EROSION AND SEDIMENT CONTROL BEST MANAGEMENT PRACTICES: LITERATURE REVIEW

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prepared by
Darrel M. Stordahl, P.E.
Jeffrey W. Jones, E.I.
CDM

RESEARCH PROGRAMS

Erosion and Sediment Control Best Management Practices: Literature Review

Prepared for:

Montana Department of Transportation

Research Section

2701 Prospect Avenue

PO Box 201001

Helena MT 59620-1001

Prepared by:

CDM

34 North Last Chance Gulch

Suite 104

Helena, MT 59601

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16. Abstract

The literature review identifies documents to aid in the development of an Erosion and Sediment Control Construction Best Management Practices (BMPs) Manual and Training Program. Documents were obtained from several state Departments of Transportation, the Environmental Protection Agency (EPA), the Montana Department of Environmental Quality (DEQ), Federal Highway Administration (FHWA), Transportation Research Information Services (TRIS), internal CDM documents, and other sources. These references contain erosion and sediment control information such as product acceptability lists; BMP selection, design, and maintenance; BMP evaluation and assessment; limitations of BMPs; and erosion and sediment control training.

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Section 1
Introduction

1.1 Project Background

The Montana Department of Transportation (MDT) has contracted Camp Dresser & McKee Inc. (CDM) and their subcontractor, the Montana State University Reclamation Research Unit (RRU) to provide an Erosion and Sediment Control Construction Best Management Practices (BMPs) Manual and Training Program. Other project tasks include a literature review of erosion and sediment control methods and an organizational survey of other state Departments of Transportation (DOTs) erosion and sediment control organizational structures. A second survey will be conducted to identify the needs of Montana erosion and sediment control construction BMPs manual and training program users. Additionally, a pilot training program will be provided by CDM and RRU. The project is being carried out under the guidance of a technical review panel that consists primarily of staff from various divisions within MDT, as well as individuals from the Montana Department of Environmental Quality (DEQ), The Federal Highway Administration (FHWA), and the United States Corps of Engineers (US COE).

1.2 Literature Review on Erosion and Sediment Control Methods

A literature review of highway construction erosion and sediment control methods has been conducted in order to identify source material for the development of MDT's erosion and sediment control construction BMPs manual and training program. State DOTs, industry, and tribal, state and federal government publications, design manuals, federal and national guidelines, and computer software tools have been identified during the search. The results of the literature review are presented in Section 2 of this report.

1.3 Report Organization

The remainder of this report summarizes the findings of the literature review described in Section 1.2 and comprises the first task to be completed as part of this project. Documents identified during this search have been organized by federal agencies, state DOTs, CDM–generated, and miscellaneous categories. A general description of the documents is included for each category and a bibliographic summary is provided for each document. CDM is obtaining electronic and hard copies of many of these documents and is organizing the documents by topics such as construction BMPs, training materials, storm water regulations, etc. Additional erosion and sediment control construction BMPs references will be found during the course of this project. These reference materials will be utilized and listed in the reference sections of the BMPs manual and/or training program.

Section 2
Literature Review

2.1 Objectives

The literature review is a key element in the creation of the MDT Erosion and Sediment Control Construction BMPs Manual. With the vast array of BMPs information available, the literature review's objective is to identify documents that may be useful in creating a manual that fulfills MDT's construction BMPs needs and requirements. The information identified in the literature review that is used in the development of the MDT manual will be incorporated into its reference section.

2.2 Literature Review Sources

The literature search was performed with the use of CDM's InfoCenter's automated literature search with the capacity to search over 900 bibliographical and numerical databases. Search sites included the United States Environmental Protection Agency (EPA), Montana DEQ, FHWA, National Transportation Library, other state DOTs and internal CDM documents. MDT's Research Bureau provided a search of the Transportation Research Information Services (TRIS) Database that is produced and maintained by the Transportation Research Board at the National Academy of Sciences. Documents listed in this report with [Printed] at the end of the reference have been printed by CDM and are filed. Documents listed in this report with [Downloaded] at the end of the reference have been obtained electronically by CDM.

2.2.1 Environmental Protection Agency

The references listed below are a compilation of data received from the CDM InfoCenter and the EPA website (http://www.epa.gov/). Many of these references address or summarize federal guidelines for storm water BMPs. The Storm Water Technologies Fact Sheets contain information on construction BMPs as well as employee training programs. References containing a Uniform Resource Locator (URL) address are web-based references. These URLs offer hot-linked direct access to the reference in electronic versions of this report.

1. United States Environmental Protection Agency. Preliminary Data Summary of Urban Storm Water Best Management Practices. EPA-821-R-99-012. August 1999. [Printed] [Downloaded] http://www.epa.gov/ost/stormwater/

EPA's Engineering and Analysis Division conducted a study of storm water best management practices during 1997 and 1998 as part of its series of preliminary studies in the effluent guidelines program. This report summarizes existing information and data regarding the effectiveness of BMPs to control and reduce pollutants in urban storm water. The report provides a synopsis of what is currently known about the expected costs and environmental benefits of BMPs, and identifies information gaps as well. Information regarding existing storm water regulations and permits, overview of storm water discharges, pollution in urban storm water, reported impacts of urban storm water, goals of storm water best management practices, types of storm water best management practices, BMP selection, monitoring BMP effectiveness, effectiveness of BMPs in managing urban runoff, and costs and benefits of storm water BMPs are also included in this manual. This manual has information about EPA guidelines as well as other agencies that will be important in the MDT manual. In addition, this manual covers a broad spectrum of BMP applications with examples.

2. United States Environmental Protection Agency. 2002. Post-Construction Storm Water Management in New Development and Redevelopment. URL: http://www.epa.gov/npdes/menuofbmps/post.htm [Printed]

This is a web site created by the EPA Office of Water. Within the web site there are regulatory and guidance issues for post-construction storm water management in new development and redevelopment. In addition, the page has links to the following BMP topics: BMP menu, public education and outreach on storm water impacts, public involvement and participation, illicit discharge detection and elimination, construction site storm water runoff control, post-construction storm water management in new developments and redevelopments, pollution prevention and good housekeeping for municipal operations, measurable goals and storm water phase II. BMP fact sheets including structural BMPs, nonstructural BMPs are also located on the post-construction storm water management in new developments and redevelopment web site. The BMP fact sheets information will be very useful in the MDT manual.

3. United States Environmental Protection Agency. 2000. National Conference on Tools for Urban Water Resource Management and Protection Proceedings. EPA-625-R-00-001. July. [Printed] [Downloaded] http://www.epa.gov/ordntrnt/ORD/WebPubs/nctuw/index.html

A wide array of effective water quality management and protection tools have been developed for urban environments, but implementation is hindered by a shortage of technology transfer opportunities. Held in Chicago, Illinois on February 8-10, 2000, the National Conference on Tools for Urban Water Resource Management and Protection was designed to facilitate the educational process and transfer state-of-the-art information to state, regional, and local urban water quality practitioners.

- Cote, M., Dr. J. Clausen, B. Morton, P. Stacy, and S. Zaremba. Jordan Cove Urban Watershed National Monitoring Project
- Waschbusch, R.J., W.R. Selbig, and R.T. Bannerman. Sources of Phosphorus in Stormwater and Street Dirt from Two Urban Residential Basins in Madison, Wisconsin, 1994-95
- Yoder, C., Miltner, R., and White, D. Using Biological Criteria to Assess and Classify Urban Streams and Develop Improved Landscape Indicators
- Sotir, R. Getting Past the Obvious
- Livingson, E. Protecting and Enhancing Urban Waters: Using all the Tools Successfully
- Sovern, D. Structures to Enhance Fish Habitat in Urban Streams
- Livingson, E. Lessons Learned About Successfully Using Infiltration Practices
- Pitt, R., M. Lalor, J. Haper, and C. Nix. Potential New Tools for the Use of Tracers to Indicate Sources of Contaminates to Storm Drainage Systems
- Landry, N., and R. Livingston. Elimination of Illicit Connections in Coastal New Hampshire Spurs Cooperation and Controversy
- Danielson, V., C. Hoover, C. Perrin, N. White, R. Elmore, and J. Platt. Using Collaborative Problem-Solving to Protect North Carolina's Coastal Resources: The Experience of the White Oak Advisory Board
- Clarke, G., Pl Lehner, D. Cameron, and A. Frank. Community Responses to Stormwater Pollution: Case Study Findings with Examples from the Midwest
- Strecker, E. and K. Reininga. Integrated Urban Stormwater Master Planning
- Horner, W. Conservation Design: Managing Stormwater through Maximizing Preventive Nonstructural Practices
- Coffman, L. Low-Impact Development Design: A New Paradigm for Stormwater Management Mimicking and Restoring the Natural Hydrologic Regime

- Collins, J. and J. Kosco. A National Menu of BMPs for the Phase II NPDES Storm Water Program
- Strecker, E., M. Quigley, and B. Urbonas. Determining Urban Stormwater BMP Effectiveness
- Promise, J., K. Kennedy, and R. Brasheeear, Ph.D. Texas Nonpoint SourceBOOK is Now On-Line !
- Harbor, J., B. Engel, D. Jones, S. Pandey, K. Lim, and S. Muthukrishnan. A Comparison of the Long-Term Hydrological Impacts of Urban Renewal Versus Urban Sprawl
- Zielinski, J., Caraco, D., and Claytor, R. Comparative Nutrient Export and Economical Benefits of Conventional and Better Site Design Techniques
- Balousek, J., A. Roa-Espinosa, and G. Bubenzer. Predicting Erosion Rates on Construction Sites Using the Universal Soil Loss Equation in Dane County, Wisconsin
- Powell, J., Z. Ball, and K. Reaume. Public Involvement Programs That Support Water Quality Management
- Aveni, M. The Water-Wise Gardener Program: Teaching Nutrient Management to Homeowners
- Rogner, J. Chicago Wilderness; Toward an Urban Conservation Culture
- Swann, C. A Survey of Resident Nutrient Behavior in the Chesapeake Bay Watershed
- Spitzman, J. Lawn Care and Water Quality: Finding the Balance
- Brosseau, M. San Francisco Bay Area's Pesticide Toxicity Reduction Strategy
- Pronold, M. Administering the NPDES Industrial Storm Water Program at the Municipal Level
- Nerenberg, S. Lessons Learned From Three Watershed-Sensitive Development Demonstration Projects in the Great Lakes Basin
- Strynchuk, J., J. Royal, and G. England. Continuous Deflection Separation (CDS) for Sediment Control in Brevard County, Florida
- Lake County Stormwater Management Commission. Use of Automated Technologies in Watershed Management Planning
- Sediment and Runoff Control on Construction Sites Using Four Application Methods of Polyacrylamide Mix
- Mumley, T. Construction Site Planning and Management Tools for Water Quality Protection
- Reice, S., and J. Carmin. Regulating Sedimentation and Erosion Control into Streams: What Really Works and Why?
- Jayes, J., M. Mathieu, and G. Lindsey. Effectiveness in Erosion and Sediment Control: New Initiatives in Indianapolis
- Harbor, J., S. Tatlovich, R. Turco, Z. Reicher, A. Spacie, and V. Poole. Using Constructed Wetlands to Reduce Nonpoint Source Pollution in Urban Areas
- Dreher, D. Advanced Identification (ADID) Techniques Used to Protect Wetlands and Aquatic Resources in a Rapidly Growing County
- Morales, L. Local Government Involvement in Mitigation Banking
- Eisenberg, B. Massachusetts Stormwater Management Policy/Regulations: Development, Implementation, an Refinement
- Cave, K., D. Bryson, K. Kelly, and J. Bails. Implementation of Michigan's Voluntary Stormwater Permit – A Community Perspective
- Hayes, J., and C. Oggins. California's Model Urban Runoff Program (MURP): Urban Runoff Programs for Small Municipalities
- Minton, G., P. Bucich, M. Blosser, B. Leif, J. Lenhart, J. Simmler, and S. True. New Stormwater Treatment BMPs: Determining Acceptability to Local Implementing Agencies
- Adams, T., V. Allen, and A. Perley. By Any Measure

- Bryant, B., R. Grant, D. Weatherbe, and V. Berg. Stormceptor Hydrology and Non-Point Source Pollution Removal Estimates
- Reese, A. NPDES Phase II Cost Estimates
- Cyre, J. The Stormwater Utility Concept in the Next Decade (Forget the Millenium)
- Herzog, M., J. Harbor, K. McClintock, J. Law, and K. Bennett. Are Green Lots Worth More than Brown Lots? An Economic Incentive for Erosion Control on Residential Developments

4. United States Environmental Protection Agency. Construction Site Storm Water Runoff Control. URL: http://www.epa.gov/npdes/menuofbmps/con_site.htm [Printed]

The EPA Office of Water created this web site. The web site contains regulatory and guidance issues for construction site storm water runoff control. In addition, the page has links to the following BMP topics: BMP menu, public education and outreach on storm water impacts, public involvement and participation, illicit discharge detection and elimination, construction site storm water runoff control, post-construction storm water management in new developments and redevelopments, pollution prevention and good housekeeping for municipal operations, measurable goals and storm water phase II. Also located on the construction site storm water runoff control web site are BMP fact sheets including structural BMPs and nonstructural BMPs. The BMP fact sheets will be very useful in the MDT manual.

5. United States Environmental Protection Agency. 2001. National Menu of Best Management Practices for NPDES Storm Water Phase II Downloadable Files. URL: http://www.epa.gov/npdes/menuofbmps/BMP_files.htm [Printed] [Downloaded]

The EPA's Storm Water Phase II Menu of Best Management Practices (BMPs) is intended to provide guidance to regulated small Municipal Separate Storm Sewer Systems (MS4s) as to the types of practices they could use to develop and implement their storm water management programs. The menu is intended as guidance only. The Storm Water Phase II rule was published on December 8, 1999, and generally requires operators of small MS4s in urbanized areas to develop and implement a storm water management program, which addresses six minimum control measures. A series of fact sheets describe the various components of the Phase II rule. This menu includes information on Public Education and Outreach on Storm Water Impacts, Public Involvement/Participation, Illicit Discharge Detection and Elimination, Construction Site Storm Water Runoff Control, Post-Construction Storm Water Management in New Development and Redevelopment, and Pollution Prevention/Good Housekeeping for Municipal Operations. The menu contains many BMPs with descriptions, applicability, siting and design considerations, limitations, maintenance considerations effectiveness, and cost considerations for each. This information will provide quality background information for the MDT manual.

The references below are EPA storm water technology fact sheets. These fact sheets give a brief description of the technology, applicability, advantages and disadvantages, design criteria, performance and cost information for different types of storm water technologies. These fact sheets contain BMP data that can be incorporated into the MDT manual.

6. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Turf Reinforcement Mats. EPA-832-F-99-002. September 1999. [Printed] [Downloaded]

This fact sheet describes the use of turf reinforcement mats (TRMs). TRMs combine vegetative growth and synthetic materials to form a high strength mat that helps to prevent soil erosion in drainage areas and on steep slopes.

7. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: On-Site Underground Retention/Detention. EPA-832-F-01-005. September 2001. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/runoff.pdf

Several different types of storm water BMPs, including retention/detention ponds, storm water wetlands, and underground storage structures, can provide storm water volume control. These BMPs capture flow and retain it until it infiltrates into the soil (storm water retention) or release it slowly over time, thereby deceasing the peak flows and associated flooding problems (storm water detention).

8. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Vegetated Swells. EPA-832-F-99-006. September 1999. [Printed] [Downloaded]

A vegetative swale is a broad, shallow channel with a dense stand of vegetation covering the side slopes and bottom. Swales can be natural or manmade, and are designed to trap particulate pollutants, promote infiltration, and reduce flow velocity of storm water runoff.

9. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Sand Filters. EPA-832-F-99-007. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/sandfltr.pdf

Sand filters have proven effective in removing several common pollutants from storm water runoff. Sand filters generally control storm water quality, providing very limited flow rate control.

10. United States Environmental Protection Agency. Storm Water Management Fact Sheet: Employee Training. EPA-832-F-99-010. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/empltrng.pdf

In-house employee training programs are established to teach employees about storm water management, potential sources of contaminants, and BMPs. Employee training programs should instill all personnel with a thorough understanding of their Storm Water Pollution Prevention Plan (SWPPP), including BMPs, processes and materials they are working with, safety hazards, practices for preventing discharges, and procedures for responding quickly and properly to toxic and hazardous material incidents.

11. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Bioretention. EPA-832-F-99-012. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/biortn.pdf

Bioretention is a BMP developed in the early 1990's by the Prince George's County, MD, Department of Environmental Resources (PGDER). Bioretention utilizes soils and both woody and herbaceous plants to remove pollutants from storm water runoff.

12. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Flow Diversion. EPA-832-F-99-014. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/fl.pdf

Flow diversion structures (such as gutters, drains, sewers, dikes, berms, swales, and graded pavement) are used to collect and divert runoff to prevent the contamination of storm water and receiving water.

13. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Hydrodynamic Separators. EPA-832-F-99-017. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/hydro.pdf

Hydrodynamic separators are flow-through structures with a settling or separation unit that are widely used in storm water treatment to remove sediments and other pollutants. No outside power source is required because the energy of the flowing water allows the sediments to efficiently separate.

14. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Infiltration Drain Fields. EPA-832-F-99-018. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/infltdrn.pdf

Infiltration drain fields are innovative technologies that are specially designed to promote storm water infiltration into subsoils. These drain fields help to control runoff and prevent the contamination of local watersheds.

15. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Infiltration Trench. EPA-832-F-99-019. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/infltrenc.pdf

Urban development is significantly increasing surface runoff and contamination of local watersheds. As a result, infiltration practices, such as infiltration trenches, are being employed to remove suspended soils, particulate pollutants, coliform bacteria, organics, and some soluble forms of metals and nutrients from storm water runoff.

16. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Porous Pavement. EPA-832-F-99-023. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/porouspa.pdf

Porous pavement is a special type of pavement that allows rain and snowmelt to pass through it, thereby reducing the runoff from a site and surrounding areas. It addition, porous pavement filters some pollutants from the runoff if maintained.

17. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Storm Water Wetlands. EPA-832-F-99-025. September 1999. [Printed] [Downloaded]

Wetlands are those areas that are typically inundated with surface or ground water and that support plants adapted to saturated soil conditions. Wetlands have been described as “nature’s kidneys” because the physical, chemical, and biological processes that occur in wetlands break down some compounds (e.g., nitrogen-containing compounds, sulfate) and filter others. The natural pollutant-removal capabilities of wetlands have brought them increased attention as storm water BMPs.

18. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Vegetative Covers. EPA-832-F-99-027. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/vegcvr.pdf

One of the most effective ways to prevent erosion and sedimentation is to stabilize disturbed land through the addition of vegetation. This practice is referred to as “vegetative cover.” Vegetative covers can be

used to preserve existing vegetation and/or revegetate disturbed soils. They can provide both dust control and a reduction in erosion potential by increasing infiltration, trapping sediment, stabilizing the soil, and dissipating the energy of hard rain.

19. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Water Quality Inlets. EPA-832-F-99-029. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/wtrqlty.pdf

Water quality inlets (WQIs), also commonly called oil/grit separators or oil/water separators, consist of a series of chambers that promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from storm water. Most WQIs also contain screens to help retain large or floating debris, and many of the newer designs also include a coalescing unit that helps to promote oil/water separation. WQIs typically only capture the first portion of the runoff for treatment and are generally used for pretreatment before discharging to other BMPs.

20. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Airport Deicing Fluid Recovery Systems. EPA-832-F-99-043. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/airplnde.pdf

A three-stage process typically consisting of a primary filtration, contaminant removal via ion exchange or nanofiltration, and distillation, accomplishes the recovery of spent ethylene glycol or propylene glycol from industrial processes.

21. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Modular Treatment System. EPA-832-F-99-044. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/modtreat.pdf

This fact sheet describes modular systems for treating storm water. One of the primary modular storm water treatment systems currently on the market is the StormTreat™ System, or STS. The STS, which was developed in 1994, is a series of sediment chambers and constructed wetlands.

22. United States Environmental Protection Agency. Storm Water Technology Fact Sheet: Wet Detention Ponds. EPA-832-F-99-048. September 1999. [Printed] [Downloaded] http://www.epa.gov/owmitnet/mtb/wetdtnpn.pdf

Wet detention ponds are storm water control structures providing both retention and treatment of contaminated storm water runoff. The pond consists of a permanent pool of water into which storm water runoff is directed.

2.2.2 Montana Department of Environmental Quality

The references listed below are a compilation of data received from the DEQ website (http://www.deq.state.mt.us/). These references contain current State regulations and guidelines that will need to be addressed in the manual.

23. Montana Department of Environmental Quality. General Permit for Storm Water Discharges Associated with Construction Activities. Permit No. MTR100000. Currently in Public Comment Period. 2002. [Downloaded]

MPDES Permit Number MTR100000 ("General Permit") was originally issued on November 17, 1992 and expired on August 31, 1997. The General Permit was then reissued on May 19, 1997 and has an expiration date of August 31, 2002. The significant conditions associated with this General Permit are to essentially ensure potential pollutant sources and site characterization are identified with respect to storm water discharges to surface waters, and to address storm water management systems, erosion/sediment control measures, and other Best Management Practices (BMPs) used to keep potential pollutants out of storm water and surface waters. This is accomplished through a plan developed and implemented by operators (owners, contractors, etc.) responsible for a construction project and the storm water discharges associated with it. In the preceding two General Permits, this plan was called an "Erosion Control Plan". In this 2002-2007 General Permit, this plan will be called by the conventional name, a "Storm Water Pollution Prevention Plan" ("SWPPP"). Most conditions which are specific to this General Permit are those addressing the development, implementation, and compliance with the SWPPP. Other significant conditions in Permit Number MTR100000 include requirements for the process and forms to be used for obtaining and terminating General Permit coverage, requirements for fees, effluent limitations, self-monitoring (inspection) requirements, reporting requirements, and records retention requirements. Standard conditions for all MPDES permits are also included in the General Permit. This information will be incorporated into the MDT manual.

24. Lincoln, R. 1993. Formerly Montana Department of Health and Environmental Sciences. Montana Sediment and Erosion Control Manual. MPDES Storm Water Program. Revised May 1996. [Printed]

This manual is designed to assist contractors, engineers and consultants with designing and implementing an Erosion Control Plan as required by a MPDES general permit for storm water discharge associated with construction activities. Many of the best management practices (BMPs) are erosion control concepts described in this manual may be applicable to activities other then construction (i.e. mining sites, logging activities, agriculture, and small development or homeowner projects). Information contained in this manual consists of designing the storm water erosion control plan, best management practices for sediment and erosion control, water quality issues for planning erosion control plans, erosion control on small parcels and individual home sites, and road construction in forested and mountainous areas.

25. Montana Department of Environmental Quality. Resource Protection Planning Bureau. Montana Nonpoint Source Management Plan: A Watershed Approach. May 2001. [Printed] [Downloaded] http://www.deq.state.mt.us/ppa/nonpoint/NonpointPlan.asp

More than 25 years ago Congress passed the Clean Water Act. The goal of the 1972 law was to make the nation's waters "fishable and swimmable" by 1984. The nation has made considerable progress in improving water quality through the control of point source pollution from industrial and municipal discharges. Today point source pollution in Montana accounts for only 10 percent of water quality impairment of streams and 20 percent of lakes. It has been almost a decade since the Department of Environmental Quality revised its nonpoint source management plan. The 1991 plan described the state's existing programs and authority for addressing nonpoint pollution problems. In the intervening years the legislature amended Montana's Water Quality Act to include the development of Total Maximum Daily Loads (TMDLs) the federal government announced a new Clean Water Action Plan and the Department of Environmental Quality began moving toward a *watershed approach* to address nonpoint pollution

priorities. This manual covers key elements of an effective state NPS program, additional nonpoint sources, description and implementation of the NPS program, programs and agencies with watershed management related projects, opportunities for coordination and collaboration, and effective administration of the NPS program. Additionally, the Montana Ground Water Plan, Montana's agricultural BMPs for control of nonpoint source pollution, best management practices for forestry in Montana, schedule for the development of total maximum daily loads (TMDLs) in Montana, and Montana DEQ nonpoint source program projects are also covered in the manual.

2.2.3 Federal Highway Administration

The references listed below are a compilation of data received from the FHWA website (http://www.fhwa.dot.gov/). These references consist of federal regulations, design manuals and research projects involving erosion and sediment control with innovative BMPs. References containing a Uniform Resource Locator (URL) address are web-based references.

26. Federal Highway Administration. Erosion and Sediment Control Final Rule. Federal Register Volume 59, No. 142, 37935-37939. July 26, 1994. [Printed]

On July 26, 1994, in Federal Register Volume 59, No. 142, 37935-37939, the Federal Highway Administration (FHWA) published the final rule revising 23 CFR 650, Subpart B, Erosion and Sediment Control on Highway Construction Projects. This revision formally adopts Volume III of the American Association of State Highway and Transportation Officials (AASHTO) Highway Drainage Guidelines 1992, as guidelines to be followed on all projects funded under Title 23, United States Code. The adoption of these guidelines fulfills the requirement of Section 1057 of the Intermodal Transportation Efficiency Act of 1991. As part of this revision, a statement was included recommending that each State Highway Agency (SHA) apply either these guidelines, or their own more stringent guidelines, to develop specific standards and practices for the control of erosion. These specific standards and practices may reference available resources, such as the procedures presented in the AASHTO Model Drainage Manual, 1991.

27. Federal Highway Administration. Federal-Aid Policy Guide Title 23 - Code of Federal Regulations (and Non-regulatory Supplements). Subchapter G, Part 650, Subpart B-Erosion and Sediment Control on Highway Construction Projects. FPAG 23 CFR 650B. December 7, 1994. Transmittal 12.

The purpose of this subpart is to prescribe policies and procedures for the control of erosion, abatement of water pollution, and prevention of damage by sediment deposition from all construction projects funded under title 23, United States Code.

28. Federal Highway Administration. United States Department of the Interior. United States Geological Survey. National Highway Runoff Water-Quality Data and Methodology synthesis. URL: http://ma.water.usgs.gov/FHWA/runwater.htm

The United States Geological Survey (USGS) and the Federal Highway Administration (FHWA) are currently cooperating in a national project to evaluate FHWA's guidelines for highway-runoff quality. The FHWA wants to determine if current guidelines for highway runoff quality are up-to-date and technically supportable, or if additional information is needed to update the guidelines. The FHWA wants a catalog of existing studies and available data. Information collected will be used to determine if available data are sufficient to characterize pollutant loadings and impacts attributable to highway Storm water runoff around the country. This web page will provide a catalog of reports, and other information as it becomes available.

2.2.4 Transportation Research Information Services

The references listed below are a compilation of data received from the Transportation Research Information Services (TRIS) Database. The TRIS Database is the world's largest and most comprehensive bibliographic resource on transportation information and is produced and maintained by the Transportation Research Board at the National Academy of Sciences (http://www4.nationalacademies.org/trb/tris.nsf). TRIS is also available as TRIS Online through the National Transportation Library's Web (http://www.ntl.bts.gov/). TRIS references contain a variety of erosion and sediment control information including innovative BMPs, BMP maintenance and BMP management. References containing a Uniform Resource Locator (URL) address are web-based references.

29. Wisconsin Department of Transportation (WisDOT) ECSW Committee. Erosion Control: Product Acceptability Lists for Multi-Modal Applications. January 2001. [Printed] [Downloaded]

Each year the Wisconsin Department of Transportation (WisDOT) compiles the Erosion Control Product Acceptability Lists (PAL) for Erosion Mats, Soil Stabilizers, Tackifiers, inlet protection, and temporary ditch checks. All products in these lists shall meet the Department's Standard Specifications for Road and Bridge Construction. Products included in these lists shall be manufactured with the same quality and composition as the test material originally submitted for evaluation.

30. National Cooperative Highway Research Program. Management of Runoff from Surface Transportation Facilities-Synthesis and Research Plan. NCHRP Web Document 37 (Project B25-20). March 2001. [Printed] [Downloaded]

A number of research problem statements on management of runoff have recently appeared, and collectively they have perplexed and confounded rational choice of which problem merits attention first, and of what should be done next – in short, how do you prioritize the diverse interests of states and Transportation Research Board (TRB) committee recommendations? The interests and recommendations overlap with regional differences coming to play to generate slightly different versions of the same need. What sets this research project apart from previous information syntheses on the subject is the objective of identifying and prioritizing research needs with an anticipation of future needs. This manual looks at BMP selection, design and maintenance among other storm water topics. This information will be useful in the development of the MDT manual.

31. Washington State Transportation Commission. The Assessment of Groundwater Pollution Potential Resulting from Stormwater Infiltration BMP's. Research Project T9902 Task 3. August 1995. [Printed] [Downloaded]

In conjunction with a statewide policy, the Washington State Department of Transportation (WSDOT) has placed an emphasis on the use of infiltration technologies as the best management practice (BMP's) for the treatment of highway storm water runoff (Ecology, 1991). With many of these waters containing trace quantities of heavy metals and various hydrocarbon residues, the environmental concern is one of preventing the long-term contamination to underlying groundwaters. Although under traditional application the unsaturated zone is commonly thought of as a "treatment column" through which the pollutants are removed or degraded, the actual mechanisms of fate and transport within this subsurface region are poorly understood. One recent example of new discovery is that of "facilitated transport." Here, the introduction of natural organic matter (NOM) present in all storm water runoff is thought to react with various heavy metal and residual hydrocarbon contaminants derived from any roadway surface. This

reaction, in turn, produces intricate physical/chemical complexes that potentially exhibit unusually rapid (or enhanced) transport characteristics. The potential effects are those of greatly reduced travel times during the infiltration process and the increased chance of significant groundwater contamination over a much shorter than expected time of operation. Such effects are, however, unaccounted for in the current design criteria.

32. Washington State Department of Transportation. Northwest Resolutions, Mowat Construction Company. Team Management for Construction Projects. URL: http://www.wsdot.wa.gov/fossc/cons/3

WSDOT and the Associated General Contractors of Washington (AGC) are leading the industry into a new training effort to be presented jointly to Agency and Contractor field managers. The two-day training, *Managing Project Teams*, has been designed to enhance the ability of these managers to work together to create and lead project teams. The objective is to initially reach all current managers and then maintain the trained status with additional classes for newcomers and with refresher classes as needed.

33. Parker, D., S. Parker, and T. Stader. A Geographic Information System to Predict Soil Erosion Potential in Rural Transportation Construction Projects. Final Report. 00681972. June 30, 1995. [Printed] [Downloaded]

Recently the Environmental Protection Agency (EPA) and locally, the Department of Pollution Control and Ecology (DPC&E) has sought to reduce the problem of soil erosion from construction sites. Soil erosion causes a loss of the productivity in the land, dumps millions of tons of sediment into waterways, and provides a substrate for toxic chemicals, which are carried into the water supply. The EPA estimates that over $13 billion is spent each year mitigating man-made erosion. Those involved in construction work, developments and other disturbances of the land are now faced with large costs to comply with state and federal regulations. The Arkansas Highway and Transportation Department (AHTD) seeks to limit the amount of soil erosion from new construction sites. It is preferable and more effective to prevent soil erosion than to correct the damaging effects of erosion after it has occurred. The AHTD could receive substantial benefit from a software system designed to predict potential soil erosion from future and present construction sites. This project provides such a predictive tool for evaluating potential soil erosion for construction sites by using a mathematical model to predict soil loss in conjunction with a geographic information system (GIS).

34. National Cooperative Highway Research Program. Evaluation of Best Management Practices for Highway Runoff. Washington, DC. Research in Progress.

The objective of this project is to provide highway practitioners with the scientific and economic information needed for selection and design of best management practices (BMPs) to control highway runoff.

35. Borroum, S. and M. McCoy. "The Calm After The Storm. Caltrans Focuses on Stormwater Management", Public Works Journal Corporation, 200 South Broad Street, Ridgewood , NJ, 07451. *Public Works* Vol. 133 Issue No. 1 pp 28-31, 01. 2002.

The California Department of Transportation (Caltrans) has developed a statewide stormwater management program to prevent the adverse effects of stormwater runoff from Caltrans roadways and facilities. The program represents a comprehensive effort to preserve and improve water quality in California. This article provides an overview of the program and its effectiveness. Caltrans experts work in partnership with private consultants to develop and apply safe, effective and efficient methods for

dealing with stormwater issues. The stormwater program is divided into two areas: technical programs and institutional programs. Technical programs include watershed planning, water-quality research and monitoring, applied research studies on best management practices, and data management and dissemination of results. Institutional programs focus on implementing Caltrans' statewide National Pollutant Discharge Elimination System permit and stormwater management plan, publishing stormwater quality handbooks, developing standard specifications and provisions, providing stormwater training, and conducting field compliance reviews. A stormwater compliance review task force has been established to improve construction site stormwater management throughout the state.

36. Johnson P. 2000. I-99 Erosion and Sediment Controls Best Management Practice. Texas Transportation Institute.

The purpose of this project is to develop evaluation and measurement procedures to effectively assess best management practices that are planned in conjunction with Interstate 99 construction to identify erosion and sediment control measures that are appropriate for use in a public highway environment.

37. Beck, D. "Storm Water Treatment Technologies."Civil Engineering News, Incorporated. 1255 Roberts Boulevard, Suite 230, Kennesaw, GA, 30144 *Civil Engineering News.* Vol. 13 Issue No. 10 pp 46-51. 2001.

One major source of water pollution is storm water runoff from urban developments. The Environmental Protection Agency has targeted the reduction of pollutants in rain and melting snow discharges in the National Pollution Discharge Elimination System (NPDES). The NPDES has two phases. Phase 1 was issued in 1990 and covers medium and large municipal separate storm sewer systems (MS4s). It also restricts runoff from construction activities disturbing more than five acres. Phase II regulations, which will become effective in 2003, extend NPDES storm water pollution controls to operators of smaller MS4s and construction sites. The new regulations use a broad, multifaceted program that covers virtually every aspect of controlling storm water pollution from origination to treatment. This article discusses some of the traditional and new structural best management practices to manage storm water runoff. Detention ponds are traditionally used to manage storm water runoff, but underground storm water treatment devices are being developed for urban areas that will eliminate the surface area requirements of detention ponds. These systems include catch basin inserts, gravity separation devices, filtration devices, and swirl concentrator systems. The systems are described in detail and general guidelines for considering these systems are given. This article also presents a list of the major types of storm water pollutants.

38. Kayhanian, M., K. Murphy, L. Regenmorter, and R. Haller. "Characteristics of Storm-Water Runoff From Highway Construction Sites in California." Transportation Research Board, 2101 Constitution Avenue, NW , Washington, DC, 20418. *Transportation Research Record.* Issue No. 1743 pp 33-40. 2001.

Fifteen highway construction sites were monitored by the California Department of transportation (Caltrans) to assess the water quality of storm-water runoff from the sites. Caltrans conducted a study to generate sufficient water quality data to further develop management strategies and evaluate existing best management practices. A wide range of construction sites was selected for monitoring throughout the state. Both flow-paced composite and single-grab samples were collected and analyzed at these sites for a total of 72 station-storm events during the 1998-1999 and 1999-2000 wet seasons. Results obtained during the 2-year characterization study indicate the following: (a) Caltrans construction-site runoff constituent concentrations detected during this study are less than typical Caltrans and non-Caltrans highway runoff constituent concentrations, with the exception of total chromium, total nickel, total phosphorus, total suspended solids (TSS), and turbidity. (b) The concentrations of TSS and turbidity

likely are due to the disturbed soils present at most construction sites. (c) The origin of the high concentrations of total chromium, total nickel, and total phosphorus concentrations is unknown. Concentrations of these constituents varied between sites, so it is possible that site-specific soils and vegetative conditions contributed to the concentrations of these constituents. (d) A correlation (R-squared values greater than 0.5) was observed between TSS runoff concentrations and particulate runoff concentrations of chromium, copper, and zinc, indicating that minimizing particulate matter may reduce total metals concentrations.

39. Lippner, G., J. Johnston, S. Combs, K. Walter, and D. Marx. "Results of California Department of Transportation Litter Management Pilot Study." Transportation Research Board, 2101 Constitution Avenue, NW, Washington, DC, 20418. *Transportation Research Record*. Issue No. 1743 Pag: pp 10-15. 2001.

Litter is receiving increasing attention as a water pollutant, especially near Southern California beaches. To investigate the characteristics of litter in freeway storm water and the effectiveness of various best management practices (BMPs) the California Department of Transportation (Caltrans) conducted a 2-year litter management pilot study in the Los Angeles area. New litter sampling and monitoring protocols were devised to characterize litter and to test BMP effectiveness. Twenty-four freeway catchments were monitored. Half the catchments were treated with one of five BMPs; the others were controls. The BMPs tested were increased street sweeping frequency, increased frequency of manual litter pickup, a modified drain inlet, a bicycle grate I inlet, and a litter inlet deflector (LID) developed during the study. Litter discharges were quantified by weight, volume, and count and were further classified by composition. Roughly half the freeway storm water litter was found to consist of paper, plastic, and Styrofoam. With the exception of cigarette butts, the origins of most litter items could not be identified because of their small size. Of the five BMPs tested, only increased litter pickup and the modified drain inlet demonstrated some apparent reduction of litter in storm water runoff, although the data are highly variable. Increased frequency of sweeping, the bicycle grate, and the LID did not reduce litter effectively in storm water discharges monitored during the study.

40. Yu, S., M. Stopinski, and D. Monika. Testing of Ultra-Urban Stormwater Best Management Practices. Virginia Transportation Research Council, 530 Edgemont Road, Charlottesville, VA, 22903. Virginia Department of Transportation, 1401 East Broad Street , Richmond, VA, 23219, Federal Highway Administration, 400 7th Street, SW, Washington, DC , 20590. 2001.

Ultra-urban areas where conventional best management practices (BMPs) are neither feasible nor cost-effective present a challenge to stormwater management. Although new BMPs have been developed for such space-limited environments, the field performance of these technologies is still largely undocumented. This study monitored the field performance of four ultra-urban BMPs: three oil and grit separators [Isoilater, Stormceptor (Trademark), and Vortechs Stormwater Treatment System (Trademark)] and a bioretention area. Storm sampling data for each site were analyzed to calculate the removal efficiency for each constituent monitored. Because the Vortechs system was installed improperly, its removal efficiency results in this study are not reliable. Therefore, the system could not be fully evaluated. The results of the study are site specific. The performance of the BMPs was affected by varying factors. The study thus concludes that the data and study site conditions must be evaluated carefully before results can be extrapolated to compare the relative and potential performance of a particular BMP under different site conditions.

41. Yu, S., G. Fitch, E. Michael, T. Andrew, and W. Douglas. Constructed Wetlands For Nonpoint Source Pollution Control. Virginia Transportation Research Council, 530 Edgemont Road , Charlottesville, VA, 22903. Virginia Department of Conservation and Recreation, 203 Governor Street, Suite 206, Richmond, VA, 23219-2094, Federal Highway Administration, 400 7th Street, SW, Washington, DC , 20590. 1998.

This report presents the results of research to evaluate the potential of utilizing mitigated wetlands as stormwater Best Management Practices (BMPs). Results of wetland monitoring, wetland modeling, and geographic information system (GIS) development are presented. Average removal rates as high as 90% for total suspended solids, 65% for chemical oxygen demand, 70% for total phosphorus and orthophosphate, and 50% for zinc were observed at study sites. Despite having stormwater runoff as a primary water source, the monitored sites supported apparently healthy and diverse vegetation and a variety of wildlife. A mathematical model of transport of a pollutant in dissolved and particulate forms in a two-segment, two-state system was developed. The model includes settling, diffusion, adsorption to plant and substrate, and vegetative uptake mechanisms. A GIS was developed to improve management of existing mitigated wetlands and to aid in siting of future mitigation sites. A link between a watershed model and this GIS is also described. The report concludes that mitigated wetlands may be as effective as conventional BMPs at improving the quality and at controlling the quantity of highway storm runoff.

42. Koob, T. and M. Barber. 1999. Washington Department of Transportation (WSDOT) BMP's For Stormwater Runoff In Confined Spaces. State Transportation Center, Washington State University, Civil & Environmental Engineering, Sloan Hall, Pullman, WA, 99164. Washington State Department of Transportation, Transportation Building, 212 Maple Park, Olympia, WA, 98504-7300, Federal Highway Administration, 400 7th Street, SW, Washington, DC , 20590.

Confined spaces Best Management Practices (BMPs) were discussed in regard to hydraulic and pollutant removal performances. Various filter media having potential for use in filtration vaults were evaluated. Column tests using fifteen types of filter media [aquarium rocks, cedar bedding, charcoal, corn cobs, garden bark, glass beads, kitty litter, iron oxide coated sand, peat moss, persolite, sand, CH zeolite, XY zeolite, sand/steel wool, and Washington State University (WSU) compost] were run with a synthetic stormwater runoff influent. Effluent samples were collected over time and analyzed for cadmium, copper, lead, zinc, nitrate, phosphate, pH, Total Suspended Solids (TSS), and Total Petroleum Hydrocarbon (TPH). Results indicate that garden bark, peat moss, sand, and WSU compost are the best filter media for treating stormwater runoff in vaults. Initially, they have acceptable hydraulic properties to pass water through the filters and have good pollutant removal abilities. Over time, however, evidence of clogging can be seen. Further field testing is recommended to determine actual operation and maintenance schedules. Design guidelines are included for the recommended filter media.

43. Fifield, J. "When Best Management Practices Become Worst Management Practices." Civil Engineering News, Incorporated, 1255 Roberts Boulevard, Suite 230, Kennesaw, GA, 30144-, *Civil Engineering News.* Vol. 11 Issue No. 8 pp 70-77. 1999.

On February 17, 1998, the Environmental Protection Agency (EPA) published their ruling for reissuance of the National Pollutant Discharge Elimination System general permits. The ruling outlined Best Management Practices (BMPs) recommended for controlling sediment from construction sites. However, not all BMPs are effective in controlling sediment in runoff waters and erosion. Unfortunately, the EPA ruling did not provide guidelines as to when mitigation measures are not to be installed. As a result, Storm Water Pollution Prevention Plans are being developed with, and contractors are installing, mitigation measures that often increase the potential for erosion, increase downstream flooding, and increase downstream sedimentation. This article reviews the proper use and limitation of different BMPs,

including straw or hay bale barriers, rock barriers, silt fence barriers, rolled erosion control products, and curb and gutter sediment traps. If reduction of sediment in runoff is to occur, it is important that limitations be recognized with all structural and nonstructural methods.

44. Davis, V., S. Gross, and M. Lockbaum. Overview of The Quality And Quantity of Roadway Runoff And Current Status of Phase II Storm Water Rules. CORPORATE SOURCE: Braun Intertec Corporation, 6875 Washington Avenue south, P.O. Box 39108, Minneapolis, MN, 55439-Minnesota Department of Transportation, Transportation Building, 395 John Ireland Boulevard, St Paul, MN, 55155. 1998.

This report provides a summary of the current Storm Water rules and proposed rules as they may affect the construction and operation of the streets and highways of Minnesota Cities and Counties. This report also summarizes "The Quantity and Quality of Runoff from Selected Guttered and Unguttered Roadways in Northeast Ramsey County, Minnesota" (U.S. Geological Survey, WRI Report 96-4284, 1997), a study and resulting report that was conducted for the Minnesota Local Road Research Board. The rules summarized include the Federal Phase II Storm Water Rules, the Minnesota Pollution Control Agency's response to the proposed rules, and the process of obtaining Industrial and Municipal Storm Water Permits and Construction Storm Water Permits.

45. Schaeffer, J. and M. Barber. 1999. Treating Stormwater In Confined Situations (Confined Space Stormwater BMPs). Washington State University, Department of Agricultural Economics. Pullman, Washington.

The goal of this research is to develop, test, and evaluate methods for Best Management Practices (BMPs) that are most effective where limited right-of-way is available. The most effective BMPs for treating stormwater in urban areas, including ferry dock and terminal areas, have a number of product and design options that are used mostly based on the claims of the product manufacturer. This research will look at various designs along with promising products and develop a systematic evaluation methodology. Such a methodology will make it easier to select best management practices that effectively protect water quality.

46. Smith K.P., 2002. “Effectiveness Of Three Best Management Practices for Highway-Runoff Quality along the Southeast Expressway, Boston, Massachusetts”.

Best management practices (BMPs) near highways are designed to reduce the amount of suspended sediment and associated constituents, including debris and litter, discharged from the roadway surface. The effectiveness of a deep-sumped hooded catch basin, three 2-chambered 1,500-gallon oil-grit separators, and mechanized street sweeping in reducing sediment and associated constituents was examined along the Southeast Expressway (Interstate Route 93) in Boston, Massachusetts.

47. Cabalka, D., and P. Newton. “Fire and Ice.” Industrial Fabrics Association International, 345 Cedar Building, Suite 800, St Paul, MN, 55101-1088, *Geotechnical Fabrics Report.* Vol. 16 Issue No. 1 pp 30-35. 1998.

Earth's weather extremes seem to demand equally different erosion control materials, but that is not necessarily the case. Two very different case studies are presented, where a common best-management practice, the excelsior erosion-control blanket, demonstrates its ability to meet the environmental challenges of both climate extremes. The conditions of a large highway construction project in southern Mexico represents fire, the first extreme. The icy end of the spectrum is then explored by a landfill-closure project in Alaska. The case studies demonstrate that the high water-absorbing capacity,

mechanical fiber interlock, and "hook-and-loop fabric" effect of their barbed edges with the subgrade, make excelsior erosion-control blankets well-suited for both environmental extremes.

48. Urbonas, B., J. Doerfer, and L. Tucker. "Stormwater Sand Filtration: A Solution Or A Problem?" American Public Works Association, 2345 Grand Boulevard, Suite 500, Kansas City, MO, 64108-2625. *American Public Works Association.* Vol. 63 Issue No. 6 p23. 1996.

The results of tests conducted recently reveal caution needs to be observed when using sand filters for stormwater quality management. Studies done in Lakewood, Colorado, indicate sand filters lose there effectiveness dramatically when the flow through rate decreases proportionate to total suspended solids accumulating on the filter surface. This decrease in the flow through rate results in either the stormwater bypassing the filters or creating large and prolonged ponding areas. The use of sand filters for stormwater quality management has been taking place since the mid-1980s. Other types of media filters have also been investigated as stormwater Best Management Practices such as peat and sand-and-peat mix filters, and compost and compost-and-sand layered filters.

49. Schaftlein, S. "Washington State's Stormwater Management Program." Transportation Research Board, 2101 Constitution Avenue, NW, Washington, DC. 20418. *Transportation Research Record*. Issue No. 1523 pp 124-129. 1996.

To comply with state and federal laws, the Washington State Department of Transportation developed a Stormwater Management Program. The program included an outfall inventory and retrofit program, a Highway Runoff Manual (HRM), and storm water research. Field crew inventoried sites where highway stormwater runoff is collected and discharged to surface water, groundwater, and municipal storm sewers. Pipes, ditches, and stormwater structures that provide quantity and quality control were inventoried. The screening assessment for potential water pollution problems was made via observation and sampling kit. The sampling kit was found to be ineffective at identifying illicit connections. Inventoried sites were mapped using global positioning and geographic information system technology. Research was conducted on sites to determine watershed characteristics, potential environmental effects, and Best Management Practice (BMP) retrofit options. A computer data base of information is maintained to facilitate stormwater management activities. A prioritization scheme was developed to identify priority sites for retrofit, based on the following factors: receiving water body, beneficial uses, pollution loading, percent highway drainage, cost-pollution benefit, and values tradeoff. The HRM was developed to direct stormwater management for existing and new state highways, rest areas, park-and-ride lots, and ferry terminals. Water quality and quantity issues for construction and maintenance are addressed by meeting the minimum requirements of the manual. Thirteen research projects have been funded to evaluate experimental BMPs, to determine BMP pollutant removal efficiencies, and to assess the costs and benefits of retrofitting outfalls. Research included bench-scale work, field projects, and a department survey.

50. Yu, S., R. Kaighn, and S. Liao. Testing of Best Management Practices For Controlling Highway Runoff, Phase II Final Report. Virginia Transportation Research Council, P.O. Box 3817, University Station, Charlottesville, VA, 22903. Virginia Department of Transportation, 1221 East Broad Street , Richmond, VA, 23219. Federal Highway Administration, 400 7th Street, SW, Washington, DC , 20590. 1994.

In order to obtain the detailed information necessary to develop design guidelines for the stormwater best management practices (BMPs) included in the Virginia Department of Transportation's "Stormwater Management Manual", a field program was initiated in 1991 for testing the pollutant removal efficiency of selected BMPs. This report summarizes Phase II of this endeavor. A dry detention pond that drained a

small, highly impervious area and a vegetated swale that received runoff from an urban highway were examined. Manual and automatic sampling techniques were used to monitor stormwater flowing into and out of the two facilities. Pollutant removal efficiencies were determined using a mass balance method. Pollutants measured were total suspended solids, chemical oxygen demand, total phosphorus, and zinc. The results suggest that, if properly designed, these types of facilities can be effective tools for removing stormwater pollution from highway runoff.

51. Hathhorn, W., and Yonge D. 1995. "The Assessment Of Groundwater Pollution Potential Resulting From Stormwater Infiltration BMP's". Washington State Transportation Center, Washington State University, Pullman WA.

This research was conducted to assess the potential for degrading the quality of underlying groundwater resources as they relate to trace heavy metal concentrations associated with the infiltration of highway storm water runoff. A focus was placed on identifying the applicability of existing design standards in meeting the State's "anti-degradation" policy for existing groundwaters. The primary interest was to examine the environmental performance of a typical infiltration basin under the framework of the possible presence of facilitated heavy metal-NOM transport mechanisms. The goal was to establish revised guidelines (if necessary) for the design of an environmentally compliant infiltration facility.

52. Sprague, C. "Silt Fence Installation Efficacy." Industrial Fabrics Association International, 345 Cedar Building, Suite 800, St Paul, MN, 55101-1088. *Geotechnical Fabrics Report.* Vol. 19 Issue No. 4 pp 22-29. 2001.

Silt fence is often the primary sediment control practice on a site in the early phases of construction for logistical reasons, (controls are not practical on the interior until the site work has been completed), and is also used along streets within a development to prevent sediment from entering the stormwater system. Its somewhat temporary nature promotes its use until more permanent stabilization practices can be utilized. However, silt fence installation is inadequate on too many construction sites, is too often installed improperly, or not maintained. This article discusses specifications and best practices to help ensure the proper installation and efficacious use of silt fence to minimize the environmental hazards of sediment-laden runoff.

53. Yu, S., J. Kuo, E. Fassman, and H. Pan. "Field Test of Grassed-Swale Performance In Removing Runoff Pollution." American Society of Civil Engineers, 1801 Alexander Bell Drive , Reston, VA, 20191-4400. *Journal of Water Resources Planning & Management.* Vol. 127 Issue No. 3 pp 168-171. 2001.

This paper presents results of field tests, conducted in Taiwan and Virginia, of the pollutant removal efficiencies of grassed swales. Swales are a low-cost, storm-water best-management practice (BMP) that have been reported as a cost-effective method for controlling runoff pollution from land surfaces, especially highways and agricultural lands. The Virginia experiments tested a highway median swale, while the Taiwan experiments were conducted on an agricultural test farm. Average pollutant removal efficiencies reported for the test swales varied from 14-99% for total suspended solids, chemical oxygen demand, total nitrogen, and total phosphorus. The wide range of performance results indicates the importance of such design parameters as length, longitudinal slope, and the presence of check dams. Minimum design guidelines for use of swales as a BMP are suggested.

2.2.5 State Departments of Transportation

The references listed below are a compilation of data received from State DOTs and related sites. A majority of this information is from the northwestern U.S., which has similar climate and soil conditions to Montana. Many of these references are other DOTs manuals and specifications dealing with BMPs and erosion and sediment control. In addition, there are several DOT bulletins concerning BMPs and sediment and erosion control issues.

54. Arkansas Highway and Transportation Department. GIS to Predict Soil Erosion in Rural Transportation Construction Projects. [Printed] [Downloaded]

The Arkansas Highway and Transportation Department (AHTD) seeks to limit the amount of soil erosion from new construction sites. It is preferable and more effective to prevent soil erosion than to correct the damaging effects of erosion after it has occurred. The AHTD could receive substantial benefit from a software system designed to predict soil erosion from future and present construction sites. This project provides such a predictive tool for evaluating potential soil erosion for construction sites by using a mathematical model to predict soil loss in conjunction with a geographic information system (GIS).

55. California Department of Transportation. Statewide Storm Water Management Plan. CTSW-RT-01-024. August 2001. [Printed] [Downloaded]

This Statewide Storm Water Management Plan (SWMP) describes a program to reduce the discharge of pollutants associated with the storm water drainage systems that serve highways and highway-related properties, facilities and activities. It identifies how the California Department of Transportation (Caltrans) will comply with the provisions of the National Pollutant Discharge Elimination System (NPDES) permit (Order No. 99-06-DWQ) (Permit) issued by the California State Water Resources Control Board (SWRCB) on July 15, 1999. The Permit requires that the previous edition of the Statewide SWMP be revised to include or describe procedures for implementing the requirements stated in several provisions of the Permit. This Statewide SWMP has been revised to show compliance with this requirement, although the format employed differs somewhat from the specific chapter designations outlined in the Permit. This manual covers an overview of storm water management plan, project management, BMP identification and implementation, project development storm water management program, maintenance storm water management program, training and public education program, monitoring and research program, program evaluation, reporting, and location-specific requirements.

56. California Department of Transportation. Construction Manual. Complete Revision. July 1, 2001. [Downloaded]

When applying Caltrans policy to the administration of construction contracts, knowing how to not only interpret contract documents and plans but also apply engineering experience and judgment is extremely important. The Construction Manual (manual) cannot replace this valuable experience and judgment. Caltrans intends this manual as a resource for all personnel engaged in contract administration. The manual establishes policies and procedures for the construction phase of Caltrans projects. Section 4-20 of the manual contains information in erosion control and highway planning. The erosion control portion of this section covers erosion control materials, items to do before work begins, and items to do during course of work and measurement and payment.

57. California Department of Transportation. Standard Specifications. July 1999. [Downloaded]

The Caltrans standard specifications cover a wide range of specifications for highway construction. Section 20-3 of the specifications is the erosion control section, which covers general description, materials, preparation, applying and incorporating straw, seeding and fertilizing, measurement, and payment.

58. California Department of Transportation. Project Development, Storm Water Quality Bulletin. Caltrans BMP Evaluation, Approval and Implementation Process. Vol. 1/No.11. January 2000. [Printed] [Downloaded]

The new Statewide Storm Water Management Plan (SWMP) and accompanying Storm Water Quality Practice Guidelines identify and summarize all of the storm water BMPs currently approved and available for use during construction, operation, and maintenance of Caltrans facilities. However, this BMP toolbox is the subject of ongoing scrutiny to develop new, innovative BMPs, refine existing BMPs, and remove BMPs that prove ineffective. From a project design standpoint, BMP selection activities will likely focus on meeting water quality standards imposed by the new Caltrans NPDES Permit. This bulletin issue discusses Caltrans BMP evaluation and approval process and how Caltrans staff can participate. Section 2 of the Statewide SWMP contains a more detailed description of the BMP selection process.

59. California Department of Transportation. Construction Storm Water Pollution Prevention Bulletin. BMP Maintenance. Vol. 3/No. 12. December 1, 1999. [Printed] [Downloaded]

Once implemented, Best Management Practices (BMPs) require continued attention. Maintaining BMPs to ensure proper functioning for the duration of the project is a critical storm water pollution prevention requirement. This maintenance includes three basic elements: inspection, repair, and evaluation.

60. California Department of Transportation. Construction Storm Water Pollution Prevention Bulletin. Storm Water Discharges…Construction Site Soil Stabilization & Sediment Control. Vol. 1/No. 7. August 1, 1997. [Printed] [Downloaded]

As the fall and winter seasons approach, it is important to review the Best Management Practices (BMPs) associated with erosion and sediment controls. Such controls prevent sediment discharges into drainage systems and waterways. This is particularly important as noxious pollutants often adhere to the sediment. Erosion and sediment control practices can be classified into two categories: (i) Soil Stabilization Practices, or (ii) Sediment Control Practices.

61. California Department of Transportation. Construction Storm Water Pollution Prevention Bulletin. Contractor and Caltrans Inspection Requirements. Vol. 2/Issue No. 14. September 15, 1998. [Printed] [Downloaded]

Regular inspection of Best Management Practices (BMPs) is critical to the success and cost-efficiency of pollution prevention practices. Improperly placed and poorly maintained BMPs have a greater chance of failing during storm events, which leads to costly clean up and replacement of BMPs. In addition, regular inspections are a requirement of the NPDES General Permit (Permit), Caltrans specifications, and Caltrans Storm Water Quality Handbooks (Handbooks).

62. California Department of Transportation. Construction Storm Water Pollution Prevention Bulletin. Using Bonded Fiber Matrix For Mulching and Soil Stabilization. Vol. 3/No. 1. January 1, 1999. [Printed] [Downloaded]

Soil stabilizing and mulching prevent or reduce discharges of sediment into drainage systems or watercourses from construction sites, by protecting the soil surface from the impact of raindrops. Using a Bonded Fiber Matrix (BFM) product is one way to reduce or eliminate soil erosion. BFMs are hydraulically applied erosion control systems that consist of various types of fibers joined by adhesives. They are used for temporary surface covers until vegetation can be established or as a short-term ground cover. BFMs can also be used with existing or recently planted landscaping, to protect the area from erosion until the landscaping is established.

63. California Department of Transportation. Construction Storm Water Pollution Prevention Bulletin. Stabilizing Soils on Construction Projects Using Vegetative Buffer Strips. Vol. 3/No. 2. February 1, 1999. [Printed] [Downloaded]

Vegetative Buffer Strips can provide effective and economical construction site soil stabilization and sediment control. Details of the BMP can be found in the Caltrans Storm Water Quality Handbooks, Construction Contractors Guide and Specifications, CD30(2)-Sodding, Grass Plugging, and Vegetative Buffer Strips.

64. California Department of Transportation. Construction Storm Water Pollution Prevention Bulletin. Reducing Storm Water Erosion With Diversion Ditches and Berms. Vol. 3/No. 4. April 1, 1999. [Printed] [Downloaded]

Erosion control is an essential element in the storm water pollution prevention program of every construction project. Erosion introduces sediment into storm water that eventually is transported to rivers, lakes, reservoirs, and the ocean. Once deposited into a water system, excessive sediment upsets the natural structure and balance of the habitat. Storm water on slopes with exposed soils creates a formidable and common foe in the battle to control erosion on construction sites. This bulletin reviews the Best Management Practices (BMP) in CD32B(2) Top and Toe of Slope Diversion Ditches/Berms that help reduce slope erosion, and reviews other erosion control practices.

65. California Department of Transportation. Construction Storm Water Pollution Prevention Bulletin. Cost Saving Tips – Part I: Soil Stabilization Practices. Vol. 4/No. 2. February 1, 2000. [Printed] [Downloaded]

After conducting more than 3,000 compliance inspections, the Storm Water Task Force has identified a number of storm water pollution prevention practices that meet compliance requirements with the added benefit of reducing overall costs. This bulletin is the first in a series that describes these practices and the financial incentives for implementing them. Part I addresses soil stabilization, a subject of concern on nearly every construction project. Parts II and III will focus on cost saving tips for sediment controls and non-storm water practices.

66. California Department of Transportation. Construction Storm Water Pollution Prevention Bulletin. Cost Saving Tips – Part II: Sediment Controls. Vol. 4/No. 3. March 1, 2000. [Printed] [Downloaded]

Part II of the Cost-Saving Tips bulletin series focuses on sediment control Best Management Practices (BMPs). Part III will focus on cost saving tips for non-storm water practices.

67. California Department of Transportation. Construction Storm Water Pollution Prevention Bulletin. Cost Saving Tips – Part III: Non-Storm Water Management and Sediment Tracking Controls. Vol. 4/No. 4. April 1, 2000. [Printed] [Downloaded]

Part III of the Cost Saving Tips bulletin series focuses on non-storm water management and sediment tracking Best Management Practices (BMPs). This is the final bulletin in the series.

68. California Department of Transportation. 1994. Best Management Practices For Highway Stormwater Runoff: Field Measured Efficiencies.

An evaluation of structural Best Management Practices (BMP) for handling nonpoint stormwater runoff from transportation facilities in northern California is documented. A BMP installed in an operating highway in San Mateo County, California, was sampled during three storm events to contrast upstream versus downstream pollutant concentrations. It was found that, according to the 80% efficiency goal as recommended in the Municipal BMP Handbook, this BMP did not adequately remove pollutants from the stormwater runoff. A second BMP, installed at a Caltrans maintenance yard in Sebastopol, was sampled during equipment washing operations. Samples were collected from the incoming waters, the outflow from the system, and from the groundwater monitoring well. It was concluded that this BMP is over 80% efficient at removing those constituents of concern. A third BMP, installed at a highway construction site in Contra Costa County, was studied. Theoretical analysis of the BMP shows that it removes 80% of the suspended material from stormwater runoff, thereby meeting the general BMP efficiency goal. Recommendations for efficiency improvement of the operating highway BMP and the maintenance BMP are presented.

69. Idaho Transportation Department. Standard Specifications for Highway Construction. July 2001. Supplemental. [Downloaded]

The supplemental standard specifications for highway construction in Idaho contains specifications on all aspects of roadway construction. Section 212 of the specifications is for erosion and sediment control. This section contains a description, materials, construction requirements, temporary control measures, permanent control measures, methods of measurement, and basis of payment. Temporary control measure listed include seeding, erosion matting and blankets, slope drains, straw bales, silt fence, sediment traps, diversion channels and ditches, dikes and berms, swales, open top culverts, water bars, rolling dips, siltation berms, stabilized construction entrances, inlet protection and soil binder. Permanent control measures include seeding, erosion matting and blankets, gabion and revet mattress, stone filter berms/dams, sediment basins, and inlet and outlet protection.

70. Idaho Transportation Department. Design Manual. July 2001. [Downloaded]

The Idaho Transportation Departments design manual is used for all aspects of roadway design. Incorporated in the design manual is section 5.8, which covers roadside seeding. This section of the manual covers seeding, mulching and erosion blankets. Appendix A.3 of the manual covers erosion and

sediment control. Areas covered in this section include water quality analysis, erosion and sediment control requirements, NPDES storm water permits, storm water pollution plan, site data/information for the erosion and sediment control plan, erosion and sediment control plan, other key erosion and sediment control issues, and erosion and sediment control contracting and implementation.

71. Illinois Department of Transportation. Erosion and Sediment Control NPDES For Standard Specifications for Road and Bridge Construction. Adopted January 1, 2002. [Printed]

This erosion and sediment control book is used by the Illinois Department of Transportation for training construction staff. The book contains hard copies of PowerPoint® slides that provide erosion and sediment control objectives and examples of BMPs. Also included are sections from Chapter 59 Erosion Control/BDE Manual, Agency letters, summary of Phase II regulations, erosion and sediment control forms, erosion control pay items, construction inspector's checklist for erosion control, and erosion and sediment control specifications and detail drawings.

72. Montana Department of Transportation. Permitting Guide for Highway Construction Permitting. 11th Edition. 2001 Construction Season. [Printed]

The MDT Permitting Guide for Highway Construction Permitting contains the following topics: stream quick permitting references; guide to contractor secured permits; erosion control program flow chart; other laws and permits that may apply due to construction changes; Montana Stream Protection Act (124 temporary facilities permit); short-term water quality standard for turbidity; Montana pollutant discharge elimination system construction dewatering general discharge permit; Indian reservation pollutant discharge elimination system construction dewatering; pollutant discharge elimination system general discharge permits for storm water; Corps of engineers – clean water act section 10 and 404 permits; joint application for proposed work in MT streams; wetlands; floodplains and water bodies, open cut mining act; Montana floodplain management act; Montana land use license or easement on navigable waters; Montana water use act, instructions for application for Right-of-Way on state lands; removal of gravel from state lands; construction and cultural resources legal authorities; solid, hazardous, petroleum, and asphalt waste requirements; environmental definitions; environmental control detail drawings definitions; and erosion control detail drawings.

73. Oregon Department of Transportation. Field Manual for Erosion and Sediment Control. November 2000. [Printed]

This manual is a field guide on erosion and sediment control for Oregon Department of Transportation personnel involved in design and construction. The purpose of the field manual is to present tools for the prevention of erosion and the containment of sediment in a user-friendly, easy to carry reference format. The reference for the field guide is the Hydraulic Manual Volume 2 entitled Erosion and Sediment Control. This manual should be referred to when more in-depth information is required. The manual contains information on erosion prevention and sediment control, erosion processes, erosion and sediment control measures and BMP's, erosion control planning, and construction implementation. This manual contains several types of BMP's with pictures, applications, advantages, disadvantages and maintenance criteria. In addition, there is information on important contacts, seeding requirements, conversion tables, slope tables, sediment trap sizing, application rates, and application example problems. Since MDT is considering a field manual, this manual will be very applicable with its content and design.

74. Oregon Department of Transportation. Hydraulics Manual – Volume 2 (Erosion & Sediment Control). December 1999. [Printed]

This manual is a guide on erosion and sediment control for Oregon Department of Transportation (ODOT) personnel involved in design and construction. The purpose of the manual is to present the ODOT program to prevent pollution of water caused by erosion from construction sites. Chapter 1 provides an introduction, background on regulations and other agencies, ODOT policies, and the responsibilities of involved parties. Chapter 2 presents information on the processes of erosion and sedimentation and associated environmental impacts. Chapter 3 presents erosion and sediment control measures and Best Management Practices (BMP's). Chapter 4 covers additional pollution control measures and BMP's. Chapter 5 presents erosion control planning, Chapter 6 presents construction implementation, and Chapter 7 presents guidelines for Erosion and Sediment Control Plan (ESCP) design. This manual contains several types of BMP's with pictures, applications, advantages, disadvantages and maintenance criteria. In addition, there is information on seeding requirements, conversion tables, slope tables, sediment trap sizing, application rates, and application example problems. This manual contains key information about erosion and sediment control measures and BMP's, which will make it highly applicable to the MDT manual.

75. Oregon Department of Transportation. Supplemental Standard Specifications for Highway Construction. 1998. [Downloaded]

The supplemental standard specifications for highway construction in Oregon contain specifications on all aspects of roadway construction. Section 00280 of the specifications is for erosion and sediment control. This section contains Scope, Erosion and Sediment Control Plan (ESCP), Preconstruction Conference, Work Restrictions, Soil and Slope Protection and Stabilization, Construction Methods, Rainfall Monitoring, Maintenance, Removal, Lump Sum Basis, Unit Basis, Length Basis, and Area Basis information.

76. Texas Transportation Institute. Guidelines Make Silt Control More Effective, Less Costly. TTI-ITEC.6.99. June 1999. [Printed] [Downloaded]

The Texas Transportation Institute (TTI) team has identified alternatives to geosynthetic fabrics for silt fences and evaluated the feasibility and cost-effectiveness of these alternatives. Research indicates that the Continuous Berm™—an extruded sand dike—works well in place of a silt fence. Installation requires less time and labor, making it a significantly cheaper alternative. Sand fill materials available on site in east and east-central Texas reduce construction costs in Texas even more. Further research shows that the Triangular Silt Dike™—a semirigid geosynthetic dike—is a more effective in-channel sediment trap than the silt fence.

77. Utah Department of Transportation. Metric Standard Specifications for Road and Bridge Construction. CSI Format. 1999. [Downloaded]

This book is a compilation of Standard Specifications in metric units for insertion by reference into the Department's construction contracts. The Standard Specifications are written to the Contractor. The Specifications define the Contractor's responsibility in meeting each specification, enumerate the Department's expectations, and explain what the Contractor is expected to provide. Unless otherwise noted, all actions are to be performed by the Contractor. Supplemental Specifications may revise the requirements in these Specifications. A Special Provision may revise the Standard for a specific contract. The specifications include temporary environmental controls, geotextiles, erosion control blankets and channel liners, and mulch.

78. Utah Department of Transportation. 1999 Metric Standard Drawings. Updated January 31, 2002. [Downloaded]

The metric standard drawings are a compilation of drawings detailing standard items used during roadway construction with the Utah DOT. Within these drawings, there are details of check dams, silt fences, slope drains, temporary berms, drop inlet barriers, sediment traps, and curb inlet barriers. These drawings were created in MicroStation and could be converted to MDT standards with little modification if desired.

79. Washington State Department of Transportation. Construction Manual. M 41-01. Revised 2001. [Downloaded]

This manual is published by the Olympia Service Center Construction Office primarily as a resource for construction engineering personnel. It is intended as a convenient guide to requirements for Washington State transportation projects. The manual recognizes established standards and describes accepted engineering practices. The guidance provided by this manual is intended to identify desired results, establish standardized requirements, and serve as a general guide for the administration and construction of transportation-related contracts. This manual contains information on temporary water pollution/erosion control, general instructions for erosion control, erosion control construction practices, and measurement and payment for erosion control.

80. Washington State Department of Transportation. Design Manual (Metric). M 22-01. Revised May 2001. [Downloaded]

This *Design Manual* is a guide for WSDOT engineering personnel. It provides policies, procedures, and methods for developing and documenting the design of improvements to the transportation network in Washington State. The manual supplements the engineering analyses and judgment that must be applied to improvement and preservation projects. It provides uniform procedures for documenting and implementing design decisions. This manual contains design criteria for erosion prevention and slope stabilization.

81. Washington State Department of Transportation. Endangered Species Act (ESA) S 7(d) Project List and Stormwater Effects Guidance. IL 4020.01. August 24, 2001. [Downloaded]

The purpose of this Instructional Letter (IL) is to provide interim guidance on making storm water-related *effect determinations* for biological assessments that are prepared for the National Marine Fisheries Service (NMFS) and the United States Fish and Wildlife Service (USFWS). It is not the purpose of this IL to create storm water treatment design criteria, but it does create design expectations in the context of ESA effect determinations. This document does not cover all the possible project elements that must be analyzed by the project biologist before a final effect determination is made. An effect determination is based upon all the project's activities, of which storm water is only one element. This letter contains information on storm water treatment design levels, ESA-storm water design and erosion questionnaire, and best management practices efficiency rates.

82. Washington State Department of Transportation. Roadside Manual. July 1999. [Downloaded]

The Washington State Department of Transportation (WSDOT) has developed the *Roadside Manual* to provide coordination between all WSDOT partners responsible for roadside activities, and to establish a

common basis for consistent roadside management decisions statewide. It also establishes a convenient and accessible reference for new and previously unpublished material related to roadside management including planning, design, construction, and maintenance. In addition, the manual supplements statewide roadside guidelines established in the *Roadside Classification Plan*. The roadside manual contains information on erosion prevention and sediment control emphasizing of the process of erosion, site analysis, erosion prevention measures, sediment control measures and methods.

83. Washington State Department of Transportation. Runoff Manual (Draft Copy). M31-16. February 1995. [Printed] [Downloaded]

This manual has been prepared as a guide for our engineering and maintenance personnel to provide policies, procedures, and methods for developing and documenting the design and maintenance of improvements to the transportation system in Washington State. This manual is a guide for the design and operation of transportation facilities that are related to or affect storm water runoff. This manual is intended to provide uniform procedures for implementing design and maintenance decisions regarding highway runoff facilities to ensure a continuity of quality of these facilities throughout the state. It is recognized that not all conceivable situations will be included in the manual and as a result, sound judgment by knowledgeable personnel will be required for successful implementation. It is also recognized that the practices suggested in this manual may be inappropriate for some projects. This manual contains information on minimum requirements for erosion and sediment control, permanent storm water control features, temporary erosion and sediment control, experimental and other best management practices, summary of permanent BMPs, temporary erosion and sediment control plans, ESA storm water design and erosion summary, BMPs for controlling pollutants other then sediments on construction sites, erosion and sediment control BMPs, water quality BMPs, and water quantity BMPs.

2.2.6 CDM

The references listed below are a compilation of data received from the CDM InfoCenter and other searches within CDM. These references reflect manuals and literature that CDM has created in the past for BMP/erosion and sediment control issues. Several of the references listed below were created in association of other organizations and corporations.

84. CDM. Nevada Department of Transportation, Report on: Water Quality/Erosion Control Draft Drainage Manual Culvert Selection Manual. June 2000. [Printed] [Downloaded]

The Nevada Department of Transportation (NDOT) has retained the services of Camp Dresser & McKee Inc. (CDM) to provide program review and guidance recommendations to the Department in the following three areas: Erosion and sediment control/water quality practices, finalizing the NDOT Draft Drainage Manual, Developing and refining culvert material selection procedures. This report identifies the internal and external factors motivating the Department to consider improvements in the above areas; reviews NDOT's current practices and procedures; summarizes other representative agencies' practices; and presents some initial observations. Compliance with applicable regulatory requirements in also evaluated with respect to the current erosion and sediment control practices. Based on this information, CDM developed goals, objectives, and recommendations for addressing short-term and long-term needs. The report is organized into four sections. Section 1 provides a summary of the project scope and methodology, as well as a brief overview of NDOT's organizational structure. Section 2 discusses erosion and sediment control/water quality issues. Section 3 reviews the Draft Drainage Manual. Section 4 examines culvert selection practices.

85. CDM. Denver International Airport Stormwater Quality Best Management Practices for Construction Activities. September 1999. [Printed]

The purpose of this manual is to provide technical guidance to the City for compliance with the Colorado General Permit for storm water discharge associated with construction activities at DIA. This manual covers construction sequence, development of a storm water management plan, selection of best management practices, best management selection methodology, best management practices fact sheets, example storm water management plans, and standard construction specifications and details.

86. CDM. 1993. North Central Texas Council of Government, Storm Water Quality Best Management Practices for Construction Activities. [Printed]

The purpose of this manual is to provide technical guidance to municipalities, property owners, engineers, contractors and other construction industries in the North Central Texas area for compliance with the requirements of the NPDES General Permit for Industrial Activities as they relate to construction. This manual focuses on the effects of the NPDES requirements on construction activities in the North Central Texas area along with methods to reduce the pollution potential of construction sites in the area. The following establishes the framework and provides the tools to produce an effective Storm Water Pollution Prevention Plan (SWPPP) in accordance with the EPA guidelines as well as locally established guidelines in storm water pollution control.

87. CDM. 1993. California Storm Water Best Management Practice Handbooks.

The California State Water Resource Control Board (SWRCB) and the California Storm Water Quality Task Force, through the Alameda County Flood Control and Water Conservation District as contracting agency, selected CDM to develop a Handbook, which describes BMPs for the control of storm water pollution. The handbooks contain information on how to develop a storm water management program, BMP selection, source controls BMPs, treatment control BMPs, measuring BMP performance, how to prepare a storm water pollution prevention plan, BMPs for contractor activities, BMPs for erosion and sediment control, and monitoring.

88. CDM. Caltrans Storm Water Quality Handbooks. April 30, 1997. [Printed]

CDM developed the first Caltrans Storm Water Quality Handbooks, including the Planning and Design Staff Guide, the Construction Staff Guide, and the Construction Contractors' Guide and Specifications. The original Handbooks were completed in a four-month work effort and published in April 1996, and were later revised in 1997 to reflect experience gained by Caltrans during the Handbooks' inaugural year. In July 1999, the State Water Resources Control Board (SWRCB) issued Caltrans a statewide NPDES storm water permit. As a requirement of their new permit, Caltrans, with the assistance of CDM, submitted a revised Storm Water Management Plan (SWMP) to the SWRCB in December 1999. CDM was then tasked with updating the Storm Water Quality Handbooks to reflect the new Permit and the SWMP. The 2000 revisions to the Handbooks required extensive coordination with Headquarters staff in Project Development, Construction, Maintenance, and Environmental areas, and with representatives from the 12 Caltrans Districts. The revised Handbooks include the Project Planning and Design Guide, Construction Site Best Management Practices (BMPs) Manual, and the Storm Water Pollution Prevention Plan (SWPPP) and Water Pollution Control Program (WPCP) Preparation Manual.

89. CDM. 2001. Gross Solids Removal Device Project, California Department of Transportation.

The Gross Solids Removal Device (GSRD) project began in the 2000-2001 storm season and is an on-going pilot study for the California Department of Transportation (Caltrans). The driving force for this project was a proposed and now implemented trash total maximum daily load (TMDL), set out by the Los Angeles Regional Water Quality Control Board (LARWQCB), with removal criteria of 10% reduction per year for 10 years. The project objective was to develop non-proprietary devices that specifically targeted litter and solids in highway runoff that discharges via the storm drain system into critical receiving waters.

90. CDM. 1996. Drain Inlet Cleaning Efficacy Study, Southern California.

To determine and evaluate the potential effectiveness of drain inlet cleaning along California highways, the California Department of Transportation (Caltrans) contracted CDM to complete the Drain Inlet Cleaning Efficacy (DICE) study as part of a four-year water quality monitoring program. The data collected and analyzed in this study would then be used to evaluate the effectiveness of drain inlet cleaning as a management practice for improving the water quality of highway storm water runoff.

91. CDM. 1992. San Bernardino County Drainage Area Management Plan.

CDM has been working for San Bernardino County and 16 cities in the County within the Santa Ana River Watershed since 1992. CDM initially completed the first Drainage Area Management Plan (DAMP). CDM has assisted the County of San Bernardino Transportation/Flood Control Department since 1992 with the development and implementation of the countywide storm water program. The program was one of the primary compliance requirements under the first area-wide NPDES storm water permit. Included in this program was the development of an implementation program that included descriptions of BMPs, a detailed implementation plan and schedule, and identification of responsibilities, cost, staffing, and equipment.

92. CDM. 1992. Storm Water Management and National Pollution Discharge Elimination System Permitting Program for Los Angeles World Airports.

Los Angeles World Airports (LAWA), formerly the Los Angeles Department of Airports, retained CDM to develop and implement a comprehensive storm water management program for Los Angeles International, Ontario International, Van Nuys, and Palmdale Airports. This comprehensive program was designed to bring these four facilities into compliance with National Pollutant Discharge Elimination System (NPDES) permitting requirements for storm water discharges associated with industrial activity in accordance with Section 402(P) of the Clean Water Act and requisite state requirements.

93. CDM. Lincoln Creek Flood Control Maintenance Plan. Milwaukee, Wisconsin. (2001) [Printed] [Downloaded]

CDM was tasked by Milwaukee Metropolitan Sewerage District (MMSD) to provide a plan that complies with Wisconsin Department of Natural Resources project-specific Chapter 30 permits and addresses formal agreements with local jurisdictions (city and county of Milwaukee) to maintain improvements made to Lincoln Creek. The Lincoln Creek Maintenance Plan covers improvements within the flood channel, providing an inventory of channel improvements (structural, erosion control, and vegetation), a compendium of maintenance agreements with local jurisdictions (including copies of intergovernmental agreements), recommended maintenance practices, debris removal activities, recommendations for a

geomorphic assessment of channel function, and stability and record keeping. An inventory of improvements is provided in the plan in tabular format. This inventory includes components (pools, revetments, outfalls, channel liner, weirs, etc.), location by river station, and responsible agency or jurisdiction and is organized by contract. Maintenance schedules and inspection frequencies are also included. The heart of the plan is the recommended maintenance practices, which will be of value to the MDT manual.

94. CDM. 1992. BMP Manual for Construction Sites, Maricopa County, Arizona.

CDM authored a BMP manual for construction sites as a part of the comprehensive storm water management program required under part 2 of the National Pollutant Discharge Elimination System (NPDES) permit application. The Maricopa County Flood Control District formed a committee of municipalities, land developers, contractors, and consultants to guide the development of the manual. CDM's role involved selecting BMPs for erosion and sediment control appropriate for the Phoenix metropolitan area, as well as maximizing the use of existing state and local manuals and available literature. The preferred BMPs were presented to the committee, which then took the lead in incorporating appropriate local conditions under CDM's supervision. The manual offers basic guidelines for selecting and implementing appropriate construction site BMPs; recommends site review and inspection procedures; and determines a framework of standard specifications to be incorporated into the Maricopa Association of Governments Standard Details and Specifications. The manual is being used by both the District and Maricopa County, and is available to other jurisdictions.

2.2.7 Miscellaneous

The references listed below are from various sources that contain information regarding BMPs/erosion and sediment control training, implementation and design.

95. American Association of State Highway and Transportation Officials. Highway Drainage Guidelines [Metric Edition]. ISBN I-56051-126-5. 1999. [Printed]

Storm drainage, which now includes storm water management facilities, is an integral and expensive aspect of highway design, highway construction and, all to often forgotten, highway maintenance. This guideline provides an overview of the concepts and practices of this challenging aspect of highway drainage. The purpose of this guideline is to acquaint the hydraulic engineer with the principles and practices of storm water management as they relate to transportation facilities. This guideline provides a brief review of the current and ever-changing maze of regulations, as well as a discussion of the potential importance of unmanaged runoff on downstream properties and ecosystems. A large section of the guideline is allotted to the development and implementation of an effective storm water management program including application, design construction and maintenance of Best Management Practices (BMPs). This guideline also offers some insight into the future of storm water management and provides a list of reference material. Volume III (Guidelines for Erosion and Sediment Control in Highway Construction) of the guidelines contain general erosion and sediment control purposes and objectives, erosion and sediment-related planning and location considerations, erosion and sediment-related geometric considerations, temporary erosion and sediment control measures, permanent erosion and sediment control measures, construction, and refinement of methods. Volume X (Guidelines for Evaluating Highway Effects on Surface Water Environments) of the guidelines cover sediment, sediment transportation, sediment data, estimating existing sediment regiments, construction erosion, sediment effects and the significant of sediment effects. Volume XII (Highway Drainage Guidelines for Storm Water Management) of the guidelines cover topics involving regulations, implementation of storm water management design, construction and maintenance. The information in this reference will be very applicable to the MDT manual because of all of the data including BMPs.

96. Fifield, J. Ph.D. Designing for Effective Sediment and Erosion Control on Construction Sites. March 1999. [Printed]

This manual is a comprehensive overview of effective sediment and erosion control design at construction sites. The manual covers water quality impact from nonpoint source pollution, regulatory requirements, NPDES general permits and SWPPPs, erosion, sediment transport and sedimentation, sediment containment systems, barriers as type-3 sediment containment systems, evaluating erosion control methods, inspection and maintenance of sediment and erosion control measures, and performance goals and effectiveness of sediment and erosion control plans.

97. Fifield, J., Ph.D. 2002. Field Manual on Sediment and Erosion Control: Best Management Practices for Contractors and Inspectors. [Purchased]

This field manual is written specifically for contractors and inspectors. However, since the majority of material is from the Fifield design workbook, designers and regulators will also find it useful. The goal of this manual is to have a practical document for use in a four-hour sediment and erosion control class taught specifically for contractors and inspectors. This manual is also valuable for use on construction sites as these individuals install, inspect, and maintain best management practices. This manual covers regulatory requirements, EPA Rulings for construction sites, erosion, sediment and sediment control, sediment containment systems, sediment containment system outlet structures, using barriers to remove sediment, methods of reducing erosion, erosion associated with wind, and inspection of BMPs.

98. Fifield, J., Ph.D. Using Erosion Control Measures During Construction Activities. April 2002. [Printed]

Fifield discusses the Environmental Protection Agency's Phase II requirements, describes the differences between erosion and sediment control, provides reasons for the predominate use of structural measures during construction and provides some reasons for implementing erosion control methods during construction. Tables comparing the estimated installation and maintenance cost and the estimated effectiveness between sediment control and erosion control BMPs are provided.

99. Toy, T. and G. Foster. Guidelines for the use of the revised Universal soil loss equation (RUSLE) version 1.06 on mined lands, construction sites, and reclaimed lands. Office of Surface Mining, Denver, CO. 1998. [Obtained document from J. Galetovic, jgaletov@osmre.gov]

Toy and Foster (1998) developed a computer program (i.e. RUSLE 1.06) that retained the structure of its predecessor, the Universal Soil Loss Equation (Wischmeier and Smith, 1978) but included numerous new input parameters to enable soil loss to be estimated on mined lands, construction sites, and reclaimed lands. The model is composed of a set of mathematical equations that estimate average annual soil loss and sediment yield from interrill and rill erosion. The program allows the testing of different slope gradients, soil characteristics, plant cover, and erosion control practices and then estimates the soil loss as a function of a set of site conditions. The rainfall/runoff erosivity factor (R) in the model is provided within the computer program for numerous locations in the United States to facilitate user convenience.

100. Kapolka, N. and D. Dollhopf. Effects of slope gradient and plant growth on soil loss on reconstructed steep slopes. International Journal of Surface Mining, Reclamation and Environment, Vol. 15, No. 2, pp. 86-99. 2001.

Kapolka and Dollhopf (2001) evaluated i) the effect of slope gradient and plant growth on soil loss on steep slopes, ii) the effect of coversoil thickness on plant growth, and iii) determined if the Revised Universal Soil Loss Equation (RUSLE) version 1.06 computer model could predict soil loss on steep slopes. Soil loss increased with slope gradients up to 40 % and decreased as slope gradient increased to 50 %. Plant biomass was significantly correlated ($r = 0.70$) to increases in coversoil thickness. Results from this study indicated that RUSLE v. 1.06 was an effective long-term planning tool to use for steep slope design. These investigators developed correction factors for use in the RUSLE model to improve estimated soil loss when rill formation was present on slopes.

101. PublicWorks. States Focus on Erosion Control in Construction and Maintenance Activities. April 2002. [Printed]

With the increased emphasis on erosion control resulting from the Clean Water Act and the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) legislation, states are implementing various new control methods to minimize the impact of construction and maintenance operations. This article briefly describes some of these new control methods that are being used by various states. Geotextile filter bags, skimmer dewatering devices, articulated block mats, triangular silt barriers, and polyacrylamide (PAM) additive are described.

102. Florida Department of Environmental Protection. The Florida Stormwater, Erosion, and Sediment Control Inspector's Manual. January 1999. [Printed] [Downloaded]

Florida's stormwater regulatory program requires the use of Best Management Practices (BMPs) during and after construction to minimize erosion and sedimentation and to properly manage runoff for both stormwater quantity and quality. However, insufficient staffing among regulatory agencies, combined with lack of awareness among contractors, has resulted in a low rate of compliance. To improve this situation the Department of Environmental Protection has developed a training program curriculum on the use, installation, and maintenance of erosion, sedimentation, and stormwater BMPs. The training program is primarily directed towards inspectors and contractors, however, permit reviewers and public works personnel will also benefit from this program. The objectives of this training and certification program are: to assure that the desired benefits of stormwater management systems are being achieved; to assure that both the public and private sectors have enough inspectors trained in the proper installation and maintenance of BMPs during and after construction and; to assure a consistent level of technical expertise and professional conduct for all individuals responsible for inspecting erosion and sediment controls and stormwater management systems.

2.3 Summary of Literature Review

The literature review identified documents that will be useful in the generation of the Erosion and Sediment Control Construction BMPs Manual and Training Program. Documents obtained from the EPA will be useful for describing the regulations associated with erosion and sediment control and for incorporating EPA approved BMPs into the manual. EPA studies on the effectiveness of BMPs will also be considered when discussing BMPs in the "new" manual. The DEQ documents will be used to explain the "new" General Permit for storm water discharges associated with construction activities and for review of BMPs utilized by DEQ for erosion and sediment control. Documents from the FHWA will be

used to identify the erosion and sediment control guidelines that are to be followed on all projects funded under Title 23, United States Code.

The Transportation Research Information Services (TRIS) database is accurately described as the world's largest and most comprehensive bibliographic resource on transportation information. Over 20 references from the TRIS database were included in this Literature Review Report. These references contain erosion and sediment control information such as product acceptability lists; BMP selection, design, and maintenance; BMP evaluation and assessment; limitations of BMPs; and erosion and sediment control training. These references will be utilized throughout the BMP manual development.

BMP manuals and associated erosion and sediment control documents that have been developed by other State Departments of Transportation and CDM were included in the literature review to provide examples of different BMP manual layouts and to review the various BMPs used by other entities throughout the country. BMP design, implementation, monitoring, maintenance, and removals are also discussed in these references.

The references contained in this literature search report provide a valuable foundation on which to build a new Erosion and Sediment Control Construction BMPs Manual and Training Program for MDT. Additional references will be identified and utilized as the new BMP Manual and Training Program are developed.

Section 3
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