Roadway Usage to Water Pollution. Report EPA- 600/2-75-004. U.S. Environmental Protection Agency. 350 pp.

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This was on a list dated October 1993 and titled "EPA Technical Guidance for Storm Water Dischargers" that was distributed at the conference "Storm Water Solutions in Alaska", April 18-20, 1994, in Anchorage, AK.

USEPA. 19xx. Urban Runoff Management Information/Education Products Catalog (Version 1).

This was on a list dated October 1993 and titled "EPA Technical Guidance for Storm Water Dischargers" that was distributed at the conference "Storm Water Solutions in Alaska", April 18-20, 1994, in Anchorage, AK.

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Zison, S.W. 1980. Sediment-Pollutant Relationships in Runoff from Selected Agricultural, Suburban and Urban Watersheds. Report EPA-600/3-80-22. Tetra Technology, Inc., Lafayette, CA. 135 pp.

Cited by Horner and Mar (1985); he also predicted other pollutant loadings from TSS.

APPENDIX C

A SEARCH FROM THE TRANSPORTATION RESEARCH INFORMATION SERVICES (TRIS)

Highway stormwater runoff (oil grit/grease...)

A SEARCH FROM THE

TRIS*
DATABASE

David Esch
Alaska Department of Transportation
Research
3132 Channel Drive
Juneau, AK 99801

If there are any questions, please call
(202) 334-3250

TRIS accession number: 634309   *TRIS files:* HRIS. H.
TRAIS. T.

TS Record Flag: 1

Title: USE OF VEGETATION TO REDUCE THE TOXICITY OF **STORMWATER RUNOFF**

Publication Information:
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Abstract: INVESTIGATE THE EFFECTIVENESS OF VEGETATED CHANNELS FOR REMOVAL OF **HIGHWAY STORMWATER RUNOFF** POLLUTANTS IN A MEDITERRANEAN CLIMATE WHERE LONG SUMMER DROUGHTS ARE FOLLOWED BY A RAINY SEASON. DETERMINE IF DORMANT OR DEAD VEGETATION ARE EFFECTIVE IN REDUCING TOXICITY OR REMOVING POLLUTANTS, METALS POLLUTION DISCHARGED FROM VEGETATED CHANNELS VIA DEAD VEGETATION, AND MAINTENANCE PRACTICES REQUIRED TO MAINTAIN POLLUTANT REMOVAL EFFICIENCY.

Performed by:
California Department of Transportation
Address:
1120 N Street
Sacramento, CA 95814
Investigator: Hunt, J
Investigator Phone: 916-227-7000
Status: Completed
Notice Date: Dec 14, 1993   **Contract Date:**
Start Date: Nov 21, 1986   **Completion Date:** Jun 30, 1993

Fiscal information

Total Dollars: 114000

Funded by:
California Department of Transportation
Address:
1120 N Street
Sacramento, CA 95814
Responsible Individual: John, B

Funded by:
Federal **Highway** Administration
Address:
400 7th Street, SW
Washington, DC 20590

TRIS accession number: 677038 *TRIS files:* HRIS. H.
TRAIS. T.

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Language(s):

Publication Information:

Source of Document: Federal **Highway** Administration

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Abstract Information

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Status: N

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316093

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Title: A REVIEW AND EVALUATION OF LITERATURE PERTAINING TO THE QUANTITY AND CONTROL OF POLLUTION FROM **HIGHWAY** RUNOFF AND CONSTRUCTION. INTERIM REPORT

Author(s):
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Springfield, VA 22161

Abstract Information
Abstract: This report is the first in a series which will address the water quantity and quality impacts of **highway** construction in the Austin, Texas area. This literature review evaluates the impact of **highway** construction and operation on surface water quality and on recharge of groundwater aquifers. The types of barriers for containment and retention of sediment and pollutants from runoff and the effectiveness of each device are discussed. The report also addresses the quantity and quality of **highway** runoff from different types of road surfaces, drainage and conveyance systems, and various types of **highways**. In addition, methods and strategies for the handling and control of **highway** runoff and effectiveness of pollution control devices are reviewed. **Highway** construction may cause changes in turbidity, suspended solids concentration, and color of the receiving waters. The extent and persistence of the effects are very site specific and are usually transitory. Prevention of erosion during construction with the use of vegetative stabilization is the most effective way to minimize the adverse effects of runoff. Previous research has identified surrounding land use, traffic volume, and rainfall characteristics as the most important factors for predicting the quality of **highway stormwater runoff**. Most studies have concluded that the type of paving material has a relatively small effect on runoff quality. The type and size of the receiving water, the potential for dispersion of the catchment area, and the biological diversity of the ecosystem are some of

the factors which determine the extent and importance of runoff effects. Most of the pollutant load in **highway** runoff is either the suspended particulate matter, or material adsorbed to the suspended solids. The most effective control measures reduce the amount of particulates in runoff through settling or filtration. Most design references specify vegetative controls because of their wide adaptability, low costs, and minimal maintenance requirements. Wet ponds are recommended when site conditions are not conducive to vegetative controls. Infiltration practices, although offering excellent treatment potential, are the least desirable because of their high maintenance requirements.

Supplementary notes: Research study title: Water Quantity and Quality Impacts Assessment of **Highway** Construction in Austin, Texas, Area.

Funding information

Contract/Grant Number:
Study 7-1943

Funding type:
Contract

TRIS accession number: 618765 *TRIS files:* HRIS. H 9201.

TRIS Record Flag: 3

Title: EVALUATION OF THE STORMWATER TREATMENT FACILITIES AT THE LAKE ANGEL DETENTION POND, ORANGE COUNTY, FLORIDA. FINAL REPORT

Language(s):

Author(s):

Wanielista, MP
Charba, J
Dietz, J
Lott, RS
Russell, B

Publication Information:
Report No: FL/DOT/RMC/3361 FL-ER-49-91
Period Covered: 9001-9106
Publication Date: 6/01/91 **Pagination:** 168p
Figures: 39 Fig. **Tables:** 20 Tab. **Photos:**
References: Refs. **Appendices:** 4 App.

Publisher/Corporate Author 1:
University of Central Florida
Dept of Civil and Environmental Engineering, P.O. Box 25000
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Florida Department of Transportation
Bureau of Materials and Research, P.O. Box 1029
Gainesville, FL 32602
blisher/Corporate Author 3:
Florida Department of Transportation
Haydon Burns Building, 605 Suwannee Street
Tallahassee, FL 32301
Publisher/Corporate Author 4:
Federal **Highway** Administration
400 7th Street, SW
Washington, DC 20590

Available from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Order Number: PB92-161157/AS

Abstract Information

Abstract: This is the final report on the use of Granulated Active Carbon (GAC beds of Filtrasorb 400 in series to reduce the Trihalomethane Formation Potential (THMFP) concentrations at the Lake Angel detention pond, Orange County, Florida. The detention pond accepts runoff from an interstate **highway** and a commercial area. Breakthrough time was estimated from laboratory analyses and used to design two beds in series at the detention pond. Breakthrough occurred in the first bed after treating 138,000 liter of water. Exhaustion of the first bed was reached after treating 1270 bed volumes with a sorption zone length of 1.70 ft. The TOC adsorbed per gram of GAC was 6.3 mg. The liquid flow rate averaged 0.0011 cfs. Similar breakthrough curves for Total Organic Carbon (TOC) and color were also reported. The used GAC can be disposed of by substituting it for sand in concrete mixes. An economic evaluation of the GAC system at Lake Angel demonstrated an annual cost of $4.39/1000 gallons to treat the **stormwater**

runoff after detention and before discharge into a drainage well. This cost could be further reduced by using the stormwater to irrigate right-of-way sections of the watershed. An alternative method of pumping to another drainage basin was estimated to be more expensive. The underdrain network for the GAC system initially became clogged with the iron- and sulfur-precipitating bacteria Leptothrix, Gallionella and Thiothrix. These bacteria were substantially reduced by altering the influent GAC system pipeline to take water directly from the lake. An alternate pipe system used a clay layer to reduce groundwater inputs and did not exhibit substantial bacterial growth.

TRIS accession number: 600481 *TRIS files:* HRIS. H 9004.

:RIS Record Flag: 2

..itle: POLLUTANT LOADINGS AND IMPACTS FROM **HIGHWAY STORMWATER RUNOFF**. VOLUME IV: RESEARCH REPORT DATA APPENDIX. FINAL REPORT

,anguage(s):

\uthor(s):
Driscoll, ED
Shelley, PE
Strecker, EW

?ublication Information:
Source of Document: Federal **Highway** Administration

Report No: FHWA-RD-88-009 NCP 3E7a1042
Period Covered: 8409-8712
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?ublisher/Corporate Author 1:
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500 12th Street, Suite 100
Oakland, CA 94607-4014
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Federal **Highway** Administration
Turner Fairbank Hwy Res Cntr, 6300 Georgetown Pike
McLean, VA 22101

Available from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Order Number: PB90-257577

Abstract Information
Abstract: This is one of four final documents of an investigation dealing with the characterization of **stormwater runoff** pollutant loads from **highways** and the prediction of water quality impacts they cause. Study results are based on monitoring data from 993 individual storm events at 31 **highway** runoff sites in 11 States. Impact prediction is based on a methodology previously developed and applied to urban runoff and adapted for **highway** runoff applications. This document provides a tabulated summary of all of the monitored data on storm rainfall, runoff volume, and pollutant concentrations. Data were recorded in spreadsheet format on microcomputer disks. Master copies of these disks have been provided to FHWA in both "Lotus 1-2-3" and "Excel" spreadsheet documents.
Supplementary notes: See also FHWA-RD-88-006, Volume I: Design Procedure (TRIS 496584); FHWA-RD-88-007, Volume II: Users Guide for Interactive Computer Implementation of Design Procedure; and FHWA-RD-88-008, Volume III: Analytical Investigation and Research Report (TRIS 496585).

Funding information

Contract/Grant Number: DTFH61-84-C-00120

Funding type: Contract

TRIS accession number: 570837 *TRIS files:* TLIB. L.

'RIS Record Flag: 3

:itle: POLLUTANT LOADINGS AND IMPACTS FROM **HIGHWAY STORMWATER RUNOFF**: VOLUME II, USERS GUIDE FOR INTERACTIVE COMPUTER IMPLEMENTATION OF DESIGN PROCEDURE

Language(s): ENGLISH

uthor(s):
DRISCOLL, ED
SHELLEY, PE
STRECKER, EW

Publication Information:
Source of Document: UC, BERKELEY, INSTITUTE FOR TRANSPORTATION STUDIES 22622534

Report No: FHWA/RD-88/007 FINAL REPO
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NATIONAL TECHNICAL INFORMATION SERVICE
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Abstract Information
Abstract: No abstract provided.
Supplementary notes: USERS GUIDE FOR INTERACTIVE COMPUTER IMPLEMENTATION OF DESIGN PROCEDURE SHELLEY AND ERIC W. STRECKER OTHER PHYS. DESCRIPTION: III COVER TITLE PERFORMED BY WOODWARD-CLYDE CONSULTANTS FOR THE FEDERAL **HIGHWAY** ADMINISTRATION, CONTRACT NO.: DTFH61-84-C-00120 APRIL 1990 INCLUDES BIBLIOGRAPHICAL REFERENCES ADDL CORP. AUTHOR INFO: UNITED STATES. FEDERAL **HIGHWAY** ADMINISTRATION ADDL CORP. AUTHOR INFO: WOODWARD-CLYDE CONSULTANTS US DEPT OF TRANSPORTATION FEDERAL **HIGHWAY** ADMINISTRATION RESEARCH DEVELOPMENT AND TECHNOLOGY

Funding information

Contract/Grant Number: **Funding type:**
DTFH61-84-C-00120.

TRIS accession number: 570838 *TRIS files:* TLIB. L.

TRIS Record Flag: 3

Title: POLLUTANT LOADINGS AND IMPACTS FROM **HIGHWAY STORMWATER RUNOFF**: VOLUME I, DESIGN PROCEDURE

Language(s): ENGLISH

Author(s):
DRISCOLL, ED
SHELLEY, PE
STRECKER, EW

Publication Information:

Source of Document: UC, BERKELEY, INSTITUTE FOR TRANSPORTATION STUDIES 2262255!

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Period Covered: 8409-8712
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Order Number:

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Abstract: No abstract provided.

Supplementary notes: OTHER PHYS. DESCRIPTION: V ILLUSTRATED COVER TITLE PERFORMED BY WOODWARD-CLYDE CONSULTANTS FOR THE FEDERAL **HIGHWAY** ADMINISTRATION, CONTRACT NO.: DTFH61-84-C-00120 APRIL 1990 INCLUDES BIBLIOGRAPHICAL REFERENCES ADDL CORP. AUTHOR INFO: UNITED STATES. FEDERAL **HIGHWAY** ADMINISTRATION ADDL CORP. AUTHOR INFO: WOODWARD-CLYDE CONSULTANTS US DEPT OF TRANSPORTATION FEDERAL **HIGHWAY** ADMINISTRATION RESEARCH DEVELOPMENT AND TECHNOLOGY

Funding information

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TRIS accession number: 564056 *TRIS files:* TLIB. L.

'RIS Record Flag: 3

ıtle: POLLUTANT LOADINGS AND IMPACTS FROM **HIGHWAY STORMWATER RUNOFF**
ıanguage(s): ENGLISH

Author(s):
DRISCOLL, ED
SHELLEY, PE
STRECKER, EW

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Report No: FHWA/RD-88/009 FINAL REPO
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MCLEAN, VA

bstract Information
Abstract: No abstract provided.
Supplementary notes: ADDL PLACE OF PUBLCATION: ADDL PUBLISHER: AVAILABLE THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE OTHER PHYS. DESCRIPTION: 4 V ILLUSTRATED COVER TITLE AUTHORS: EUGENE D. DRISCOLL, PHILIP E. SHELLEY, ERIC W. STRECKER PERFORMED BY WOODWARD-CLYDE CONSULTANTS FOR THE FEDERAL **HIGHWAY** ADMINISTRATION, CONTRACT NO.: DTFH61-84-C-00120 APRIL 1990 INCLUDES BIBLIOGRAPHICAL REFERENCES V. I. DESIGN PROCEDURE -- V. II. USERS GUIDE FOR INTERACTIVE COMPUTER IMPLEMENTATION OF DESIGN PROCEDURE -- V. III. ANALYTICAL INVESTIGATION AND RESEARCH REPORT -- V. IV. RESEARCH REPORT DATA APPENDIX- ADDL CORP. AUTHOR INFO: WOODWARD-CLYDE CONSULTANTS ADDL CORP. AUTHOR INFO: UNITED STATES. FEDERAL **HIGHWAY** ADMINISTRATION US DEPT OF TRANSPORTATION FEDERAL **HIGHWAY** ADMINISTRATION RESEARCH DEVELOPMENT AND TECHNOLOGY

Funding information

Contract/Grant Number: **Funding type:**
DTFH61-84-C-00120.

TRIS accession number: 600480 *TRIS files:* HRIS. H 9004.

:RIS Record Flag: 2

ıitle: POLLUTANT LOADINGS AND IMPACTS FROM **HIGHWAY STORMWATER RUNOFF**. VOLUME II: USERS GUIDE FOR INTERACTIVE COMPUTER IMPLEMENTATION OF DESIGN PROCEDURE. FINAL REPORT

Language(s):

ıuthor(s):

Driscoll, ED
Shelley, PE
Strecker, EW

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Turner Fairbank Hwy Res Cntr, 6300 Georgetown Pike
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Order Number: PB90-257544

Abstract Information

Abstract: This is one of four final documents of an investigation dealing with the characterization of **stormwater runoff** pollutant loads from **highways** an the prediction of water quality impacts they cause. Study results are based on monitoring data from 993 individual storm events at 31 **highway** runoff sites in 11 States. Impact prediction is based on a methodology previously developed and applied to urban runoff and adapted for **highway** runoff applications. This document is a users guide for an interactive computer procedure for computing the estimated impacts on water quality of a stream or lake that receives **highway** runoff. The program provides guidance for evaluating whether or not a water quality problem will result and the degree of pollution control required to mitigate predicted impacts to acceptable levels. The computer program is based on the methodology presented in the Design Procedures report of this study.

Supplementary notes: See also FHWA-RD-88-006, Volume I: Design Procedure (TRIS 496584); FHWA-RD-88-008, Volume III: Analytical Investigation and Research Report (TRIS 496585); and FHWA-RD-88-009, Volume IV: Research Report Data Appendix.

Funding information

Contract/Grant Number: DTFH61-84-C-00120

Funding type: Contract

TRIS accession number: 496584 *TRIS files:* HRIS. H 9003.

TRIS Record Flag: 3

Title: POLLUTANT LOADINGS AND IMPACTS FROM **HIGHWAY STORMWATER RUNOFF**. VOLUME I: DESIGN PROCEDURE. FINAL REPORT

Language(s):

Author(s):
Driscoll, ED
Shelley, PE
Strecker, EW

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Figures: 7 Fig. **Tables:** 16 Tab. **Photos:**
References: 9 Ref. **Appendices:** 3 App.

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Available from:
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Abstract Information

Abstract: This is one of four final documents of an investigation dealing with the characterization of **stormwater runoff** pollutant loads from **highways**, and the prediction of water quality impacts they cause. Study results are based on monitoring data from 993 individual storm events at 31 **highway** runoff sites in 11 States. Impact prediction is based on a methodology previously developed and applied to urban runoff and adapted for **highway** runoff applications. This document provides a step-by-step procedure for computing the estimated impacts on water quality of a stream or lake that receives **highway** runoff. Guidance is provided for evaluating whether or not a water quality problem will result, and the degree of pollution control required to mitigate impacts to acceptable levels.

Supplementary notes: See also FHWA-RD-88-007, Volume II: Users Guide for Interactive Computer Implementation of Design Procedure; FHWA-RD-88-008, Volume III: Analytical Investigation and Reseach Report; and FHWA-RD-88-009, Volume IV: Research Report Data Appendix.

Funding information

Contract/Grant Number: DTFH61-84-C-00120

Funding type: Contract

TRIS accession number: 496585 *TRIS files:* HRIS. H 9003.

TRIS Record Flag: 3

Title: POLLUTANT LOADINGS AND IMPACTS FROM **HIGHWAY STORMWATER RUNOFF.** VOLUME III: ANALYTICAL INVESTIGATION AND RESEARCH REPORT

Language(s):

Author(s):
Driscoll, ED
Shelley, PE
Strecker, EW

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Report No: FHWA-RD-88-008 NCP 3E7a1042
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Figures: 50 Fig. **Tables:** 27 Tab. **Photos:**
References: 68 Ref. **Appendices:**

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500 12th Street, Suite 100
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Available from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Order Number: PB90-257569/AS

Abstract Information

Abstract: This is one of four final documents of an investigation dealing with the characterization of **stormwater runoff** pollutant loads from **highways,** and the prediction of water quality impacts they cause. Study results are based on monitoring data from 993 individual storm events at 31 **highway** runoff sites in 11 States. Impact prediction is based on a methodology previously developed and applied to urban runoff and adapted for **highway** runoff applications. This document describes the procedures used to assemble and analyze the data base and reports the results of these analyses. Included in this document are statistical summaries of the data base, along with a description of procedures to use to predict pollutant discharges from **highway** sites and the impacts that they will cause to receiving waters.

Supplementary notes: See also FHWA-RD-88-006, Volume I: Design Procedure; FHWA-RD-88-007, Volume II: Users Guide for Interactive Computer Implementation of Design Procedure; and FHWA-RD-88-009, Volume IV: Research Report Data Appendix.

Funding information

Contract/Grant Number: FH61-84-C-00120
Funding type: Contract

TRIS accession number: 485679 *TRIS files:* HRIS. H 8904.

TRIS Record Flag: 3

Title: THE USE OF VEGETATION TO REDUCE THE TOXICITY OF **STORMWATER RUNOFF**. INTERIM REPORT

Language(s):

Author(s):
Umeda, P-J

Publication Information:

Report No: FHWA/CA/TL-88/06
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Publication Date: 9/00/88 **Pagination:** 46p
Figures: 8 Fig. **Tables:** **Photos:**
References: 20 Ref. **Appendices:** 2 App.

Publisher/Corporate Author 1:
California Department of Transportation
Transportation Laboratory, 5900 Folsom Boulevard
Sacramento, CA 95819

Publisher/Corporate Author 2:
California Department of Transportation
1120 N Street
Sacramento, CA 95814

Publisher/Corporate Author 3:
Federal **Highway** Administration
400 7th Street, SW
Washington, DC 20590

Available from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Order Number: PB89-229454/AS

Abstract Information

Abstract: The purpose of the research is to determine if dead or dormant vegetation effectively reduces the toxicity of and removes pollutants from **highway stormwater runoff** and to determine the amount of metallic pollution discharged from vegetated ditches via the transort of dead vegetation. The research will also determine the type of maintenance practices that are necessary to maintain the pollutant removal capacity of vegetated channels. This research project will consist of three phases. Each phase will require several tasks to be completed. The purpose of this report is to present the findings of Phase I. The tasks involved included a literature survey, site selection, and equipment design, fabrication and installation. Two sites were selected for the research project. The irrigation system was installed, grass seed was sown and runoff samplers were fabricated and placed in the channel.

Funding information

Contract/Grant Number:
"87TL16

Funding type:
Contract

TRIS accession number: 489707 *TRIS files:* HRIS. H 9001.

:RIS Record Flag: 3

ıitle: DETENTION BASINS FOR WATER QUALITY IMPROVEMENT AT A HIGH MOUNTAIN MAINTENANCE STATION

ıanguage(s):

\uthor(s):

Racin, JA
Howell, RB

?ublication Information:

?ublication Title: Transportation Research Record

Volume: **Number:** 1201

?ublication Date: 0/00/88 **Pagination:** pp 62-72

ISBN: 0-309-04762-5 **ISSN:** 03611981

Figures: 7 Fig. **Tables:** 2 Tab. **Photos:** 10 Phot.

References: 9 Ref. **Appendices:**

?ublisher/Corporate Author 1:

Transportation Research Board
2101 Constitution Avenue, NW
Washington, DC 20418

Available from:

Transportation Research Board Business Office
2101 Constitution Avenue, NW
Washington, DC 20418
Order Number:

Abstract Information

Abstract: An evaluation of a detention basin system at a snow removal maintenance station is documented. In response to concerns by the US Forest Service, the basins were built as a mitigation measure to clarify storm **runoff** and snowmelt from the maintenance station before it entered Benwood Creek. The creek is a tributary of the headwaters of the South For of the American River. A portion of the creek was realigned. The three-basin system, completed in September 1981, is above elevation 7000 feet at the Echo Summit Maintenance Station in California. Sediment and dissolved materials in storm **runoff** and snowmelt from the maintenance yard were reduced. The capacity of the basins was approximately 10,000 cubic feet as measured in 1982. The basin riser outlets were fitted **with grease** rings, which retain most oil, **grease,** and floatables. Snow melt **was** sampled and tested in spring 1982. Samples were tested for turbidity, chloride, specific conductance, filterable residue, and chloride. Sedimen accumulation in the basins was measured, and a biological assessment of th construction impacts on Benwood Creek was made.

Supplementary notes: This paper appears in Transportation Research Record No. 1201, Arid Lands: Hydrology, Scour, and Water Quality.

TRIS accession number: 469227 *TRIS files:* HRIS. H 8803.

RIS Record Flag: 2

ıitle: RETENTION, DETENTION, AND OVERLAND FLOW FOR POLLUTANT REMOVAL FROM **HIGHWAY STORMWATER RUNOFF**: INTERIM DESIGN GUIDELINES FOR MANAGEMENT MEASURES. FINAL REPORT

Language(s):

uthor(s):

Dorman, ME
Hartigan, J
Johnson, F
Maestri, B

ublication Information:

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Turner Fairbank Hwy Res Cntr, 6300 Georgetown Pike
McLean, VA 22101

vailable from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Order Number: PB89-133292/AS

bstract Information

Abstract: This report provides interim guidelines for the design of management measures for the removal of pollutants from **highway stormwater runoff.** Three general types of management measures have been determined, through previous FHWA studies, to be effective in treating **highway** runoff: vegetative controls (overland flow and grassed channels), detention basins (wet detention basins and wetlands), and retention measures (retention basins, trenches and wells). These interim design guidelines have been developed based on experience of the project team and by a thorough review of available literature. Field and laboratory studies are currently underway to verify the design procedures and assumptions presented in this report.

Funding information

Contract/Grant Number: DTFH61-85-C-00117

Funding type: Contract

TRIS accession number: 457819 *TRIS files:* HRIS. H 8701.

TRIS Record Flag: 3

Title: STORMWATER MANAGEMENT DETENTION POND DESIGN WITHIN FLOODPLAIN AREAS
Language(s):

Author(s):
Smith, PH
Cook, JS

Publication Information:
Publication Title: Transportation Research Record
Volume: **Number:** 1017
Publication Date: 0/00/85 **Pagination:** pp 31-38
ISBN: 6-1 **ISSN:** 03611981 0-309-0390
Figures: 9 Fig. **Tables:** 9 Tab. **Photos:**
References: 8 Ref. **Appendices:**

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Transportation Research Board
2101 Constitution Avenue, NW
Washington, DC 20418

Available from:
Transportation Research Board Business Office
2101 Constitution Avenue, NW
Washington, DC 20418
Order Number:

Abstract Information

Abstract: A unique approach to stormwater management for projects requiring mitigation of additional runoff caused by increases in paved surface areas is presented in this paper. Based on a design project developed for the General Foods Corporate Headquarters site in Rye, New York, a stormwater detention pond has been implemented within the floodplain of an adjacent watercourse. Encroachment of construction activities within a floodplain required the development of a detention pond that was capable of controlling excess runoff from adjacent areas while providing continued floodplain storage volume capacity. This methodology minimized the impacts of flooding on adjacent properties and provided suitable land areas for development in accordance with the intended use of the property. Occurrence of peak flooding along the watercourse did not coincide with peak **stormwater runoff** conditions from the smaller adjacent drainage area. By utilizing flood hydrograph principles and analyses that were developed by the Soil Conservation Service, U.S. Department of Agriculture, it was possible to develop a detention pond to provide a stormwater management phase and a flood control phase. Computerized analyses were compared for pre- and postdevelopment conditions using **stormwater runoff** and flood flow data on the basis of storms with return period frequencies of 10, 25, 50, and 100 years. By providing inlet pipes and outlet structures to control detention pond storage, peak flows from the pond to the watercourse and peak flood flows on the watercourse were reduced. The detention pond provides an aesthetic and effectve method of mitigating flooding impacts that might have resulted from site development.

Supplementary notes: This paper appeared in Transportation Research Record N1017, Surface Drainage and **Highway** Runoff Pollutants.

TRIS accession number: 457820 *TRIS files:* HRIS. H 8701.

RIS Record Flag: 3

itle: FORECASTING POLLUTANT LOADS FROM HIGHWAY **RUNOFF**
anguage(s):

Author(s):
Kerri, KD
Racin, JA
Howell, RB

ublication Information:
ublication Title: Transportation Research Record
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igures: 10 Fig. **Tables:** 2 Tab. **Photos:**
References: 12 Ref. **Appendices:**

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Transportation Research Board
2101 Constitution Avenue, NW
Washington, DC 20418

Available from:
Transportation Research Board Business Office
2101 Constitution Avenue, NW
Washington, DC 20418
Order Number:

Abstract Information
bstract: Forecasting regression equations for estimating pollutant loads in **runoff** from highways are developed in this paper. Data were collected during the **runoff** seasons at completely paved urban highway sites in Redondo Beach, Walnut Creek, and Sacramento, California. Information was also obtained from a rural site near Placerville. Rainfall and **runoff** were monitored continuously. Bubbler flow meters were used with automatic sequential samplers so that storm water samples could be collected to characterize entire storm events. The constituents that were analyzed were boron, total lead, total zinc, nitrate (nitrogen), ammonia (nitrogen), total Kjeldahl nitrogen, total phosphorus, dissolved orthophosphate, oil and **grease,** nonfilterable residue, filterable residue, total cadmium, and chemical oxygen demand. The number of vehicles during the storm was evaluated and accepted as a satifactory independent variable for estimating the loads of total lead, total zinc, filterable residue, chemical oxygen demand, and total Kjeldahl nitrogen. The total residue was evaluated and accepted as a satisfactory independent variable for estimating total zinc, nonfilterable residue, and chemical oxygen demand. Estimates by using these equations should be limited to highways with average daily traffic of at least 30,000 vehicles. The numbers of antecedent dry days was found not to be a satisfactory independent variable.
Supplementary notes: This paper appeared in Transportation Research Record N1017, Surface Drainage and Highway **Runoff** Pollutants.

TRIS accession number: 457821 *TRIS files:* HRIS. H 8701.

RIS Record Flag: 3

…itle: ASSESSING THE IMPACTS OF OPERATING **HIGHWAYS** ON AQUATIC ECOSYSTEMS
…anguage(s):

Author(s):
Horner, RR
Mar, BW

Publication Information:
…ublication Title: Transportation Research Record
…olume: **Number:** 1017
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…igures: 5 Fig. **Tables:** 4 Tab. **Photos:**
…eferences: 47 Ref. **Appendices:**

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Washington, DC 20418

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Order Number:

…bstract Information
Abstract: A protocol has been developed for assessing the impacts of **highway** operations and maintenance and determining the need for impact mitigation measures. The general strategy applies nationally, and specific elements of the method have been developed for the state of Washington and other Pacific Northwest locations on the basis of comprehensive research that was conducted in that region on **highway** runoff water quality. The basic premise of the protocol is that the **highway** impact on the receiving water can be assessed most realistically in the context of the aggregate burden that is created by all activities in the watershed. By using an initial screening process a determination can be made as to whether or not a case is likely to have an insignificant impact. Substantial resources are expended on assessing only those cases that may have a significant impact on aquatic ecosystems. Those cases are subjected to analyses of both cumulative pollutant loadings and changes in pollutant concentrations in the receiving waters, which emphasize the most critical conditions under the circumstances. Mitigation is considered in both steps. The Washington results were employed to develop a deterministic model for the pollutant loading analysis and a probabilistic procedure for the pollutant concentration assessment. The protocol offers opportunities to forecast potential aquatic impacts of a **highway** at an early stage of project development and to allocate impact mitigation measures on the basis of need. This advance improves the cost-effectiveness of **stormwater runoff** management and aids in avoiding the expense and delay of legal challenges to **highway** agency actions that have potential water quality impacts.
Supplementary notes: This paper appeared in Transportation Research Record N1017, Surface Drainage and **Highway** Runoff Pollutants.

Contract/Grant Number:
80533

Funding type:
Contract

TRIS accession number: 461764 *TRIS files:* HRIS. H 8703.

TRIS Record Flag: 2

Title: EFFECTS OF **HIGHWAY** RUNOFF ON RECEIVING WATERS. VOLUME I: EXECUTIVE SUMMARY

Language(s):

Author(s):

Dupuis, TV
Bertram, P
Meyer, J
Smith, M
Kobriger, N
Kaster, J

Publication Information:

Source of Document: Federal **Highway** Administration

Report No: FHWA/RD-84/062 FCP 33B1-012
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Turner Fairbank Hwy Res Cntr, 6300 Georgetown Pike
McLean, VA 22101

Available from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Order Number:

Abstract Information

Abstract: This volume, the 1st of 5, summarizes the research undertaken to determine the effects of **highway stormwater runoff** on receiving waters. Included in this effort were one-year field studies at three sites and preparation of three user oriented manuals: (1) a guidelines manual for conducting field studies of receiving water effects, (2) a procedural manual for use in writing NEPA documents, and (3) a resource document whic summarizes all existing information on receiving water effects.

Supplementary notes: See also Volume II - Research Report (TRIS 461765), Volum III - Resource Document for Environmental Assessments (TRIS 461766), Volum IV - Procedural Guidelines for Environmental Assessments (TRIS 461767), ar Volume V (TRIS 461768).

Funding information

Contract/Grant Number: DOT-FH-61-80-C-00001

Funding type: Contract

TRIS accession number: 461766 TRIS files: HRIS. H 8703.

RIS Record Flag: 2

itle: EFFECTS OF **HIGHWAY** RUNOFF ON RECEIVING WATERS. VOLUME III: RESOURCE DOCUMENT FOR ENVIRONMENTAL ASSESSMENTS. FINAL REPORT

anguage(s):

uthor(s):

Dupuis, TV
Kobriger, N
Kreutzberger, WK
Trippi, V

Publication Information:

ource of Document: Federal **Highway** Administration

Report No: FHWA/RD-84/064 FCP 33B1-012
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Order Number:

Abstract Information

Abstract: This resource document, the 3rd volume of 5, is intended to serve as a user tool to supplement the Procedural Guidelines Manual (Volume IV). State **highway** agencies can use these resources to more comprehensively address the effects of **stormwater runoff** in environmental documents (i.e., EISs and EAs). This document provides a critical summary and review of the technical literature on hydrological, water quality, sediment, and biological impacts of runoff from operating **highways**. Major pollutant categories include oxygen-consuming materials, nutrients, bacteria, road salt, petroleum hydrocarbons, and metals.

Supplementary notes: See also Volume I - Executive Summary (TRIS 461764), Volume II - Research Report (TRIS 461765), Volume IV - Procedural Guidelines for Environmental Assessments (TRIS 461767), and Volume V - Guidelines for Conducting Field Studies (TRIS 461768).

Funding information

Contract/Grant Number: DOT-FH-61-80-C-00001

Funding type: Contract

TRIS accession number: 378789 *TRIS files:* HRIS. H 8401.

RIS Record Flag: 2

itle: DESIGN OF URBAN **HIGHWAY** DRAINAGE--THE STATE OF THE ART
anguage(s):

Publication Information:
eport No: FHWA-TS-79-225
Period Covered:
Publication Date: 8/00/79 **Pagination:** 285p

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Consulting Engineers, 1040 North Lindbergh Boulevard
St. Louis, MO 63122
Publisher/Corporate Author 2:
Federal **Highway** Administration
Office of Implementation
McLean, VA 22101

Available from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Order Number: PB83-259903

Abstract Information
stract: This manual represents the state-of-the-art for the design of urban **highway** drainage. Historical practice has involved a philosophy of intersecting, collecting, and disposing of **stormwater runoff** as rapidly as possible. The cumulative effects of such past concepts of urban storm drainage have been a principal cause of increased frequency of downstream flooding, often accompanied by diminishing groundwater supplies as direct results of urbanization; or they have necessitated development of large-scale downstream engineering works to prevent flood damage. Stormwater management diminishes these problems by the use of integral and interrelated systems of collection, storage, treatment, and disposal of stormwater. This manual provides information necessary for the design of individual components as well as interrelated stormwater systems. (Author)

TRIS accession number: 461767 *TRIS files:* HRIS. H 8703.

TRIS Record Flag: 2

Title: EFFECTS OF **HIGHWAY** RUNOFF ON RECEIVING WATERS. VOLUME IV: PROCEDURAL GUIDELINES FOR ENVIRONMENTAL ASSESSMENTS

Language(s):

Author(s):

Dupuis, TV

Kobriger, N

Publication Information:

Source of Document: Federal **Highway** Administration

Report No: FHWA/RD-84/065 FCP 33B1-012

Period Covered: 791000-8507

Publication Date: 7/00/85 **Pagination:** 121p

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McLean, VA 22101

Available from:

National Technical Information Service

5285 Port Royal Road

Springfield, VA 22161

Order Number:

Abstract Information

Abstract: This volume, the 4th of 5, is a guidelines manual intended to provide the **highway** engineer and/or agency responsible for preparation of environmental assessments with the necessary procedures to evaluate potential impacts from **stormwater runoff** from operating **highways.** Included are descriptions of institutional factors such as water uses, standards, and other regulations pertaining to nonpoint source programs; and technical considerations such as effects of **highway** type and documented or potential impacts (including information from Vols. II and III). Mitigation strategies are also described for those cases where they are required or advisable.

Supplementary notes: See also Volume I - Executive Summary (TRIS 461764), Volume II - Research Report (TRIS 461765), Volume III - Resource Document for Environmental Assessments (TRIS 461766), and Volume V - Guidelines for Conducting Field Studies (TRIS 461768).

Funding information

Contract/Grant Number: DOT-FH-61-80-C-00001

Funding type: Contract

TRIS accession number: 461783 *TRIS files:* HRIS. H 8703.

TRIS Record Flag: 2

Title: MANAGEMENT PRACTICES FOR MITIGATION OF **HIGHWAY STORMWATER RUNOFF** POLLUTION. VOLUME I: GUIDELINES. FINAL REPORT

Language(s):

Author(s):

Burch, CW
Johnson, F
Maestri, B

Publication Information:

Source of Document: Federal **Highway** Administration

Report No: FHWA/RD-85/001 FCP 33B1-022
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Available from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Order Number:

Abstract Information

Abstract: The research identifies practical, effective, and implementable mitigation measures to reduce or eliminate the impacts from **highway stormwater runoff**. The guidelines are presented in this volume, the 1st o 4, in three parts: General Guidelines - General design principles and practices intended for use wherever practicable without the necessity of identifying a specific problem (The guidelines presented are relatively low-cost and can be incorporated into existing **highway** design procedures and maintenance programs.); Design Guidelines - Guidelines for designing four effective site-specific management measures: vegetative controls, detention basins, infiltration systems, and wetlands; and **Highway** Applications - Examples of applications of the management measures (singly and in combination) to **highway** systems.

Supplementary notes: See also Volume II - Literature Review (TRIS 461784), Volume III - Research Report (TRIS 461785), and Volume IV - Executive Summary (TRIS 461786).

Funding information

Contract/Grant Number: DOT-FH-61-82-C-00028

Funding type: Contract

TRIS accession number: 461784 *TRIS files:* HRIS. H 8703.

TRIS Record Flag: 2

Title: MANAGEMENT PRACTICES FOR MITIGATION OF **HIGHWAY STORMWATER RUNOFF** POLLUTION. VOLUME II: LITERATURE REVIEW. FINAL REPORT

Language(s):

Author(s):
Burch, CW
Johnson, F
Maestri, B

Publication Information:
Source of Document: Federal **Highway** Administration

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Order Number:

Abstract Information
Abstract: The research identifies practical, effective, and implementable mitigation measures to reduce or eliminate the impacts from **highway stormwater runoff**. This volume, the 2nd of 4, presents the results of the review of published and unpublished literature, and interviews with state **highway** agencies, as the state-of-the-art for **highway** stormwater pollution control. Management practices were evaluated as to their pollutant removal effectiveness, design, physical characteristics, environmental considerations, cost, and overall applicability to **highway** runoff pollution control.
Supplementary notes: See also Volume I - Guidelines (TRIS 461783), Volume III - Research Report (TRIS 461785), and Volume IV - Executive Summary (TRIS 461786).

Funding information

Contract/Grant Number:
DOT-FH-61-82-C-00028

Funding type:
Contract

TRIS accession number: 461785 *TRIS files:* HRIS. H 8703.

TRIS Record Flag: 2

Title: MANAGEMENT PRACTICES FOR MITIGATION OF **HIGHWAY STORMWATER RUNOFF** POLLUTION. VOLUME III: RESEARCH REPORT. FINAL REPORT

Language(s):

Author(s):

Burch, CW
Johnson, F
Maestri, B
Dawson, BL

Publication Information:

Source of Document: Federal **Highway** Administration

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ailable from:

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Order Number:

Abstract Information

Abstract: The research identifies practical, effective, and implementable mitigation measures to reduce or eliminate the impacts from **highway stormwater runoff.** This volume, the 3rd of 4, documents the approach used to implement this research program. The project approach was divided into four steps: data collection, identification of Best Management Practices (BMPs), identification of BMPs applicable to **highways,** and development of design/implementation guidelines. A complete bibliography of all identified references and trip reports describing interviews with state **highway** agency personnel are provided.

Supplementary notes: See also Volume I - Guidelines (TRIS 461783), Volume II - Literature Review (TRIS 461784), and Volume IV - Executive Summary (TRIS 461786).

Funding information

Contract/Grant Number: DOT-FH-61-82-C-00028

Funding type: Contract

TRIS accession number: 461786 *TRIS files:* HRIS. H 8703.

'RIS Record Flag: 2

'itle: MANAGEMENT PRACTICES FOR MITIGATION OF **HIGHWAY STORMWATER RUNOFF** POLLUTION. VOLUME IV: EXECUTIVE SUMMARY. FINAL REPORT

.anguage(s):

'uthor(s):
Burch, CW
Johnson, F
Maestri, B

?ublication Information:

Source of Document: Federal **Highway** Administration

Report No: FHWA/RD-85/004 FCP 33B1-022
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Order Number:

Abstract Information

Abstract: The research identifies practical, effective, and implementable mitigation measures to reduce or eliminate the impacts from **highway stormwater runoff**. This volume, the 4th of 4, summarizes the purpose and objectives of the research and presents an overview of the results.

Supplementary notes: See also Volume I - Guidelines (TRIS 461783), Volume II - Literature Review (TRIS 461784), and Volume III - Research Report (TRIS 461785).

Funding information

Contract/Grant Number: DOT-FH-61-82-C-00028

Funding type: Contract

TRIS accession number: 468697 *TRIS files:* HRIS. H 8802.

RIS Record Flag: 2

ıitle: CONSEQUENTIAL SPECIES OF HEAVY METALS. FINAL REPORT
anguage(s):

Author(s):
Yousef, YA
Harper, HH
Wiseman, L
Bateman, M

'ublication Information:
Source of Document: National Technical Information Service

:eport No: FHWA/FL/BMR-85/286 FL-ER-29-85
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University of Central Florida
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Orlando, FL
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Bureau of Materials and Research, P.O. Box 1029
Gainesville, FL 32602
Publisher/Corporate Author 3:
Florida Department of Transportation
Bureau of Environment, Haydon Burns Bldg, 605 Suwannee St
Tallahassee, FL 32301
Publisher/Corporate Author 4:
Federal **Highway** Administration
400 7th Street, SW
Washington, DC 20590

Available from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Order Number: PB86-113107/XAB

Abstract Information
Abstract: **Highway stormwater runoff** contains significantly higher concentrations of trace metals, particularly Pb, Zn, Cd, Cu, Cr, Fe, and Ni than the water samples from adjacent receiving water bodies. The metals associated with **highway** runoff tend to be detoxified by the organic content and chemical conditions of natural waters and sediments. Most of the metals are retained by the bottom sediments on a permanent basis if aerobic conditions and high redax-potential (Eh) values are maintained. Retention/detention ponds similar to the Maitland Pond site are very effective in nutrient and heavy metal removal from **highway** runoff.

TRIS accession number: 469219 *TRIS files:* HRIS. H 8803.

RIS Record Flag: 2

ıitle: EFFECTS OF **HIGHWAY** RUNOFF ON RECEIVING WATERS. VOLUME III: RESOURCE DOCUMENT FOR ENVIRONMENTAL ASSESSMENTS. FINAL REPORT

ıanguage(s):

ᐩuthor(s):
Dupuis, TV
Kobriger, NP
Kreutzberger, WK
Trippi, V

Publication Information:
Source of Document: Federal **Highway** Administration

Report No: FHWA/RD-84/064 FCP 33B1 012
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400 7th Street, SW
Washington, DC 20590

ailable from:
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5285 Port Royal Road
Springfield, VA 22161
Order Number:

Abstract Information

Abstract: This resource document is intended to serve as a user tool to supplement the Procedural Guidelines Manual (Volume IV). State **highway** agencies can use these resources to more comprehensively address the effects of **stormwater runoff** in environmental documents (i.e., EIS's and EA's). This document provides a critical summary and review of the technical literature on hydrological, water quality, sediment, and biological impacts of runoff from operating **highways**. Major pollutant categories include oxygen-consuming materials, nutrients, bacteria, road salt, petroleum hydrocarbons, and metals.

Supplementary notes: Subcontract work by: University of Wisconsin-Milwaukee, Center for Great Lake Studies, Milwaukee, WI 53201. See also FHWA/RD-84/062 - Volume I: Executive Summary; FHWA/RD-84/063 - Volume II: Research Report; FHWA/RD-84/065 - Volume IV: Procedural Guidelines for Environmental Assessments; and FHWA/RD-84/066 - Volume V: Guidelines for Conducting Field Studies.

Funding information

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Funding type: Contract

TRIS accession number: 469220 *TRIS files:* HRIS. H 8803.

'RIS Record Flag: 2

ıitle: EFFECTS OF **HIGHWAY** RUNOFF ON RECEIVING WATERS. VOLUME IV: PROCEDURAL GUIDELINES FOR ENVIRONMENTAL ASSESSMENTS. FINAL REPORT

ıanguage(s):

'uthor(s):

Dupuis, TV
Kobriger, NP

?ublication Information:

Source of Document: Federal **Highway** Administration

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Publication Date: 7/00/85 **Pagination:** 127p

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Available from:

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Abstract Information

Abstract: This guidelines manual is intended to provide the **highway** engineer and/or agency responsible for preparation of environmental assessments wit the necessary procedures to evaluate potential impacts from **stormwater runoff** from operating **highways**. Included are descriptions of institutiona factors such as water uses, standards, and other regulations pertaining tc nonpoint source programs; and technical considerations such as effects of **highway** type and documented or potential impacts (including information from Volumes II and III). Mitigation strategies are also described for those cases where they are required or advisable.

Supplementary notes: Subcontract work by: University of Wisconsin-Milwaukee, Center for Great Lakes Studies, Milwaukee, WI 53201. See also FHWA/RD-84/062 - Volume I: Executive Summary; FHWA/RD-84/063 - Volume II: Research Report; FHWA/RD-84/064 - Volume III: Resource Document for Environmental Assessments; and FHWA/RD-84/066 - Volume V: Guidelines for Conducting Field Studies.

Funding information

Contract/Grant Number: DTFH-61-80-C-00001

Funding type: Contract

TRIS accession number: 395926 *TRIS files:* HRIS. H 8604.

'RIS **Record Flag:** 3

'ıitle: DETENTION BASINS AT TWO SNOW REMOVAL MAINTENANCE STATIONS: AN EVALUATION. INTERIM REPORT

_anguage(s):

'uthor(s):

Racin, JA
Parks, DM

?ublication Information:

Report No: FHWA-CA-TL-84/11
Period Covered: 820400-8304
Publication Date: 4/00/84 **Pagination:** 79p
Figures: 27 Fig. **Tables:** 11 Tab. **Photos:**
References: 11 Ref. **Appendices:** 1 App.

?ublisher/Corporate Author 1:

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Transportation Laboratory, 5900 Folsom Boulevard
Sacramento, CA 95819

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Federal Highway Administration
400 7th Street, SW
Washington, DC 20590

Available from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Order Number: PB85-227056/AS

Abstract Information

Abstract: The evaluation of two detention basin systems at snow removal maintenance stations is documented. The basins were built as mitigation measures to clarify storm **runoff** or wash water from maintenance activities that enters nearby streams. The three basin system at the Echo Summit Maintenance Station removed sediment and was effective in reducing turbidity, floatables (oil and **grease**), and to a lesser extent, chloride. The system has a capacity of approximately 10,000 cubic feet. The riser outlets are fitted with **grease** rings. The three basin system at the Truckee Maintenance Station did not fill with water during the study. The basins were filled witth sand, and they performed more like a sand filter trap than a detention basin. The capacity of the three basin system is 3600 cubic feet, and there are no **grease** rings. The water volume from washing trucks does not produce **runoff** to cause the basins to overflow. (Author)

Supplementary notes: Research was accomplished under the Federal Highway Administration Project, Mitigation of Highway Related Chemical Water Quality Pollutants. Phase III, Study 8, Drainage Basins at Maintenance Yards to Improve Water Quality.

Funding information

_ntract/Grant Number: E75TL03

Funding type: HP&R

TRIS accession number: 385359 *TRIS files:* HRIS. H 8404.

TRIS Record Flag: 3

Title: DRAINAGE OF HIGHWAY PAVEMENTS
Language(s):

Author(s):
Johnson, FL
Chang, FFM

Publication Information:
Report No: FHWA-TS-84-202
Period Covered:
Publication Date: 3/00/84 **Pagination:** 151p

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Tye Engineering, Incorporated
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Federal Highway Administration
Office of Implementation, 6300 Georgetown Pike
McLean, VA 22101

Abstract Information
Abstract: This edition of Hydraulic Engineering Circular No. 12 incorporates new design charts and procedures developed from laboratory tests of interception capacities and efficiencies of highway pavement drainage inlets. A chart for the solution of the kinematic wave equation for overland flow and a new chart for the solution of Manning's equation for triangular channels are provided. Charts and procedures for using the charts are provided for 7 grate **types**, slotted drain inlets, curb-opening inlets, and combination inlets on grade and in **sump** locations. Charts, tables, and example problem solutions are included in the text where introduced and discussed. The text includes discussion of the effects of roadway geometry on pavement drainage; the philosophy of design frequency and design spread selection; storm **runoff** estimating methods; flow in gutters; pavement drainage inlets, factors affecting capacity and efficiency, and comparisons of interception capacity; median inlets; embankment inlets; and bridge deck inlets. Five appendixes are included with discussion of the development of rainfall intensity-duration-frequenc curves and equations, mean velocity in a reach of triangular channel with unsteady flow, the development of gutter capacity curves for compound and parabolic roadway sections, and the development of design charts for grate of specific size and bar configuration. (FHWA)

TRIS accession number: 394753 *TRIS files:* HRIS. H 8601.

TRIS Record Flag: 3

Title: WATER-QUALITY ASSESSMENT OF **STORMWATER RUNOFF** FROM A HEAVILY USED URBAN **HIGHWAY** BRIDGE IN MIAMI, FLORIDA

Language(s):

Author(s):
McKenzie, DJ
Irwin, GA

Publication Information:
Report No: FHWA-FL-BMR-84-270 Final Rpt.
Period Covered:
Publication Date: 12/00/83 **Pagination:** 35p
Figures: 12 Fig. **Tables:** 2 Tab. **Photos:**
References: Refs. **Appendices:**

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227 North Bronough Street, Suite 3015
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Florida Department of Transportation
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Tallahassee, FL 32301
Publisher/Corporate Author 3:
Federal **Highway** Administration
400 7th Street, SW
Washington, DC 20590

Available from:
Geological Survey
227 North Bronough Street, Suite 3015
Tallahassee, FL 32301
Order Number:

Abstract Information
Abstract: Runoff from a 1.43-acre bridge section of Interstate 95 in Miami, Florida, was monitored during five storms to estimate loads of selected water-quality parameters washed from this heavily traveled roadway. The monitoring was conducted periodically from November 1979 to May 1981 in cooperation with the Florida Department of Transportation for the specific purpose of quantifying the concentrations and loads of selected water-quality parameters in urban-roadway runoff. Automated instrumentation was used during each of the five storms to collect periodic samples of bridge runoff and to measure continuously the storm discharge from the bridge surface and the local rainfall. For most target parameters, 6 to 11 samples were collected for analyses during each event. Results of these analyses generally indicated that the parameter concentrations in the **stormwater runoff** and the parameter load magnitudes were quite variable among the five storms, although both were similar to the levels reported for numerous other roadway sites. Storm intensity influenced the rate of loading, but parameter concentration was the dominant variable controlling the overall magnitude of loading. (Author)

Funding information

Contract/Grant Number: **Funding type:**

TRIS accession number: 341003 *TRIS files:* HRIS. H 8104.

:RIS Record Flag: 2

'itle: CONSTITUENTS OF **HIGHWAY** RUNOFF VOLUME 1, STATE-OF-THE-ART REPORT
.anguage(s):

Author(s):
Gupta, MK
Agnew, RW
Kobriger, NP

?ublication Information:
:eport No: FHWA-RD-81- 42 Final Rpt. FCP 33E3-014
Period Covered:
?ublication Date: 2/00/81 **Pagination:** 121p

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Office of Research and Development, 400 7th Street, SW
Washington, DC 20590

Available from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Order Number: PB81-241895

Abstract Information
Abstract: This state-of-the-art report documents the constituents of **highway** runoff and their pollutional effects. It provides a general background about the problem, its recognition and the emerging emphasis to address t problem and its solutions. It discusses **highway** design and drainage characteristics and their relationship to runoff quantity. An extensive review of the available literature on the quality of **stormwater runoff** fr urban areas in general and from **highway** drainage areas in particular, has been made. (FHWA)

Funding information

Contract/Grant Number: DOT-FH-11-8600

Funding type: Contract

APPENDIX D

SEARCH STRATEGY USED AT OREGON STATE UNIVERSITY'S KERR LIBRARY-OTHER THAN JOURNALS

(1) stormwater runoff

results: nothing found

(2) stormwater

results: found 2 categories, 1 of which was possibly pertinent:

<u>1. stormwater infiltration - 1 title, which may be pertinent:</u>

[1] Ferguson, Bruce K. 1994. Stormwater infiltration. Lewis Publishers. Boca Raton, LA. [OSU Call # TD657.5 .F47 1994]

9 June 1995: Reviewed; not pertinent; infiltration only.

(3) runoff

results: found 211 categories, 6 of which were possibly pertinent:

<u>1. runoff - 38 titles, 3 of which may be pertinent:</u>

[1] Wanielista, Martin P. 1978. Stormwater management: quantity and quality. Ann Arbor Science Publishers. Ann Arbor, MI. [OSU Call # TC409 .W36]

9 June 1995: Reviewed; not pertinent; discusses detention and retention ponds, parking lot percolation basin, rooftop seepage pits.

[2] Zison, Stanley W. 1980. Sediment-pollutant relationships in runoff from selected agricultural, suburban, and urban watersheds: a statistical correlation study. EPA-600/3-80-022. USEPA Environmental Research Laboratory, Office of Research and

Development.
[OSU Call # DOCS / EP1.23:600/3-80-022]

[3] Haan, C.T., B.J. Barfield, and J.C. Hayes. 1994. Design hydrology and sedimentology for small catchments. Academic Press. San Diego, CA.
[OSU Call # TC409 .H3 1994]
9 June 1995: Reviewed; not pertinent; discusses sediment detention basins, constructed wetlands, vegetative filter strips, riparian vegetation, porous structures (check dams, filter fences, straw bales), sediment traps (small, temporary ponds), and inertial separation (swirl concentrator--portable but controversial).

<u>2. urban runoff - 20 titles, 15 of which may be pertinent:</u>

[1] Blendermann, L. 1979. Controlled storm water drainage. Industrial Press. New York, NY.
[OSU Call # TD653 .B54]

[2] Stephenson, D. 1981. Stormwater hydrology and drainage. Elsevier Scientific Publishing Co.
[OSU Call # TD657 .S73]

[3] Bartlett, R.E. 1981. Surface water sewerage. Wiley. New York, NY.

[4] Whipple, W. 1983. Stormwater management in urbanizing areas. Prentice-Hall. Englewood Cliffs, NJ.
[OSU Call # TD657 .S76 1983]

[5] Sheaffer, J.R. 1982. Urban storm drainage management. M. Dekker. New York, NY.
[OSU Call # TC530 .U91]

[6] Geiger, W.F. 1987. Manual on drainage in urbanized areas: a contribution to the International Hydrological Programme. UNESCO. Studies and reports in hydrology 43. Paris.
[OSU Call # TD657 .M371 1987 vols. 1 & 2]

[7] Walesh, S.G. Urban surface water management. Wiley. New York, NY. [OSU Call # TC409 .W325 1989]

[8] Stare, P., and B. Urbonas. 1990. Stormwater detention: for drainage, water quality, and CSO management. Prentice Hall. Englewood Cliffs, NJ.

[9] Moffa, P.E. 1990. Control and treatment of combined-sewer overflow. Van Nostrand Reinhold. New York, NY.
[OSU Call # TD662 .C66 1990]

[10] Ferguson, B.K., and T.N. Debo. 1990. On-site stormwater management: applications for landscape and engineering. 2nd Edition. Van Nostrand Reinhold. New York, NY.
[OSU Call # TC409 .F47 1990]

[11] Lazaro, T.R. 1990. Urban hydrology: a multidisciplinary perspective. Revised edition. Technomic Publishing Co. Lancaster, PA.
[OSU Call # TC409 .L39 1990]

[12] Stare, P., and B. Urbonas. 1993. Stormwater: best management practices and detention for water quality, drainage, and CSO management. PTR Prentice Hall. Englewood Cliffs, NJ. [OSU Call # TD665 .S72 1993]

[13] Field, R., M.L. O'Shea, and K.K. Chin. 1993. Integrated stormwater management. Lewis Publishers. Boca Raton, LA. [OSU Call # TD665 .I54 1993]

[14] Hickok, E.A., M.C. Hannaman, and M.C. Wenck. 1977. Urban runoff treatment methods. EPA-600/2-77-217. USEPA Office of Research and Development, Municipal Environmental Research laboratory.
[OSU Call # DOCS / EP 1.23/2:600/2-77-217]

[15] McCuen, R.H., S.G. Walesh, and W.J. Rawls. 1983. Control of urban stormwater runoff by detention and retention. Miscellaneous publication no. 1428. U.S. Department of Agriculture, Agricultural Research Service. Washington, DC.
[OSU Call # MICRO / Fiche A 1.38:1428]

<u>3. urban runoff - management - manuals, handbooks, etc. - 1 title, which may be pertinent:</u>

[1] Imhoff, K., and V. Novotny. 1989. Karl Imhoff's handbook of urban drainage and wastewater disposal. Wiley. New York, NY. [OSU Call # TD657 .K37 1989]

<u>4. urban runoff - management - 1 title, which may be pertinent:</u>

[1] American Society of Civil Engineers Urban Water Resources

Research Council and Water Environment Federation. 1992. Design and construction of urban stormwater management systems. ASCE manuals and reports of engineering practice no. 77; WEF manual of practice no. 20. American Society of Civil Engineers and Water Environment Federation. New York, NY.
[OSU Call # TD657 .D47 1992]

<u>5. urban runoff - United States - 26 titles, 4 of which may be pertinent:</u>

[1] U.S. Federal Highway Administration, Implementation Division. 1979. Design of urban highway drainage: the state-of-the-art. FHWA-TS-79-225. Dept. of Transportation, FHWA. Washington, DC.
[OSU Call # DOCS / TD 2.30/4:79-225]

[2] Lynard, W.G. 1980. Urban stormwater management and technology: case histories. EPA-600/8-80-035. Prepared for USEPA by Metcalf & Eddy. Municipal Environmental Research Laboratory, Office of Research and Development, USEPA.
[OSU Call # DOCS / EP 1.2:Ur 1/6]

[3] USEPA, Water Planning Division. 1983. Results of the nationwide urban runoff program. Water Planning Division, USEPA. [OSU Call # MICRO / Fiche EP 1.2:Ur 1/8/v.1-3]

[4] Center for Environmental Research Information (US). 1993. Urban runoff pollution prevention and control planning [microform]. USEPA Office of Research and Development, Center for Environmental Research Information. Cincinnati, OH.
[OSU Call # DOCS / EP 1.8:UR 1]

6. urban runoff - information services - United States - 1 title, which may be pertinent:

[1] Huber, W.C. 1982. Urban rainfall-runoff-quality data base. USEPA Municipal Environmental Research Laboratory Center for Environmental Research Information. Cincinnati, OH.
[OSU Call # MICRO / Fiche EP 1.89/2:R 13]

(4) highway runoff

results: nothing found

(5) highway

results: found 262 categories, 15 of which may be pertinent:

1. highway engineering - abstracts - periodicals - 2 titles, both of which may be pertinent:

[1] National Research Council (U.S.): Highway Research Information Service, Highway Research Board, and Transportation Research Board. 1967-1989 in collection. HRIS abstracts, a SERIAL.
[OSU Call # TE1 .N717]

[2] Highway Research Abstracts. 1990-. Highway research abstracts, a SERIAL. [OSU Call # Ref /TE1 .N1717]

2. highway engineering - indexes - periodicals - 1 title, which may be pertinent:

[1] National Research Council, Transportation Research Board, Special Technical Activities Division. 1973-1976 in collection. Publication index - Special Technical Activities Division, Transportation Research Board.
[OSU Call # TE1 .N189 1973/1976]

3. highway engineering - research - periodicals - 1 title, which may be pertinent:

[1] National Research Council (U.S.), Transportation Research Board. 1974-. Transportation research circular, a SERIAL. [OSU Call # TE1 .H47]

4. highway engineering - research - United States - periodicals - 1 title, which may be pertinent:

[1] National Research Council (U.S.) Highway Research Board, National Academy of Sciences (U.S.), and National Academy of Engineering. 1965-1974. Highway research circular, a SERIAL. Kerr Library has no. 1-110, 112-159. [OSU Call # TE1 .H47]

5. highway engineering - United States - Periodicals - 1 title, which may be pertinent:

[1] U.S. Federal Highway Administration, U.S. Bureau of Public Roads, U.S. Federal Highway Administration Offices of Research and Development, and U.S. Federal Highway Administration Offices of Research, Development, and Technology. 1918-present. Public Roads, a SERIAL. [OSU Call # TE23 .A7]

6. highway planning - United States - 34 titles of which 4 may be pertinent:

[1] U.S. Federal Highway Administration. 1977. Planning and environment: highway engineer training program, November 8-17, 1977. [OSU Call # MICRO / Fiche TD 2.2:P 69/977]

[2] U.S. Federal Highway Administration. 1981. Ecology and highway development. [OSU Call # DOCS / TD 2.2:Ec 7/15]

[3] U.S. Congress, Senate Committee on Environment and Public Works. 1994. National Highway System Designation Act of 1994: report (to accompany S. 1887)
[OSU Call # DOCS / Y 1.1/5:103-357]

[4] U.S. Congress, Senate Committee on Environment and Public Works. 1994. National Highway System Designation Act of 1994: hearings before the Committee on Environment and Public Works, U.S. 1887 ... June 6, 1994-Bozeman, MT; July 15, 1994-Washington, DC.
[OSU Call # DOCS / Y 4.P 96/10:S.HRG.103-755]

7. Highway research - Periodicals - 3 titles, all of which may be pertinent:

[1] U.S. National Research Council, Highway Research Board. 1968-1975. Highway research in progress.
[OSU Call # TE1 .N196 1-8. 1968-1975.]

[2] International Road Federation and U.S. Federal Highway Administration. 1974-. World survey of current research and development on roads and road transport, a SERIAL.
[OSU Call # SerRec HE333 .W65]

[3] Texas Transportation Institute. no date. Texas transportation researcher, a SERIAL.
[OSU Call # HE1 .T47]

8. Highway research - United States - 16 titles, 6 of which may be pertinent:

[1] National Cooperative Highway Research Program, U.S.

National Research Council Highway Research Board, ... 1969-. Synthesis of highway practice, a SERIAL.
[OSU Call # TE1 .N16]

[2] U.S. Federal Highway Administration. 1977. Federally coordinated program of research and development in highway transportation.
[OSU Call # DOCS / TD 2.2:R 31/2/v.2/975]

[3] U.S. Federal Highway Administration, Construction and Maintenance Division, Experimental Projects Branch. 1982. National experimental projects tabulation.
[OSU Call # MICRO / Fiche TD 2.2:P 94/3]

[4] U.S. Federal Highway Administration, Experimental Application and Evaluation Branch. 1985. National experimental projects tabulation.
[OSU Call # DOCS / TD 2.2:P 94/3/985]

[5] U.S. Federal Highway Administration, Experimental Application and Evaluation Branch. 1987. National experimental projects tabulation.
[OSU Call # MICRO / Fiche TD 2.2:P 94/3/987]

[6] U.S. Federal Highway Administration, Research and Development (1990-). 1994. TFHRC research facilities [microform].
[OSU Call # DOCS / TD 2.30:93-192]

9. Highway research - United States- Collected works - 1 title, which may be pertinent:

[1] National Cooperative Highway Research Program, National Research Council, U.S. Transportation Research Board. 1964-. Report - National Cooperative Highway Research Program, a SERIAL.

[OSU Call # TE7 .N25]

10. Highway research - United States - Periodicals - 1 title, which may be pertinent:

[1] U.S. Federal Highway Administration, U.S. Bureau of Public Roads, ... no date. Public Roads, a SERIAL.

[OSU Call # TE23 .A7]

11. National Research Council. Highway Research Board - 1 title, which may be pertinent:

[1] U.S. National Research Council, Highway Research Board. 1970. Ideas & actions; a history of the Highway Research Board 1920-1970.

12. National Research Council (U.S.). Highway Research Board - Periodicals - 1 title, which may be pertinent:

[1] National Research Council (U.S.), Highway Research Board. - 1973. Annual report for the year ending June 30, ...

[OSU Call # TE1 .N1855 1967/1968-1973/1974.]

13. United States. Federal Highway Administration - 26 titles, 1 of which may be pertinent:

[1] U.S. Federal Highway Administration. 1990. The Federal

Highway Administration's environmental policy statement.
[OSU Call # DOCS / TD 2.2:En 8/7]

14. National Highway Institute (U.S.) - 1 title, which may be pertinent:

[1] U.S. Federal Highway Administration. 1989. The National Highway Institute: [microform] NHI: RTAP status report.
[OSU Call # DOCS TD 2.30/11:89-051]

15. Highway engineering - Environmental aspects - United States - 1 title, which may be pertinent:

[1] U.S. Federal Highway Administration. 1994. Wetlands and highways [microform]: a natural approach.
[OSU Call # DOCS / TD 2.30/16:94-004]

(6) water pollution

results: found 810 categories, 5 of which may be pertinent:

1. Water - Pollution - 274 titles, 6 of which may be pertinent:

[1] U.S. Environmental Protection Agency, Water Quality Office. 1970-. Water quality criteria data book.
[OSU Call # TD370 .W3 -- IN HMSC LIBRARY, NOT KERR]

[2] Ellis, K.V., G. White, and A.E. Warn. 1989. Surface water pollution and its control. MacMillan. London.
[OSU Call # TD420 .E551 1989]

[3] California State Water Resources Control Board. no date. Publication - California State Water Resources Control Board, a SERIAL. [OSU Call # TD425 .C3]

[4] Allard, B. 1991-. Water pollution, Vol. 5 of The Handbook of Environmental Chemistry.
[OSU Call # QD31 .H335 v.5 pt.A]

[5] Hamilton, R.S. 1991. Highway pollution. Elsevier. Amsterdam.
[OSU Call # TD195.R63 H531 1991]

[6] Wullschleger, R.E., A.E. Zanoni, C.A. Hansen, U.S. Environmental Protection Agency Office of Research and Development, and Envirex Inc. 1976. Methodology for the study of urban storm generated pollution and control.
[OSU Call # DOCS / EP 1.23/2:600/2-76-145]

2. Water pollution control industry - periodicals - 1 title, which may be pertinent:

[1] Municipal & industrial water & pollution control. 1985.
[OSU Call # TD1 .M9]

3. Water pollution control - United States - 1 title, which may be pertinent:

[1] U.S. Environmental Protection Agency. 1974. Facilities planning summary: Title II, Federal Water Pollution Control Act amendments of 1972.
[OSU Call # TD223 .A315]

4. Water - Pollution - Periodicals - 8 titles, of which 5 may be pertinent:

[1] Institution of Water and Environmental Management. no date. IWEM newsletter, a SERIAL.
[OSU Call # TD1 .I571]

[2] International journal of air and water pollution. 1961.
[OSU Call # TD883 .I63 4. 1961.]

[3] Water Pollution Control Federation. c1989-. Research journal of the Water Pollution Control Federation, a SERIAL.
[OSU Call # TD511 .S4 v.61]

[4] International Association on Water Pollution Research. 1981-. Water science and technology, a SERIAL.
[OSU Call # TD424.5 .P71]

[5] Water Environment Federation. c1992-. Water environment research, a SERIAL.
[OSU Call # TD511 .S4]

5. Water - Pollution - Research - Periodicals - 1 title, which may be pertinent:

[1] International Association on Water Pollution Research. no date. Water research, a SERIAL.
[OSU Call # TD420 .W37]

7. separators

results: nothing pertinent found (closest: skimmers)

8. oil-grit

results: nothing found

9. grit

results: nothing found

10. vault

results: nothing found

APPENDIX E

SEARCH STRATEGY USED AT OREGON STATE UNIVERSITY'S KERR LIBRARY-JOURNALS

Database: Applied Science and Technology (CD ROM)

stormwater + runoff + highway: 0 found
stormwater + runoff: 51 found & reviewed
pollution + control + highway: 0 found
pollution + control: 1,060 found, not reviewed (too broad)
pollution + control + water: 217 found & reviewed
highway + runoff: 4 found & reviewed
highway + pollution: 9 found & reviewed
highway + sediment: 1 found & reviewed
sediment + control: 13 found & reviewed
sediment + basins: 22 found & reviewed (all geological)
separator: 105 found & briefly reviewed (all petroleum refining)
separator + pollutant: 0 found
separator + sediment: 0 found
separator + stormwater: 0 found
separator + runoff: 0 found
separator + grit: 0 found
highway + stormwater: 1 found & reviewed
stormwater + vault: 0 found
vault: 19 found & briefly reviewed (all nuclear industry)
runoff + treatment: 6 found & reviewed
stormwater + treatment: 4 found & reviewed
detention + basin: 8 found & reviewed

Lee, G.F., and A. Jones-Lee. 1995. Stormwater runoff management; are real water quality problems being addressed by current structural best management practices? Public Works 126 (January): 54-56.
[OSU Call # TD1 P9]

Lee, G.F., and A. Jones-Lee. 1994. Stormwater runoff management; are real water quality problems being addressed by current structural best management practices? Public Works 125 (November): 53-55+.
[OSU Call # TD1 P9]

Morrison, T., M. Alter, and R.H. Wassum. 1994. Comprehensive stormwater management study. Public Works 125 (February): 40-41.
[OSU Call # TD1 P9]

Bautista, M.F., and N.S. Geiger. 1993. Wetlands for stormwater treatment. Water Environment & Technology 5 (July): 50-55.
[OSU Call # TD365 W35]

Connell, K. 1993. Stormwater runoff quality improves. Water Environment & Technology 5 (July): 13-14.
[OSU Call # TD365 W35]

No author. 1993. New stormwater management technology. Public Works (June): 92.
[OSU Call # TD1 P9]

Scheuerman, R.F. 1991. Stormwater management should have a watershed approach. Water Environment & Technology 3 (September): 238-239.
[OSU Call # TD365 W35]

Tracy, C. 1991. Steel pipe detention chambers dispose of stormwater runoff. Water Environment & Technology 3 (March): 9+.
[OSU Call # TD365 W35]

McCuen, R.H., and G.E. Moglen. 1988. Multicriterion stormwater management methods. Journal of Water Resources Planning and Management 114 (July): 414-431.
[OSU Call # TC401 J61]

Pimentel, D.V., and G.E. Oswald. 1986. High tech approach to urban stormwater management. Public Works 117 (December): 32-34.
[OSU Call # TD1 P9]

Loganathan, V.G., J.W. Delleur, and R.I. Segarra. 1985. Planning detention storage for stormwater management. Journal of Water Resources Planning and Management 111 (October): 382-398. Discussion, 1988: 114 (March): 241-244.
[OSU Call # TC401 J61]

Nix, S.J. 1985. Residence time in stormwater detention basins. Journal of Environmental Engineering 111 (February): 95-100.
[OSU Call # TA170 J61]

McKinnon, R.J. 1984. Simplifying stormwater detention basin discharge control determinations. Public Works 115 (June): 68-69.
[OSU Call # TD1 P9]

Kaufman, M., and W. Marsh. 1995. CSO control is no longer mere engineering. American City & County 110 (February): 10. [OSU Call # HT101 A5]

No author. 1992. Control pollution from storm water runoff. Pollution Engineering 24 (December 1): 27.
[OSU Call # TD172 P66]

Gilson, M.P., J.F. Maliva, and R.J. Charbeneau. 1994. Highway runoff studied. Water Environment & Technology 6 (August): 37-38.
[OSU Call # TD365 W35]

Hewitt, C.N., and M.B. Rashed. 1992. Removal rates of selected pollutants in the runoff waters from a major rural highway. Water Research 26 (March): 311-319.
[OSU Call # TD420 W37]

Ellis, J.B., D.O. Harrop, and D.M. Revitt. 1986. Water Research 20 (May): 589-595. Contains a bibliography, p. 594-595.
[OSU Call # TD420 W37]

Chui, T.W., B.W. Mar, and R.R. Horner. 1983. Pollutant loading model for highway runoff (discussion of Am Soc C E Proc 108 (Dec 1982): 1193-1210). Journal of Environmental Engineering 109 (December): 1452-1453.
[OSU Call # TA170 J61]

Roberts, A.H., J.B. Ellis, and W.B. Whalley. 1988. Water Research 22 (June): 775-781.
[OSU Call # TD420 W37]

Romero-Lozano, J. 1995. Highway design considers stormwater drainage and treatment options. Public Works 126 (January): 32.
[OSU Call # TD1 P9]

No author. 1994. Dallas employs nylon fibers for storm vault reinforcement. Public Works 125 (February): 41.
[OSU Call # TD1 P9]

Schellinger, G.R., and J.C. Clausen. 1992. Vegetative filter treatment of dairy barnyard runoff in cold regions. Journal of Environmental Quality 21 (January/March): 40-45.
[OSU Call # TD172 J6]

Wolf, D.R., and R. Phillips. 1994. Retention basin reduces CSOs, increases treatment. Water Environment & Technology (October): 17.
[OSU Call # TD365 W35]

No author. 1993. Basin stores wet weather sewage overflows. Water/Engineering & Management 140 (March): 21.
[OSU Call # TD1 M81]

Holler, J.D. 1989. Storm water detention basin nutrient removal efficiency. Journal of Water Resources Planning and Management 115 (January): 52-63.
[OSU Call # TC401 J61]

APPENDIX F

PROJECT CONTACTS

ACADEME

Richard R. **Horner**
as of 1985:Environmental Engineering and Science Program
FX-10
Department of Civil Engineering
University of Washington
Seattle, WA 98195
co-author (w/Mar) of TRB 1017 article "Assessing the Impacts of Operating Highways on Aquatic Ecosystems"
5/22/95: RRHorner has moved to another program at UW
CONTACTED BRIAN MAR INSTEAD

Brian W. **Mar**

same address/telephone # as Horner

CONTACTED

FEDERAL AGENCY

Fred **Bank**, FHWA 202-366-5004

recommended by Chris Dunn

CONTACTED

Chris **Dunn**, Regional Hydraulics Engineer 503-326-2053

FHWA Region 10 (Portland office)

recommended by both FHWA researcher J. Sterling Jones (VA) and Chris's supervisor, Gary Kasza (Director, Office of Structures, Region 10)
CONTACTED

J. Sterling **Jones**, Head

FHWA Rural and Urban Hydrology Research Laboratory

Division of Hydraulics and Hydrology

CONTACTED

John **Lohrey**, FHWA, Area Engineer 907-586-742x

recommended by Scott Thomas

Louis N. **Triandafilou**, FHWA

May be a good contact with MD OSG work (per Scott Thomas)
1987 telephone: 708-469-6896 <---has been disconnected (5/21/95)
from Fred Bank: LNT is in Baltimore, Region 3, 410-962-2460
CONTACTED

Joe **Wallace**, EPA Region 10 Stormwater 206-553-8399 or 800-424-4372

CONTACTED

MUNICIPALITY AND LOCAL GOVERNMENTS

Tom **Bacon**, MOA Dept of Public Works 907-786-8187

Head, Project Management & Engineering

CONTACTED

Warren **Bell**, City of Alexandria Public Works 703-838-4327

Alexandria, VA

Recommended by Dave Shepp, WashCoG, as a good contact about sand filters, the technology Dave sees as supplanting OGSs; from Ken Young (GKY & Associates, Inc., Springfield, VA) via Stuart Stein (GKY), expanded by Chris Dunn (FHWA Region 10): Warren Bell has a complete, detailed plan for an ultra-urban system of pipes, sand filters, and detention pools, all underground.

Steve **Bonebrake**, Soldotna, City Engineer 907-269-9107

suggested by Scott Thomas as very knowledgeable about the Moose River OGS

CONTACTED

Phil **Cohen**, City Engineer, Redmond, WA 206-556-2815

fax: 206-454-0220

suggested by Bert Bowen, Water Quality Specialist, Washington State DOT (a presenter at the 1995 Western Hydraulics Conference), because Phil has recently submitted a monitoring scheme with excellent QA/QC for a 2-year study of an OGS in Redmond's stormwater runoff system.
CONTACTED

Gary **Oberts**, Senior Environmental Planner

Metropolitan Council

Mears Park Centre

230 East Fifth Street

St. Paul, MN 55101

612-291-6484

CONTACTED

Dave **Shepp**, Metropolitan Washington Council of Governments

202-962-3349

recommended by Tom Schueler

CONTACTED

Ben **Urbonas** 303-455-6277

Urban Drainage and Flood Control District

Denver, CO

co-author of 1990 book "Stormwater Detention..."

CONTACTED

Harriet **Wagner**, Coastal Coordinator, Kenai Peninsula Borough

907-262-4441

suggested by Gaye Molberg, F&G Habitat, Anchorage

Scott R. **Wheaton**, MOA Dept of Public Works 907-786-8117

Civil Engineer II, Watershed Management Section
lead person for MOA's EPA-funded separator project
CONTACTED

PRIVATE

American Petroleum Institute (API)

recommended by Prof. Brian Mar (UW)

CONTACTED

Dan **Billman**, HDR 907-274-2000

hydrologist, recommended by RFC
Scott Wheaton: yes, but Tim Shimaluski may be more immediately involved & therefore more help

Richard **Claytor**, Center for Watershed Protection 301-589-1890

Silver Springs, MD

Head Engineer; Tom Schueler's supervisor

CONTACTED

Floyd **Damron**, CH2M-Hill in Anchorage 907-278-2551

recommended by Scott Wheaton

a project manager

Brett **Jokela**, Montgomery Watson 907-248-8883

Principal Engineer

CONTACTED

Allison **Kerester** (pronounced care-eh-stir), API 202-862-8346
"clean water" person in Policy Analysis Section
CONTACTED

Dan **Rowley**, CH2M-Hill in Anchorage
907-278-2551

Bill **Ryan**, CH2M-Hill in Portland (moved to Medford)
503-734-5088 (Medford)
503-235-5022 x4229 (Portland)
CONTACTED

Tom **Schueler**, Center for Watershed Protection 301-589-1890
presenter at 1994 Stormwater Runoff Conference, Anchorage
CONTACTED

Tim **Shimaluski**, HDR 907-274-2000
recommended by Scott Wheaton
from MN; water quality; manages project with OGS at AIA

Eric **Streckler**, Woodward-Clyde (Portland) 503-561-1020
recommended by RFC
CONTACTED

STATE AGENCY

W.F. "Skip" **Barber**, Hydrologist, Central Region DOT&PF

907-266-1438 or 907-243-6927

CONTACTED

George **Church**, Superintendent, Kenai DOT&PF 907-266-1692

suggested by Scott Thomas

CONTACTED

Kevin **Claweveno**, Anchorage DEC 907-269-7519

suggested by Gaye Molberg, F&G Habitat

Dave **Esch** 907-465-6956

CONTACTED

Harold **Henderson**, DOT&PF Construction 907-277-6456

suggested by Scott Thomas

Bill **Hulbert**, South Carolina DOT 803-737-1658

Suggested by Johnny Morris, FHWA, because he deals with requirements of zero highway runoff from tidal bridges. The bridge has a series of catch basins that receive from the guttering system, and it's very maintenance intensive.

Dave **Johnson**, Env'l Engr, DEC Kenai District

suggested by Scott Thomas

CONTACTED

Nate Johnson, ADOT&PF Statewide Environmental Coordinator

Bill **Lamoreaux**, District Supervisor, ADEC, Anch 907-349-7755

suggested by Scott Thomas

Ginny **Litchfield**, Soldotna ADF&G 907-262-9368

suggested by Scott Thomas

She reviews consistency w/AK Coastal Mgmt Plan, involved w/stormwater outfall sampling at 4 locations on Kenai for Kenai River Advisory Board.

CONTACTED

Shawn **McLemore**, Florida State Hydraulics Engr, Tallahassee

904-392-0378

Suggested by Johnny Morris, FHWA presenter at the 1995 Western Region Hydraulics Conference, because he's knowledgeable about Florida's OGSs.

Eric L. **Miyashiro**, ADOT&PF 907-266-1551

Design Engineer, designed the separator

CONTACTED

Gaye **Molberg**, ADF&G Habitat Division, Anchorage

907-267-2286

source of F&G regulations

CONTACTED

Northeastern Illinois Planning Commission

Publications Department

222 South Riverside Plaza, Suite 1800

Chicago, IL 60606

312-454-0400

Jerry **Reuhle**, DOT&PF Environmental Team Leader 907-266-1512

knows water quality regs

CONTACTED

Scott **Thomas**, ADOT&PF 907-266-1505

Project Manager

CONTACTED

Lance **Trasky**, Regional Supervisor, F&G Habitat Division

907-267-2335

suggested by Ginny Litchfield as a good source for applicable F&G regulations

ON LEAVE; CONTACTED GAYE MOLBERG IN HIS OFFICE

Susan **Wick**, DOT&PF Environmental Team Leader 907-266-1507

identified by Scott Thomas, may be a good contact if Jerry Reuhle isn't available

APPENDIX G

COMMENTS BY CONTACT PEOPLE

PERSONAL CONTACTS

Bacon, Thomas. 1995. Department of Public Works, Municipality of Anchorage. Personal communication, 10 and 11 May.

The Municipality of Anchorage (MOA) has contracted with Montgomery Watson to develop a sampling scheme for testing an oil-grit separator. The plan is due at the end of May, and Bacon would be pleased to share it with UAF/DOT&PF. This scheme is being devised to solve the separator-sampling problem that MOA has encountered in previous studies, that more sediment was leaving the units than entering at the same time that the units were filling. There is no easy way to sample the OGSs because particle distribution is influenced by flow conditions. Their rain season start in mid-July, so they'll get this summer's flow and runoff through break-up 1996. The work is being funded with an EPA grant, but they re-examined their assumptions and redesigned the project, so that now he's had to put money into the project on about a 1-to-1 match.

As far as the national literature, the sampling has been inconsistent, sometimes lacking and often ill defined. They're seeing lots of bedload, but it isn't mentioned in the literature. They won't have any funds for publication of their study.

Bank, Fred. 1995. Ecologist, FHWA. Personal communication. 6 June.

He's not up on the literature about effectiveness of OGS units. He knows they've been installed for parking lots, especially in the East. He is familiar with some Washington-area installations. The only research work he knows of is by WashCoG (Shepp/Schueler). He's heard that they are <u>very</u> maintenance-intensive. He's also heard that their effectiveness depends on the amount of abrasives that have been used for deicing. The capacity of the early units was small, two storms could fill them. Maybe the design has been improved. Some municipalities required them for parking lots; he knows that Montgomery County, north of Washington, DC, was requiring them for parking lots. He does have a file on hand, and he'll look for OGS info for me, especially the Shepp/Schueler report. He can't guarantee anything, but if he's successful, he'll bring the stuff with him to the Western Hydraulics Conference in Seattle. (12 June 1995: He didn't find anything.)

Louis Triandafilou is in Region 3, Baltimore, 410-962-2460. He may be a hydraulics engineer.

Barber, "Skip". 1995. Hydrologist, DOT&PF. Personal communication. 13 June.

He calculated flows for the Moose River OGS designs, but he favors wetland and other more natural treatments for highway stormwater runoff.

He's looked at MOA's OGSs and feels that the catch basins upstream of their OGSs are a critical element. They are much easier to vacuum than an OGS, and, if they are properly maintained, they drastically reduce the amount of hydrocarbons that are trapped in the OGS. In his experience, both are maintenance-intensive, so it's a cost the public may have to accept, but, again, the OGSs are much more difficult. He reported that an OGS in Wasilla wasn't cleaned until pollutant concentrations were at an almost-dangerous level.

Bowen, Bert. 1995. Water Quality Specialist, Washington State DOT. Presenter at 1995 Western Hydraulics Conference and Personal communication. 14 June.

From his presentation: Oil-water separators are one possible runoff treatment, but stormwater runoff is episodic in nature and there's not much petroleum in stormwater. Also, an NPDES requirement is monitoring of BMPs, including oil-water separators.

Speaking with him: He's recently received a copy of a monitoring/sampling scheme from Redmond, WA, where an OGS has been installed in their stormwater system. The scheme has excellent QA/QC, and we ought to contact the engineer in charge, Phil Cohen (206-556-2815). Their unit is a coalescing plate oil-water separator, and it's wonderful for sediment, trapping particles to 10µ. It can be used to de-water waste. It's a multi-vault system.

Using vaults, not tight underground catch basins, is much easier for maintenance because of OSHA close-space restrictions. They require air sampling and monitoring for workers to enter the chambers, and it's a real headache.

Bonebrake, Steve. 1995. Soldotna City Engineer. Personal communication. 13 June.

First, the background: Ten-eleven years ago we started the rebuild of Binkley, Redoubt, and ½ of ___ Streets. The outfall was to go to the Kenai River, just like always. Fish & Game and DEC were getting sensitive, though, because EPA was studying this sort of thing. Then the next project was Knight Drive, from which the runoff would also be routed into the river. The Kenai and Moose Rivers had become highly publicized and political issues.

The City starting looking at options and found that very little land was available, and property was at a premium, so that above-ground options were expensive alternatives. At the same time, DEC sanctioned a sediment pond in Anchorage that subsequently failed miserably. Water flowed into it during breakup, when it was still frozen, then flowed over the ice directly to the Inlet.

The City of Soldotna decided to go underground and had Mike Taurianen design a unit that had multiple safety factors. No one really knows the stormwater situation. There are sand and silt particles, and the toxics and oil adhere to them, affecting their specific gravity. They <u>won't settle</u>, they semi-float. The rules and regulations of DEC were impossible to meet with the technology.

Soldotna engineers contacted EPA for the technology, and EPA's response was to use filters. Bonebrake maintains that, at that time, he was convinced that filters wouldn't work in the cold regions because the system has to be open to the air for equal pressure; cold air would sink and settle in the storm drains, freezing everything. He now knows that there's enough thermal energy in the earth to counteract this. Anyway, they opted for an OGS for Knight Drive. Taurianen designed a 10-foot corrugated metal pipe (CMP) unit with baffles, 2 permanent and 1 movable. The unit could be steam thawed. It was build with DEC concurrence. Soldotna engineers asked F&G if they should use rubber bands to seal joints; F&G said "no". There's never been any water at the outfall. Success is relative; for F&G it's a success because no water flows out of the unit and into the river. From a water quality perspective, though, it's probably not a success because it's leaking everything that flows into it.

The next project was the DOT&PF project. They looked at Soldotna's design, modified it, then installed it in 1992. DEC agreed to a 2-year design storm, which means that it catches a smaller amount. He feels that is better because all the later flow won't have the contaminant load, and it is routed through a by-pass. The concrete construction is also good, and, as far as he knows, it's working fine.

Soldotna built another OGS at the airport in 1993. It's a 3-compartment unit with a by-pass. There hasn't been any documented testing on it, but there's nothing in there, and it's two years old. By visual inspection, it's working on the oil.

It's impossible to know if you're meeting DEC's test. DEC wants 65% removal of stormwater runoff sediments and 80% of the amount that's in the inflow to the oil-grit separator, but we don't know how much is in the inflow.

It works well, though. We had a 1" sheen in the airport unit one time, and sedimentation works well. I mentioned the Maryland study that apparently showed that sediments in the system get flushed by the next storm. SB: There seem to be 3 particle size ranges, sand, sand-to-200μ, and 200μ, and it won't work if there are water currents. The airport unit has top and bottom baffles to prevent that problem, and water is taken from the center.

OGSs are very expensive. The airport unit cost about $90,000, and the contractor said we got a "steal"; he was $15,000 under the next bidder, so I agree. Now more people are going to above-ground treatments. The header system works well. For our next project we're planning to use a swampy area; the distribution header is laid level, and it's 100-200 feet long. The pipe has ½" holes every foot. By the time the water gets to the river, it's clean.

In 1986 there were 18" catchments in every catch basin, and they had to be cleaned out every 4-5 years. They worked well for sediment, but there was no oil/grease separation. The OGS maintenance routine: suck up the oil and grease, then run it through the separator at the shop; pump the clear water; suck the sediment with the vacuum truck. Haven't had any problem with contaminated sediment. Oil and grease does attach to particles that do settle; a small sheen can be seen when <u>some</u>, not all, catchments are cleaned. This OGS is designed for a 2-year flow, maximum, so the rest goes to the by-pass, so there's not much in the system. Top-down baffles would allow flush; top and bottom baffles work.

The Kenai River is glacial, but turbidity is low, about 20 (NTUs). It's about 50-60 in the storm drain, depending on flow. Half is nonsettleable solids, so it needs a filter. It's a difficult problem.

He wants a copy of the report.

There's a basic problem that's he's seen for which he'd like an answer: What CIA should planners use? (C = a coefficient, I = storm intensity, A = area) In his view, the current guideline is very suspect because the flow he sees in the field is not close to what the formula predicts. He's a realist. In 1986 there was a

100-year flood, and the 36" pipe should have been flowing full; it was only ½ full, so the safety factors are unreasonable. This overbuilding leads to unnecessary expenditure of funds. He knows that a lower limit is a 15" - 18" pipe to keep from glaciating.

Church, George. 1995. Kenai DOT&PF Superintendent. Personal communication. 13 June.

The Moose River OGS units are on an annual clean out schedule, but he can't have it done this year until after June 30, when he has a new budget. He doesn't consider the cleaning a bother, but it's still a new, so they're in a learning process. It was done last year by a contractor, but this year they're supposed to get the Anchorage vacuum truck after the Municipality is finished with their cleaning schedule.

He thinks that Debbie of the DOT&PF Environmental Section monitored it one time and that tests were taken last year. When I mentioned MOA's problem with sediment bedload, he responded that the Moose River units should be fairly clean because there's not much sediment source; the road is paved and has paved curb and gutter. They don't use the quantity of sand for deicing that MOA does, plus the city has more traffic and therefore more petroleum by-products.

He will have someone pull a manhole cover tomorrow morning and check the sediment accumulation. I'll Call in the afternoon for the report.

Scott Thomas had called and told him that I might be calling, also that Bob might be down for an on-site visit.

Cohen, Phil. 1995. City of Redmond, Washington. Personal communication. 16 June.

Responding to a complaint by Washington State Department of Ecology, the City of Redmond Public Works Department designed and installed an OGS for treating stormwater runoff from about 180 acres of residential/light commercial/ green way. The unit was constructed in the fall and winter of 1993-1994. It has 5 distinct, separate vaults. The first, the diversion vault, is directly in-line in the storm drain trunk line; it reduces velocity and diverts flow off-line to a fore vault, which further reduces velocity and distributes flow through 6 ports to a coalescing vault. Runoff flows through a 4'x4'x8.5' thinly spaced array of corrugated fiberglass plates, then enters the after vault. From this chamber, flow is directed to a catch basin located in the trunk line.

He is generally pleased with it, but maintenance is a bother. He may request a retrofit to install a rotating mesh drum before the coalescing plates to catch leaves and grass litter that clogs the plates. Such units are common in wastewater treatment plants. His other complaint is that the Washington State Department of Ecology hasn't certified an on-site test for pollutants in the pool sediment, so there's a 3-week turnaround between sampling time and permission to clean the unit and dispose of the sediment. By that time, it could have gotten contaminated.

Phil gave us a copy of an article he co-authored with the consultants for the project (Odegard, Nelson, and Oppenheimer, of Entranco); it discusses the project from inception through construction and the initial post-construction water quality monitoring. He also gave us a copy of "Final Monitoring and Quality Assurance Plan, Redmond Way Oil/Water Separator, Phase 2", a detailed sampling/monitoring scheme and a Schedule of Drawings of the system. He did not mention the budget; Bert Bowen, though, had said $300,000.

Dunn, Chris. 1995. FHWA, Region 10. Personal communication. 23 May and 12 June.

23 May: No, he's not the best OGS person in FHWA. I should talk with Fred Bank in the Environmental Group in Washington, DC. He'll be at the conference.

The Western Hydraulics Conference will be a good place to find people to talk with about OGS. All the FHWA hydraulics/water quality people will be attending. Tuesday afternoon: national water quality concerns. Monday's TRB meetings will be of 3 committees: hydrology, hydraulics, and water quality.

He's under the impression that there isn't much research available about OGS technology, that it's relatively new. It hasn't been used a whole lot and hasn't been evaluated.

12 June: Projects funded by FHWA as "experimental", such as the Moose River OGS, should be monitored for 5 years after installation, at which time a determination is made whether or not it works. If it doesn't, FHWA <u>fully funds</u> a replacement.

Johnson, David. 1995. Environmental Engineer, DEC, Kenai. Personal communication. 13 June.

The problem with OGSs is that they are labor intensive, and they create as much of a problem as they solve. They do have their place. In the Moose River situation, there wasn't much of an option. They were limited on space, so they couldn't do a constructed wetland and chose to go with an underground vault.

He worked with DOT&PF on design recommendations; they used the MOA design guidelines and used a 2-year 6-hour design storm. He can't remember the target particle size that should settle; he does remember that it has floatables storage.

There haven't been any complaints from the public, and the rivers are a very contentious issue. Moose River is a slow moving, clear water stream, much more so than the Kenai River.

The statute that applies is 18AAC72, the wastewater disposal regulations. Stormwater runoff is considered non-domestic wastewater, so plan review is necessary. Technically a permit is required, but the department chose not to do that. They do plan review instead. The formal regulations are much more proactive. He'll send a copy.

The other regulations that apply are Water Quality, but DEC doesn't use it, though the parameters apply; they use the wastewater regs.

One maintenance issue that "scares" him a little is the disposal of the sediments taken from the stilling basin -- are they taken to the landfill? What if they need treatment? This issue fits into Solid Waste regulations for disposal.

The airport unit is similar to the Moose River OGS, but they've tried to get away from underground facilities. The last highway project they designed a long grassy swale with rock dams. He's looking at another that has a constructed wetland.

Their choice of discharge to the river limited their choice. Sterling is at the confluence of the Moose and Kenai Rivers, and the highway that this system drains parallels the Kenai River about ½ mile away. They could have taken the runoff flow that direction, but perhaps it wasn't cost effective.

Does MOA plan by-passes for their units? CB: I don't know.

He wants to be on our mailing list.

Jokela, Brett. 1995. Senior Engineer, Montgomery Watson Consultants, Anchorage, Alaska. Personal communication, 11 May.

...

Jones, J. Sterling. 1995. Head, FHWA Rural and Urban Hydrology Research Laboratory, Division of Hydraulics and Hydrology. Alexandria, Va. Personal communication, 19 May.

> Oil-grit separators are used occasionally, when there's no other option. He believes that little research has been done on them and that there is very little reported in the literature. The general impression is that they don't work and, therefore, are not a good expenditure of funds.

Kasza, Gary. 1995. FHWA, Region 10. (Chris Dunn's supervisor). Personal communication. 22 May.

> Chris Dunn is the person to talk with concerning OGS technology. Two years ago he was involved with a couple in Anchorage. [Correction by Chris Dunn, 12 June: He was not involved with the Anchorage OGS units; he was the one who agreed to experimentally fund the DOT&PF Moose River units.]

Kerester, Allison. 1995. American Petroleum Institute.

> According to Jim Lockhart, a research analysts in the Statistics Department, there is no specific environmental section of API. The Policy Analysis Section, though, handles those issues, and Allison Kerester is in charge of "clean water". DID NOT CONTACT; HAVE LEFT RECORDED MESSAGE ON VOICE MAIL.

Litchfield, Ginny. 1995. Alaska Department of Fish & Game, Soldotna. Personal

communication. 13 June.

She has no personal knowledge of oil-grit separators. She was on a water quality project several years back that included hydrocarbons.

She did sit in on sessions about the Moose River installations; she was there to monitor activities pertaining to the Kenai River. She was trying to get proposals to monitor hydrocarbons (F&G has a chemistry lab in Soldotna), and she could test for volatiles and do some sediment work. If we go further with our study, contact her again and she'll get together her historic data.

She'd like to have a copy of our report.

As far as regulations that apply to this situation, she'll demur to Fish Habitat Division; she's part of Commercial Fisheries Division. She suggests Lance Trasky, Regional Supervisor of Habitat Division, Anchorage: 907-267-2335.

Mar, Brian. 1995. Professor, University of Washington Department of Civil Engineering. 22 May.

Didn't have any information about OGS technology, suggested that I contact the American Petroleum Institute. API has "lots of data" and standards. He's under the impression that the separators don't work very well, but they work.

Molberg, Gaye. 1995. Habitat Division, Alaska Department of Fish and Game, Anchorage. Personal communication. 13 June.

The primary regulation that would apply is Title 16.05.870, the Anadromous Fish Act, but they defer to DEC for enforcement of Alaska water quality standards. They don't go out to sample outfalls. She might have a copy of Title 16; if so, she'll send it along with a brief regulation summary that she will definitely send.

We need to talk with David Johnson, Soldotna DEC, because he did the water quality variance for the bridge construction. Another good contact is Kevin Claweveno, Anchorage DEC; his number is 269-7519.

As far as the Coastal Management Plan standards, she includes them as policy that she cites when she looks at habitat standards, but we should contact Harriet

Wagner, the Coastal Coordinator at the Kenai Peninsula Borough, 262-4441.

She wants to be on the project "see-list" for the testing procedures in the proposal.

Oberts, Gary. 1995. Senior Environmental Planner, Metropolitan Council (a St. Paul, MN research organization). Personal communication.

He doesn't know of any OGS units in either St. Paul/ Minneapolis or the north central US. He saw Tom Schueler at a meeting about one month ago. Tom's presentation about OGSs was negative. Tom has a design that may dissipate energy to solve the problem of flushing of sediments. The work was done in Washington, DC, and they probably have the model.

Ryan, Bill. 1995. Hydrologist, CH2M-Hill. Personal communication.

The oil-grit separator article that he was going to fax to me turned out to be about urban sedimentation basins.

Shepp, Dave. 1995. Washington Council of Governments. Personal communication. 6 June.

The report that he co-authored with Tom Schueler hasn't been published and made available, even though it is the basis for Maryland local governments deciding to reject use of OGS technology, because it's an interim report. They made a limited number of copies and gave them out at a workshop last year. Now they've run out of the extra copies. He will make more; he foresees a new wave of inquiries. He took my address (OR) to send me a copy and my telephone/fax # to fax me the Executive Summary. (Fax received 13 June at the Seattle hotel where the 1995 Western Hydraulics Conference was held.)

I described the Moose River situation. He asked if it is a standard two-chambered (two-pool) design; CB: yes.

Dave is project manager. This study started as a 3-year project, then became a 4-year project. Their summary of findings to this point:

(1) The OGS, as generally designed and as generally employed, is not

retentive of sediment.

(2) OGSs <u>do</u> trap quite a few potential priority pollutants <u>temporarily</u>. They've found substantial hydrocarbons.

There is a crying need for pollutant interception, but he's pretty sure that OGSs aren't the way.

This year they're doing high-intensity performance inflow/outflow tests to determine mass flow. They'll have preliminary results by the end of the summer. They expect that the data will probably confirm that the OGS is not retentive, that trapped sediments get flushed by succeeding storms. Their OGS is designed such that every storm's runoff flows through the unit. They've found wide fluctuation in the depth of sediment in the pools. I mentioned Ben Urbonas's work-in-progress in Denver, that his sand filter clogged before he put an OGS upstream of it. Dave says that they are leaning toward sand filters as a technology to supplant OGS. They're wrapping up work monitoring sand filters, and a good contact is Warren Bell, Public Works Department, City of Alexandria, VA: 703-838-4327.

Streckler, David. 1995. Woodward-Clyde Consultants. Portland, OR. Personal communication. 14 June.

He hasn't worked on OGSs in Alaska, though he has done some runoff work in Juneau. He has done some OGS work, but he suggested Rich Horner. Rich and Brian Mar did a study for metro-Seattle. Eric has done some monitoring of parking lot BMPs that included OGS units.

Tom Schueler has done quite a bit of work on big, giant tanks, as well as other, smaller ones.

Eric has done a design guide manual for Portland, and he had Tom Schueler, Rich Horner and Brian Mar work on the project.

There is some monitoring going on in San Francisco. In Snohomish County they're using filter pads. He knows that Tom has done some monitoring, too.

Triandafilou, Louis. 1995. FHWA Hydraulics Engineer. Personal communication. 7 June.

He dealt with the issue 2-to-3 years ago. There was a project under design in Washington, D.C. At that time, he questioned the use of an OGS. Then, based on background from headquarters, he recommended again using it. As he recalls, the primary reason was the very high maintenance cost. He will send me copies of the correspondence by the end of next week. FHWA has a several-volume set that they used as background (CB suggested the 5-volume Impact on Receiving Waters set; he said yes). He will be gone 6/16 through 7/7.

Urbonas, Ben. 1995. Denver. Personal communication. 25 May.

As far as quantitative data, there's not much. The grey literature is where to find mention of OGSs. People are testing.

Ben U. is testing an OGS in the Lakewood, CO, maintenance yard. This is the first year, so there's no data yet, and it will be another year until there is any. They've designed their test OGS for a 2-year peak storm so that the average velocity design is less than 0.5 fps during peak storm, therefore there is settling during lighter storms.

For episodic events, for example, in Maryland, the work by Tom Schueler, the results have been poor, so Tom is not favorable about OGSs. The units don't accumulate much sediment, and we don't know why. (CB mentioned the Municipality of Anchorage's situation.) Concerning the MOA's situation, it depends on the size of the material, the type of storm (e.g.: sudden downpour vs. constant light rain); each situation is site-specific. If it is urbanized, fully paved, with no erosion, there is no sediment; if there are dirt roads, with erosion, there will be sediment.

They're trying to trap =<500µ - 60µ size particles, as that's the size that clogs fish redds. They want the larger particles to pass, which can be a positive (didn't get him to explain his reason for this). CB: The smaller particles also have a large surface area (thinking of heavy metal adsorption).

The devices have been installed because it was expedient, often recommended by planners. There's a crying need for good testing all over the country, in different situations.

The Lakewood test scheme: They are doing inlet/outlet sampling. Rainfall triggers automatic samplers (when rainfall exceeds 0.1"), therefore they sample the rise in flow automatically. At the inlet, they takes samples every 10 minutes for 1 hour, then every ½ hour after 1 hour until flow falls. They sample at the outlet every 15 minutes. Hopefully, there are enough bottles in the automatic sampler to receive samples until the graduate students can get there to replenish the supply.

There is a sand filter downstream of the OGS that was the primary unit being tested. They tested it for 1 year without the OGS, but it was disastrous. Now, with the OGS in place, the sand filter is not filling, so the OGS must be doing something.

Anchorage's problem is bedload. They shouldn't be getting bedload.

Ben will publish the results of this study. He has an article in a recent Water Resources Planning & Engineering, ASCE, in which he recommends consistency of reporting BMP parameters with data; efficiencies alone don't help anyone.

Ben asked me to send him any literature I might find. His counter to my protest that he knows more about the literature than I could possibly know: No, it's scattered and can/may be found in obscure places.

Wallace, Joe. 1995. U.S. Environmental Protection Agency, Stormwater Section (Seattle). Personal Communication. May and 16 June.

May: He has never heard of oil-grit separators. He has a good publication by the Department of Ecology, Washington State University (Pullman), about best management practices (BMPs): Stormwater Management Manual for the Puget Sound Basin. It does briefly mention oil-water separators. I can copy that portion when I am in Seattle the week of June 12. His location: 1200 6th Avenue, Seattle. He's on the 13th floor, but go to the 14th and have him called. He will also look for a DOT manual on BMPs.

16 June: Joe gave me a copy of Chapter III-7, Oil/Water Separators, from the Stormwater Management Manual for the Puget Sound Basin, published by Washington State Department of Ecology. He gave me information about an ASCE-sponsored course this summer: "Design and Construction of Urban Stormwater Management Systems, Introducing the ASCE/WEF Manual of Practice" (WEF = Water Environment Federation). The presenters are John Blanchard (Wright Water Engineers, Denver, CO), Mark Glidden (Merrick and Company, Denver), and Stuart Walesh (Professor of Civil Engineering, Valparaiso University, Valparaiso, IN). He suggested that they might be good contacts. And he also showed me literature distributed by two different companies that manufacture OGS units, Amcor Precast and Stormceptor Corp.,

and passed on contact names and numbers for both. He also suggested that I contact Rich Horner, who is already on our list, and told me that he is now associated with UW program "PEPL", headed by Ron Bucknam. Dr. Bucknam's number is 206-543-1178.

Wheaton, S.R. 1995. Civil Engineer, Municipality of Anchorage Department of Public Works. Personal Communication. 10 & 11 May.

May 10: He's watching break-up, "into cheap sampling". There are three significant place where sand was left: the snow dump, on the street, and in the side storage berm, especially along the arterials.

The Municipality of Anchorage (MOA) has more than 100 oil-grit separators. Several studies have been performed to test their efficiency, but between-study comparability has been reduced because different parameters were analyzed. Also, some of the studies have been internally inconsistent, tests showing more pollutant in the outflow than in the highway runoff. Wheaton and department head Tom Bacon suggest that the source of the inconsistency comes from the sediment that has settled in the pipe transport system leading to the separator.

Their current EPA/MOA-funded study centers on this problem. Field sampling and measurements, planned from July 1995 through breakup 1996 and all upstream of the separator, will be the basis for a model that should estimate particle size range and sediment settling/re-entrainment behavior. This study will barely scratch the surface of a complex system. They're not even looking at end-of-pipe or climatological & meteorological data. OGSs are flow-sensitive as well as particle-size sensitive, and flow is temperature dependent. The actual mobilization of a pollutant is another issue.

For the $150,000, they'll be making a lot of assumptions. The small amount that DOT&PF can dedicate to the problem won't support a viable project. Perhaps DOT&PF should do some small portion of MOA's sampling, tie in with MOA. The worst they could do is fund another stand-alone project.

One limitation to OGS technology that he's found in the national literature is that they are best used on watersheds of 3 acres, maximum. He says that wastewater treatments concur.

Wheaton agrees that "vehicles during storms" is an important factor but his rationale is that the turbulence caused by vehicle passage through runoff transfers the energy that can entrain more sediment of greater mass. This is a different perspective from Racin, et al. (1982), who identify VDS as a contaminant source.

May 11: OGS means different things to different people: oil-grit and oil-grease. The literature doesn't make the distinction, but oil-grease is common. This is a basic determining design factor.

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