An Integrated Storm Water Management Approach and a Summary of Clear Water Diversion and Isolation Best Management Practices for Use in the State of Hawaii, by the Federal Highway Administration and Hawaii Department of Transportation

Practitioners Guide

Prepared By:

U.S. Department of Transportation
Federal Highway Administration
Central Federal Lands Highway Division
Lakewood, Colorado

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ABBREVIATIONS AND ACRONYMS

AASHTO	American Association of State Highway and Transportation Official
BFM	Bonded Fiber Matrix
BMP	Best Management Practice
CCS	Cellular Confinement System
CFLHD	Central Federal Lands Highway Division
CFR	Code of Federal Regulations
CFT	Cross Functional Team
CNPCP	Coastal Nonpoint Pollution Control Program
CWA	Clean Water Act
CWB	Clean Water Branch
CZARA	Coastal Zone Act Reauthorization Amendments
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act
DLNR	Department of Land and Natural Resources
DOH	Department of Health
DOT	Department of Transportation
DSA	Disturbed Soil Area
EMD	Environmental Management Division
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Environmentally Sensitive Area
ETAP	Environmental Technologies Action Plan
FAC	Facultative
FACU	Facultative Upland
FACW	Facultative Wetland
FHWA	Federal Highway Administration
FH	Forest Highway
FLAP	Federal Lands Access Program
FLH	Federal Lands Highway
GPS	Global Positioning System
HAR	Hawaii Administrative Rules
HDOT	Hawaii Department of Transportation
HGM	Hydrogeomorphic
HRS	Hawaii Revised Statutes
IWPPP	In Water Pollution Prevention Plan
JD	Jurisdictional Delineation
LEDPA	Least Environmentally Damaging Practicable Alternative
LOP	Letter of Permission
LRR	Land Resource Region
MLRA	Major Land Resource Area
NAEL	National Elk Wildlife Refuge
NHD	National Hydrographic Datum
NPDES	National Pollution Discharge Elimination System
NPS	Non-Point Source
NRCS	Natural Resource Conservation Service
NRPW	Non-Relatively Permanent Water
NWI	National Wetland Inventory
NWPL	National Wetland Plant List
OBL	Obligate
OHWM	Ordinary High Water mark
OP	Office of Planning
PAH	Polycyclic Aromatic Hydrocarbons
PDT	Project Delivery Team
PE	Project Engineer
PEM	Palustrine Emergent
PFO	Palustrine Forested
POC	Pollutants of Concern
PSS	Palustrine Scrub/Shrub
QA	Quality Assurance
QSP	Qualified Stormwater Professional
RE	Resident Engineer
REAP	Rain Event Action Plan
ROW	Right of Way
RPW	Relatively Permanent Water

SR	State Route
SRNF	Six Rivers National Forest
SWANCC	Solid Waste Agency of Northern Cook County
TMDL	Total Maximum Daily Load
TNW	Traditional Navigable Water
TSS	Total Suspended Solids
SDWA	Safe Drinking Water Act
SWPPP	Storm Water Pollution Prevention Plan
UPL	Upland
US	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
USGS	United States Geological Service
USFWS	United States Fish and Wildlife Service
UTM	Universal Transverse Mercator
WUS	Waters of the United States
WWB	Wastewater Branch

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CHAPTER 1:

1 INTRODUCTION

1.1. PURPOSE

The Federal Highway Administration (FHWA), Central Federal Lands Highway Division (CFLHD) in Partnership with the Hawaii Department of Transportation (HDOT) is proposing updates to improve stormwater management and the implementation of Best Management Practices (BMPs) on their transportation projects in the state of Hawaii.

The purpose of this manual is to provide guidance on common BMPs used in protecting water quality during planning, design and construction activities, with a heavy emphasis on work that is occurring adjacent to, over, or in the boundaries of waters meeting the definition of Waters of the United States (US) (WUS) under the Clean Water Act (30 Code of Federal Regulations [CFR] 328). A key component to successfully accomplish of this goal is an integrated storm water management approach to protecting water quality throughout the life of a project; from project planning and design to after construction completion.

In Hawaii, water is the life blood of the islands and the strong interconnection between precipitation, surface water and ground water is extremely pronounced. Integrated stormwater management is simply thinking about all of the factors that somehow affect this precipitation as it moves from the land surface to an eventual receiving water. It is the process of accounting for all of these factors (e.g. rate, volume, quality, ground water impact) in a logical process so that inadvertent mistakes are not made that could eventually harm a resource. The treatment train approach to stormwater and non-stormwater management mimics this natural sequence as the project design and construction team looks at potential pollutant sources and determines how best to address them, starting with the most basic of solutions and increasing in complexity only if needed, since simple methods of management are often the most practical.

Numerous planning, design, and construction techniques known as BMPs exist to protect natural receiving waters against pollutants commonly associated with the operation, maintenance and construction of transportation facilities. Early consideration of storm water management and BMP alternatives during project design is critical to successful water quality management during construction. The correct selection, installation, and maintenance of BMPs are also paramount in ensuring they effectively treat the pollutants of concern (POC) identified for a particular project.

The purpose of this practitioner guide is to provide regulators, developers, contractors, site managers and inspectors with a guide to an integrated stormwater management approach to project design and construction. Chapter 2 of this guide provides a summary of key components of an integrated stormwater management approach. Chapter 3 provides a BMP Selection Tool through the utilization of preferred BMPs for managing pollutants on transportation construction projects. Improvements in construction techniques and BMP technologies are constantly evolving. Most of the

preferred BMPs discussed in this manual have been used effectively by departments of transportation across the country. The BMP Selection Tool provides a transparent and technically based BMP selection process that documents the decisions and streamlines overall the stormwater management process in an effort to improve permitting with the regulatory agencies.

Chapter 4 summarizes the standard construction stormwater and non-stormwater controls BMPs that are commonly implemented on transportation construction projects. This manual builds off of the wealth of available information on the subject of BMPs and proper implementation during construction. The BMPs contained in the Selection Tool do not constitute an exhaustive list of BMPs, but instead provide a summary of common practices utilized for managing pollutants on transportation projects. This manual does not supersede any existing BMP manual for Hawaii instead this manual has incorporated the BMPs included in existing manuals into the stormwater design process. Specifically, all BMPs included in Appendix A (*State of Hawaii (HDOT 2008), Department of Transportation; 2008 Construction Best Management Practices Field Manual*) and Appendix B (*State of Hawaii (HDOT 2015a), Department of Transportation; Storm Water Management Program, 2015 Storm Water Permanent Best Management Practices Manual*) are incorporated into this manual. These appended manuals provide further design details for the individual temporary and permanent BMPs that are commonly incorporated into transportation projects in Hawaii.

Finally, Chapter 5 provides a summary of additional BMPs not included in the before mentioned manuals, but which are commonly utilized for isolating construction from flowing or standing water.

Each additional BMP measure provided in this manual consists of the following:

- General description;
- Applications;
- Standards and Specifications;
- Limitations; and
- Inspections and Maintenance.

The BMPs included in this manual focus on the areas of site management, erosion control, and sediment control during construction including clean water diversion or isolation of a work area from water. They are established practices and procedures to control potential pollutants at their source. These BMPs supplement the standard erosion and sediment control measures included in project plans. Proper installation maintenance and inspection of these BMPs will further help protect Hawaii's valuable water resources from harmful pollutants.

1.1 ACKNOWLEDGEMENTS

Appreciation and acknowledgment is extended to the California Department of Transportation (Caltrans), Idaho Department of Transportation (IDOT), Oregon Department of Transportation (ODOT), The Sacramento Region Stormwater Quality Design Steering Committee and the Lake Tahoe Regional Planning Agency for use of their publications in preparing the information contained in this manual.

This manual was made possible by the combined efforts of many professionals:

- Thomas Parker (Lead), Federal Highway Administration, Central Federal Lands Highway Division, Environmental Protection and Permitting Specialist.
- Nicole Winterton, FHWA-CFLHD, Environmental Protection Specialist.
- Todd Nishioka, Hawaii Department of Transportation

1.2 DISCLAIMER

The information presented in this Practitioners Guide was taken from available and relevant sources deemed to be representative of appropriate BMPs (including clear water diversion and isolation techniques). This manual has been prepared as a reference guideline, however, due to site specific conditions, the selection of the BMPs must be used in conjunction with best professional judgment and sound engineering principles to assure proper function and performance of the BMPs contained herein. The author does not guarantee the accuracy or completeness of this document and will not assume any liability or responsibility for the use of, or for any damages resulting from the use of any information contained herein. The detail and the wording in this manual will not necessarily result in compliance with the appropriate Standard Specifications. Compliance with other requirements such as the Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects (FP-14), 2005 Hawaii Standard Specifications for Road and Bridge Construction and subsequent changes, Hawaii Administrative Rules (HAR), Chapter 11-54 (Water Quality Standards), and/or HAR, Chapter 11-55 (Water Pollution Control) are deemed the responsibility of the engineer / planner.

The FHWA and HDOT, their employees, contractors, and subcontractors make no warrant, expressed or implied, and assume no legal liability for the information in this manual; nor does any party represent that the uses of this information will not infringe upon privately owned rights. This manual has been prepared by the FHWA and HDOT and endorsed by the Department of Health-Clean Water Branch as voluntary guidance and best management practices (BMPs). The recommendations and protocols discussed in this manual are intended to be suggestions for FHWA and HDOT to use at their discretion. The guidance and BMPs are strictly voluntary and are not intended to implement, replace, duplicate, interpret, amend, or supplement any current statute or regulation. Adherence to the guidance and BMPs does not ensure compliance with any local, state, or federal statute or regulation nor does failure to follow the guidance and BMPs necessarily imply a violation of the National Environmental Policy Act, Hawaii Environmental Policy Act, Clean Water Act, Federal Endangered Species Act or other relevant statutes or legal requirements.

This guide is not intended to be a manual for designing plans and specifications, but a source of information about erosion, sediment, stormwater and non-stormwater control best management practices. The contents should not be interpreted as necessarily representing the policies or recommendations of other referenced agencies or organizations. Refer to state, federal and local regulations and permits for applicable design criteria. For additional detailed design guidance, please refer to the numerous references and manuals listed in the References section of this document. For further

reference, see Federal, state and local stormwater and water quality regulations and requirements.

1.3 Scope of this Guide

Water quality can be affected when runoff carries sediment or other pollutants into streams, wetlands, lakes, marine waters and/or into groundwater. Stormwater management can help to reduce these effects. Stormwater management involves careful application of site design principles, construction techniques and source controls to prevent sediment and other pollutants from entering surface or groundwater, treatment of runoff to reduce pollutants, and flow controls to reduce the impact of altered hydrology. This is especially true during the planning, construction and maintenance of clear water diversion and isolation techniques implemented for infrastructure projects.

Numerous Department of Transportations and Stormwater Associations have evaluated and prepared BMP manuals to evaluate their effectiveness. Non-stormwater BMPs including clear water diversion and isolation techniques for construction projects that require work within or around wet areas are especially important given the nature of the work. An understanding of techniques is required to understand the anticipated in-water impacts from construction related erosion and sediment. Construction activities in or near open water can be managed to mitigate risks to water quality through the implementation of these or similar techniques. Technology is always changing, and additional materials, techniques, and products may be developed which expand upon the BMPs referenced within this manual.

1.4 Regulatory Setting

Legal protection of Hawai'i's water resources are guided by federal statutes and state statues and rules. The three primarily federal laws include: the Clean Water Act , the Coastal Zone Management Act, Coastal Zone Act Reauthorization Amendments , and the Safe Drinking Water Act.

1.4.1 Federal Requirements:

1.4.1.1 Clean Water Act

In 1972, Congress amended the Federal Water Pollution Control Act, making the addition of pollutants to the WUS from any point (A point source is any discrete conveyance such as a pipe or a man-made ditch.) unlawful unless the discharge is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. This act and its amendments are known today as the Clean Water Act (CWA). Congress has amended the act several times. In the 1987 amendments, Congress directed dischargers of storm water from municipal and industrial/construction point sources to comply with the NPDES permit scheme. The following are important CWA sections:

- Sections 303 and 304 require states to issue water quality standards, criteria, and guidelines.
- Section 401 requires an applicant for a federal license or permit to conduct any activity that may result in a discharge to waters of the U.S. to obtain certification from the state that the discharge will comply with other provisions of the act.

This is most frequently required in tandem with a Section 404 permit request (see below).

- Section 402 establishes the NPDES, a permitting system for the discharges (except for dredge or fill material) of any pollutant into waters of the U.S. The Department of Health, Clean Water Branch (DOH-CWB) administers this permitting program in Hawaii. Section 402(p) requires permits for discharges of storm water from industrial/construction and municipal separate storm sewer systems (MS4s).
- Section 404 establishes a permit program for the discharge of dredge or fill material into waters of the United States. This permit program is administered by the U.S. Army Corps of Engineers (USACE).

The goal of the CWA is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

1.4.1.1.1 Waters of the United States

The USACE derives its regulatory authority over potential WUS from two federal laws: 1) Section 10 of the Rivers and Harbors Act of 1899 and 2) Section 404 of the Clean Water Act (CWA) of 1972.

Section 10 of the Rivers and Harbors Act of 1899 prevents unauthorized obstruction or alteration of navigable WUS. Navigable waters are defined as "*subject to the ebb and flow of the tide and/or presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce*" (33 CFR 322.2(a)). A Section 10 permit is required for non-fill discharging activities that would place any structure below, within, or over navigable WUS, or would involve excavation/dredging or deposition of material or any obstruction or alteration in navigable WUS.

The CWA defines WUS subject to agency jurisdiction in 40 CFR 230.3. Under Section 404 of the CWA, dredged and fill material may not be discharged into jurisdictional WUS (including wetlands) without a permit. Wetlands are a subset of jurisdictional WUS and are jointly defined by the USACE and the U.S. Environmental Protection Agency (40 Code of Federal Regulations [CFR] 230.3) as "*those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.*"

The USACE issues two types of 404 permits: General and Standard permits. There are two types of General permits: Regional permits and Nationwide permits. Regional permits are issued for a general category of activities when they are similar in nature and cause minimal environmental effect. Nationwide permits are issued to allow a variety of minor project activities with no more than minimal effects.

Ordinarily, projects that do not meet the criteria for a Nationwide Permit may be permitted under one of the USACE's Standard permits. There are two types of Standard permits: Individual permits and Letters of Permission. For Standard permits, the USACE decision to approve is based on compliance with U.S. Environmental Protection Agency's (EPA) Section 404 (b)(1) Guidelines (EPA Code of Federal Regulations [CFR] 40 Part 230), and whether the permit approval is in the public interest. The Section

404(b)(1) Guidelines (Guidelines) were developed by the U.S. EPA in conjunction with the USACE, and allow the discharge of dredged or fill material into the jurisdictional waters (i.e. WUS) only if there is no practicable alternative which would have less adverse effects. The Guidelines state that the USACE may not issue a permit if there is a least environmentally damaging practicable alternative (LEDPA) to the proposed discharge that would have lesser effects on WUS and not have any other significant adverse environmental consequences. According to the Guidelines, documentation is needed that a sequence of avoidance, minimization, and compensation measures has been followed, in that order. The Guidelines also restrict permitting activities that violate water quality or toxic effluent (The U.S. EPA defines "effluent" as "wastewater, treated or untreated, that flows out of a treatment plant, sewer, or industrial outfall.") standards, jeopardize the continued existence of listed species, violate marine sanctuary protections, or cause "significant degradation" to WUS. In addition, every permit from the USACE, even if not subject to the Section 404(b)(1) Guidelines, must meet general and regional requirements. See 33 CFR 320.4 for general policies for evaluating permit applications. Below in Figure 1 is a graphical depiction of the boundary of WUS under Section 10 of the RHA and Section 404 of the CWA.

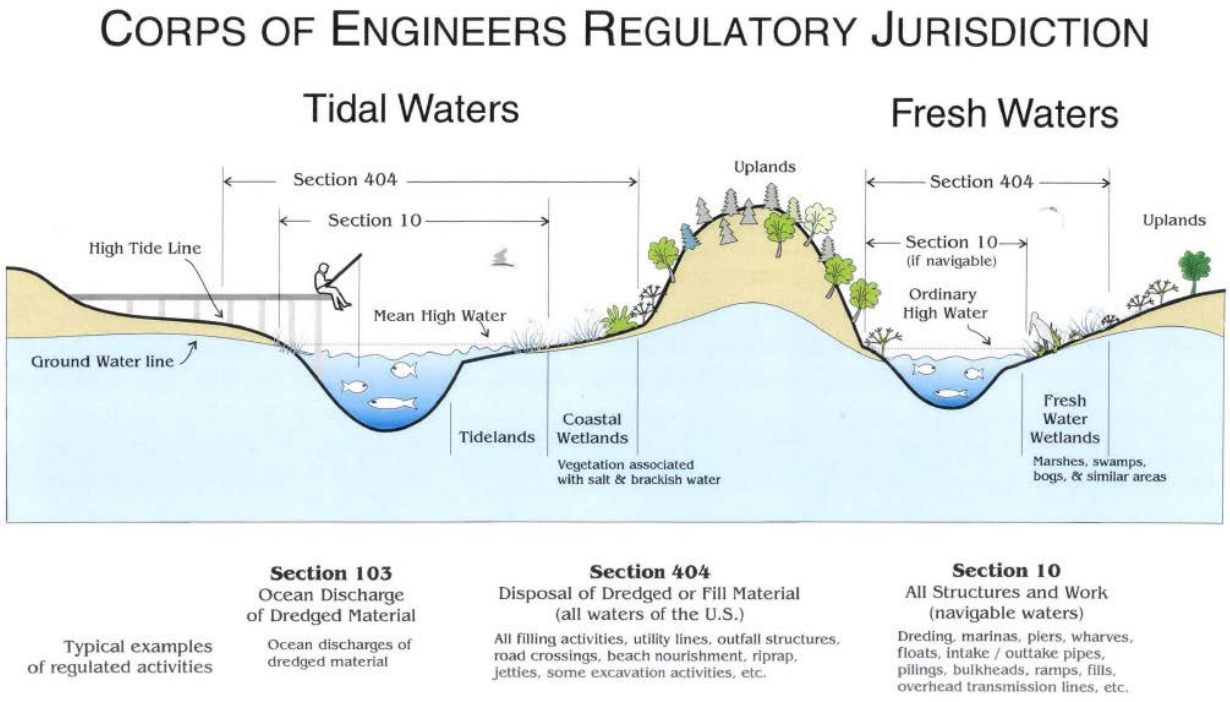


Figure 1. Regulatory Boundaries in Waters of the United States.

1.4.1.2 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) (United States Code (USC) Sections 3501 et seq., as amended in 1990 under the Coastal Zone Act Reauthorization Amendments), administered by the National Oceanic and Atmospheric Administration's (NOAA) Office of Ocean and Coastal Resource Management, provides for management of the nation's coastal resources and balances economic development with environmental

conservation. The national goal for the CZMA program is to "preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone."

The purpose of the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 is to improve the management of the coastal zone and enhance environmental protection of coastal zone resources. Section 6217 of CZARA seeks to address Non-Point Source (NPS) pollution problems in coastal waters by implementing the Coastal Nonpoint Pollution Control Program (CNPCP). The CNPCP is a statewide coastal zone program that establishes and oversees a set of management measures to prevent and reduce NPS pollution from six sources: forestry, agriculture, urban areas, marinas, hydromodifications, and wetlands and riparian areas. The CNPCP also includes a monitoring and tracking condition to ensure that the management measures are being implemented. This program is administered jointly by the EPA and the NOAA.

Section 307 of the CZMA, requires federal agency activities and development projects affecting any coastal use or resource to be undertaken in a manner consistent to the maximum extent practicable with the state's Coastal Zone Management (CZM) program. Also, activities requiring a federal permit or license, and activities conducted with federal financial assistance, that affect coastal uses and resources must be conducted in a manner consistent with the state's CZM program. The CZMA federal consistency provision ensures that federal agencies cannot act without regard for, or in conflict with, state policies that have been officially incorporated into a state's CZM program. Federal actions affecting any coastal use or resource must be reviewed by the state CZM program to ensure that proposed activities are consistent with state enforceable policies.

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In 1961, Act 187, SLH 1961 Hawai'i's cornerstone state land use law was codified as HRS chapter 205 with the intent to "*preserve, protect, and encourage the development of the lands in the State for those uses to which they are best suited for the public welfare.*" The program is administered by the State Land Use Commission and oversees amendments to the state land use districts, designation of important agricultural lands, declaratory rulings, and special permits (>15 acres in agricultural and rural districts).

In 1977, Hawaii enacted HRS Chapter 205A, Hawaii CZM Program, to carry out the State's CZM policies and regulations under the CZMA. The CZM area encompasses the entire State, including all marine waters seaward, to the extent of the State's police power and management authority, including the 12-mile U.S. territorial sea and all archipelagic waters. As a result, all projects in Hawaii are within the CZM area and are subject to consistency with the objectives and policies of the Hawaii CZM Program. The CZM Federal Consistency Certification is reviewed by the State Office of Planning (OP).

The Hawaii CZM Program focuses on ten policy objectives (HRS Chapter 205A):

1. Recreational resources;

(A) Provide coastal recreational opportunities accessible to the public.

2. Historic resources;

(A) Protect, preserve, and, where desirable, restore those natural and manmade historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture.

3. Scenic and open space resources;

(A) Protect, preserve, and, where desirable, restore or improve the quality of coastal scenic and open space resources.

4. Coastal ecosystems;

(A) Protect valuable coastal ecosystems, including reefs, from disruption and minimize adverse impacts on all coastal ecosystems.

5. Economic uses;

(A) Provide public or private facilities and improvements important to the State's economy in suitable locations.

6. Coastal hazards;

(A) Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, subsidence, and pollution.

7. Managing development;

(A) Improve the development review process, communication, and public participation in the management of coastal resources and hazards.

8. Public participation;

(A) Stimulate public awareness, education, and participation in coastal management.

9. Beach protection;

(A) Protect beaches for public use and recreation.

10. Marine resources;

(A) Promote the protection, use, and development of marine and coastal resources to assure their sustainability.

The Special Management Area (SMA) permit was established in 1975 with the enactment of Act 176, known as the Shoreline Protection Act. The Hawaii legislature in enacting Part II of HRS Chapter 205A found that: *"special controls on developments within an area along the shoreline are necessary to avoid permanent losses of valuable resources and the foreclosure of management options, and to ensure that adequate access, by dedication or other means, to public owned or used beaches, recreation areas, and natural reserves is provided."* Figure 2 below provides a spatial perspective for where the SMA fits within the larger CZM network.

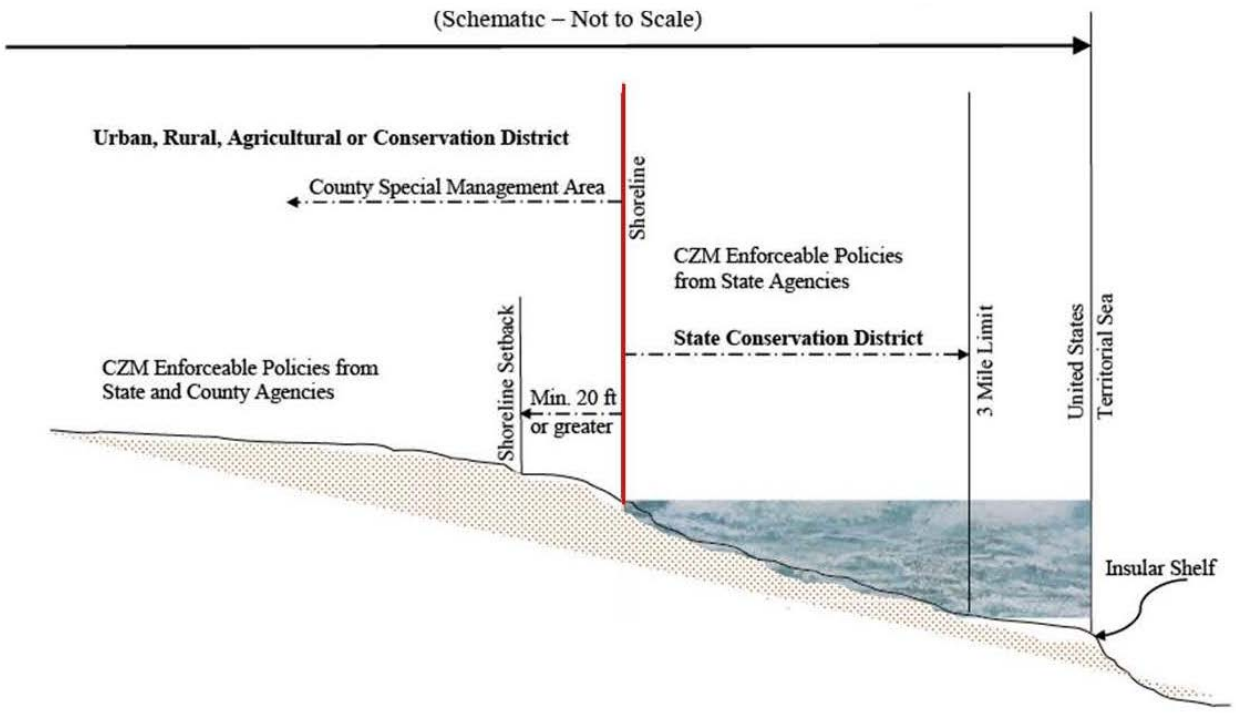


Figure 2. Hawaii CZM Network- A Spatial Perspective.

The Hawaii OP administers HRS Chapter 205A, the CZM law. The purpose of HRS Chapter 205A is to "*provide for the effective management, beneficial use, protection, and development of the Coastal Zone.*" The SMA permitting system is part of the CZM Program approved by Federal and State agencies. The SMA permitting system regulates all types of land uses and activities under a broad definition of "development" within the SMA. For an SMA permit approval the proposed action must be determined to be consistent with the CZM objectives and policies, and SMA guidelines or conditions (unless otherwise exempt). The SMA permit must precede any other permit authorization pertaining to an development within the SMA (HRS 205A 28 and 29). Some such SMA conditions may include:

- Provision of public shoreline access;
- Preservation of important archaeological sites;
- Building height restrictions;
- Boundary setback requirements to preserve coastal views from public access;
- Drainage improvements to mitigate flooding or to control siltation in coastal waters.

The shoreline setback boundaries have been established to conserve open space, minimize interference with natural shoreline processes; and minimize loss of improvements due to erosion (HRS § 205A-2(c)(9)(A)). The shoreline certification process was created to establish a baseline from which each County (utilizing its regulations) can measure the start of the "no build zone". This boundary is determined

in the field utilizing survey techniques. The Department of Land and Natural Resources (DLNR) looks at the vegetation line and debris line along the shoreline though other types of evidence such as elevation, salt deposits, rock coloration, and other geomorphologic indicators, biological indicators, neighboring shorelines, anecdotal evidence provided by people familiar with the area, and evaluation of seasonal wave run-up statistics and models may be utilized.

1.4.1.3 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA), which was originally passed in 1974, protects public health by regulating the nation's drinking water supply. It is administered by the EPA and implemented by the DOH Safe Drinking Water Branch (SDWB). The SDWB is responsible for protecting the State's drinking water resources, including both surface and groundwater sources, and ensures that public water systems meet federal and state health-related standards for drinking water. The DOH's Wastewater Branch (WWB) is also responsible for protecting drinking water and public health by ensuring that the use and disposal of wastewater does not contaminate water sources.

1.4.1.4 Endangered Species Act

The purpose of the Endangered Species Act (ESA) is to protect and promote recovery of imperiled species and the ecosystems upon which they depend. The federal ESA is administered by NOAA Fisheries Service for marine mammal species and anadromous species. USFWS administers the ESA for freshwater fish species, and for birds, mammals, reptiles, amphibians, invertebrates, and plants.

Three provisions of the ESA may apply directly to stormwater management: Section 4(d) rules, Section 7 consultations and Section 10 habitat conservation plans.

Section 4(d) of the ESA requires USFWS or NOAA Fisheries Service to implement protective measures that prevent further damage to threatened species. Section 4(d) applies only to threatened species; endangered species are afforded full legal protection without room for maneuvering. "Take" of any species listed as endangered is prohibited by the ESA. Take of threatened species may be allowable under permit, provided project-related take does not interfere with species survival or recovery.

ESA compliance involves determination of effect on listed species, and may lead to consultation with USFWS/NOAA Fisheries Service under Section 7.

1.4.1.5 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) is the primary law governing marine fisheries management in U.S. Federal waters. It establishes a national program for the conservation and management of the fishery resources of the United States to prevent overfishing, rebuild overfished stocks, ensure conservation, facilitate long-term protection of essential fish habitats (EFH), and realize the full potential of the Nation's fisheries. In accordance with Section 305(b) of the MSA, Funding Agencies must consult with NOAA's NMFS regarding any of their actions authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken that may adversely affect EFH. For additional guidance, please view the EFH Regulatory Guidelines (http://www.habitat.noaa.gov/pdf/efhregulatoryguidelines.pdf).

1.4.2 STATE REQUIREMENTS:

The state statutes and rules governing water quality are captured in the Hawai'i Revised Statutes (HRS) and the Hawai'i Administrative Rules (HAR).

Water quality management in Hawai'i is guided by the State Water Code (HRS Chapter 174C) and the Hawai'i Water Plan. The Hawai'i Water Plan serves as a framework for comprehensive water resource planning to address the State's water quantity and quality issues. Specifically, it sets forth an integrated and coordinated approach to managing the State's waters and consists of plans prepared and implemented by the State DOH, the DLNR, the Department of Agriculture (HDOA), and the four counties of Hawaii. These agencies and their respective plans address the State's water protection policies, water quality, water needs, and sustainable water use. DLNR's Water Resource Protection Plan and DOH's Water Quality Plan provide the overall legal and policy framework that guides the development, conservation, and use of water resources. DLNR's State Water Projects Plan and HDOA's Agricultural Water Use and Development Plan provide guidance for the State's agricultural water needs and development. The information from these plans is integrated into County Water Use and Development Plans, which set forth the broad allocation of water use within each county.

The DOH Environmental Management Division (EMD) establishes the State's water quality standards and is the lead agency responsible for protecting the State's surface and groundwater quality. The EMD administers the State's surface water and groundwater quality assessment, management, permitting, and enforcement programs through the Clean Water Branch (CWB), the Safe Drinking Water Branch (SDWB), and the Wastewater Branch (WWB).

The DOH-CWB is responsible for implementing the Surface Water Quality Management Program for recreational and ecosystem protection. This is accomplished through a coordinated approach that includes water quality monitoring and assessment, engineering and permitting, water quality violation enforcement, and polluted runoff control management.

Pursuant to the CWA and HRS Chapter 342D, HAR Chapter 11-54 (Water Quality Standards) establishes Hawai'i's water quality standards, including limits for conventional and toxic pollutants. Chapter 11-54 also classifies the State's water bodies and prohibits unauthorized discharges from both point source and NPS in inland and marine waters. HAR Chapter 11-55 (Water Pollution Control) provides for the prevention, abatement, and control of new and existing water pollution, primarily through permitting and permit compliance. Chapters 11-54 and 11-55 are administered by the CWB and are reviewed and amended every three years or as needed.

Sections 305(b) and 303(d) of the CWA drive Hawai'i's surface water quality assessment efforts. Under Section 305(b), the State is required to assess, characterize, and report the quality of its surface waters every two years. Under Section 303(d), the State identifies impaired waters and develops Total Maximum Daily Loads (TMDLs) to address these impairments. Impaired waters do not meet the State's numeric water quality criteria, which are governed by HAR Chapter 11-54. The State of Hawai'i Water Quality Monitoring and Assessment Report, known as the Integrated Report, addresses 305(b)

and 303(d) requirements and is submitted to the EPA and U.S. Congress by the DOH-CWB every two years. The DOH CWB Monitoring and Analysis Section is responsible for monitoring State surface waters, updating water quality standards, conducting assessments for the 303(d) list of impaired waters and the 305(b) report, and developing TMDLs.

The Hawai'i counties may also become involved in the management of CWA resources through the implementation of their grading ordinances and other permit or approval processes. One county, the City and County of Honolulu, has incorporated into its SMA ordinance (Chapter 25, ROH, "Shoreline Management") provisions for wetland protection in the permitting process, and for rulemaking and enforcement pertaining to the conservation, protection, and restoration of wetlands.

1.4.2.1 National Pollutant Discharge Elimination System (NPDES) Program

The Hawai'i legislature enacted HRS Chapter 342D (Water Pollution) and Chapter 342E (NPS Pollution Management and Control) to address point source and NPS water pollution in the State. HRS Chapter 342D is Hawai'i's equivalent to the CWA and states that *"[n]o person, including any public body, shall discharge any water pollutant to state waters, or cause or allow any water pollutant to enter state waters except in compliance with this chapter, rules adopted pursuant to this chapter, or a permit or variance issued by the director [of the DOH]."* Under Chapter 342D, the DOH has the authority to administer, enforce, and carry out all laws, rules, and programs relating to both point source and NPS pollution.

1.4.2.1.1 Municipal Separate Storm Sewer Systems (MS4)

Section 402(p) of the CWA requires the issuance of NPDES permits for five categories of storm water discharges including:

A. A discharge with respect to which a permit has been issued under this section before February 4, 1987.

B. A discharge associated with industrial activity.

C. A discharge from a municipal separate storm sewer system serving a population of 250,000 or more.

D. A discharge from a municipal separate storm sewer system serving a population of 100,000 or more but less than 250,000.

E. A discharge for which the Administrator or the State, as the case may be, determines that the stormwater discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to WUS.

An MS4 is defined as *"any conveyance or system of conveyances (roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, human-made channels, and storm drains) owned or operated by a state, city, town, county, or other public body having jurisdiction over storm water, that is designed or used for collecting or conveying storm water."* Currently in O'ahu and Maui counties, a portion of urban runoff is controlled through NPDES MS4 permits. MS4 permits require these counties to develop and implement stormwater management program plans, which include pollution prevention measures. The CNPCP also devotes several management measures to the prevention and reduction of pollution generated by development and maintenance of roads, highways, bridges, and facilities in urban areas.

1.4.2.1.2 Construction General Permit

The DOH-CWB amended HAR, Chapter 11-55 and readopted the NPDES General Permits in HAR, Chapter 11-55 (Appendices A through L). These NPDES General Permits, became effective on December 6, 2013. The NPDES General Permit in Appendices B through L cover numerous discharges of stormwater from various construction and operational activities., The permit regulates storm water discharges from construction sites that result in a Disturbed Soil Area (DSA) of one acre or greater, and/or are smaller sites that are part of a larger common plan of development. By law, all storm water discharges associated with construction activity where clearing, grading, and excavation result in soil disturbance of at least one acre must comply with the provisions of the Construction General Permit. A construction activity that results in soil disturbances of less than one acre is subject to this Construction General Permit if there is potential for significant water quality impairment resulting from the activity as determined by the DOH-CWB. Operators of regulated construction sites are required to develop storm water pollution prevention plans (SWPPP); to implement sediment, erosion, and pollution prevention control measures; and to obtain coverage under the Construction General Permit.

FHWA and/or HDOT, as the agency responsible for construction management and oversight for transportation projects, are responsible for obtaining the NPDES permit and for signing certification statements (when necessary). FHWA and/or HDOT are also responsible for ensuring that all permit conditions are included in the construction contract and fully implemented in the field during construction.

1.4.2.2 Section 401 Water Quality Certification Permitting

Under Section 401 of the CWA, any project requiring a federal license or permit that may result in a discharge to a water of the United States must obtain a 401 Certification, which certifies that the project will be in compliance with state water quality standards. The most common federal permits triggering 401 Certification are CWA Section 404 permits issued by the USACE. The 401 permit certifications are obtained from the DOH-CWB, dependent on the project location, and are generally required before the USACE issues a 404 permit.

In some cases, the DOH-CWB may have specific concerns with discharges associated with a project. As a result, the DOH-CWB may issue a set of requirements that define activities, such as the inclusion of specific features, effluent limitations, monitoring, and plan submittals that are to be implemented for protecting or benefiting water quality. These requirements can be issued to address both permanent and temporary discharges associated with a project.

1.5 Considerations for Working in Riverine Systems

Rivers, Streams, drainages, gulches and other aspects of the riverine systems involve complex processes that do complicated work. In their natural state, streams gather, store, and move water. However, it is important for understanding stream processes to realize that streams and rivers are not only moving water (streams also move sediment, nutrients, and woody debris from mountain peaks to the sea).

Human land uses that significantly alter the ability of a creek to transport water and sediment will likely cause a stream to become unstable and increase the likelihood that

catastrophic erosion or sedimentation may occur during a flood event. The relationship between water in a stream and its ability to transport sediment is shown as a balancing scale (Figure 3). When any one or more of the variables of this scale change, the system is no longer in balance, and aggradation or degradation of the river/stream bed and banks may occur. Given time and freedom to make adjustments, a stream will adjust its slope and sediment transport capability toward an equilibrium condition.

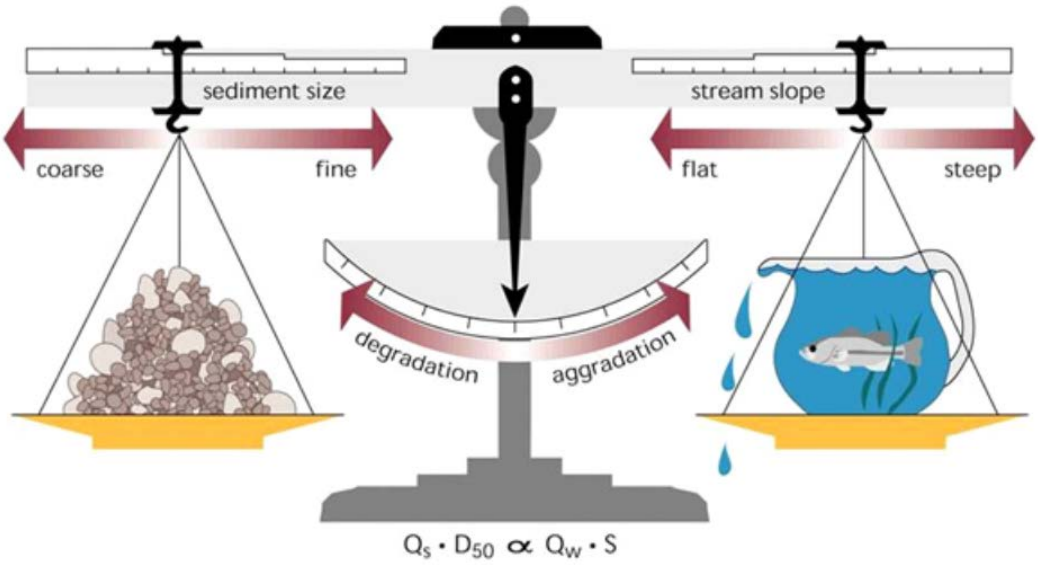


Figure 3: Lane's Balance of Sediment Supply & Sediment Size with Slope (energy grade) & Discharge

Throughout North America, river scientists and managers are now bringing this principle of river "stability" into the management of river channels by recognizing that stable rivers carry water, sediment and debris, even during high water, without drastic changes occurring in the depth, width, length, or slope of the channel. The term "dynamic equilibrium" is often used to describe a naturally stable stream channel. The channel may shift its location over time but ultimately will maintain consistent dimensions and habitat values. Channels remain stable when they are not impeded by unnatural constrictions like undersized transportation structures such as bridges and culverts and have access to a vegetated floodplain. When development changes the relationship of the river with its floodplain or alters the ability of a channel to transport its water and sediment load, it becomes increasingly difficult to protect this infrastructure.

Fluvial (river-related) erosion refers to streambed and streambank erosion associated with the sudden and catastrophic physical adjustment of stream channel dimensions (width and depth) and location that can occur during elevated discharges. Much of this damage occurs where rivers and streams have been separated from their floodplains by some kind of development (either temporarily or permanently) thus concentrating erosive energy within the channel. Other examples are where rivers are unable to transport their sediment due to a constriction in the channel (e.g. culvert, weir, diversion structure, road embankment) which creates a sediment deficit downstream, or where

excessive inputs (e.g. massive soil erosion from a burn or landslide scar) build up the river bed and exacerbate overbank flows. In these instances, a stream is likely to become destabilized and is more prone to sudden lateral or vertical shifting which may produce unexpected consequences for surrounding landowners. The dollar cost of such damage may well be equaled by other economic losses including diminished recreation opportunities, impaired ecological functions, and long-term channel instability.

Cutting a river off from its floodplain by building levees, berms and roadways, armoring with stone, or dredging a channel will cause a river to adjust through physical change. The result of containing greater flows in the channel (i.e., preventing access to the floodplain) is to increase the erosive power (friction) that must be resisted by the channel boundary materials; i.e., the rocks, soil, vegetation, or manmade structures that make up the bed and banks of the river. Figure 4 shows a common scenario of channel evolution process as described by Stanley Schumm (1984). It is important to note that this diagram only illustrates channel response at one location. There are equally profound physical adjustments that occur upstream and downstream from the site of a river corridor alteration as bed degradation (head cuts) migrate up through the system and aggradation in the form of sedimentation occurs downstream. Similarly another common form of channel evolution may occur where a stream starts in a stable condition but is overloaded with sediment from upstream sources and quickly aggrades (i.e. fills in) its channel spilling out onto the surrounding floodplain with significant destructive potential.

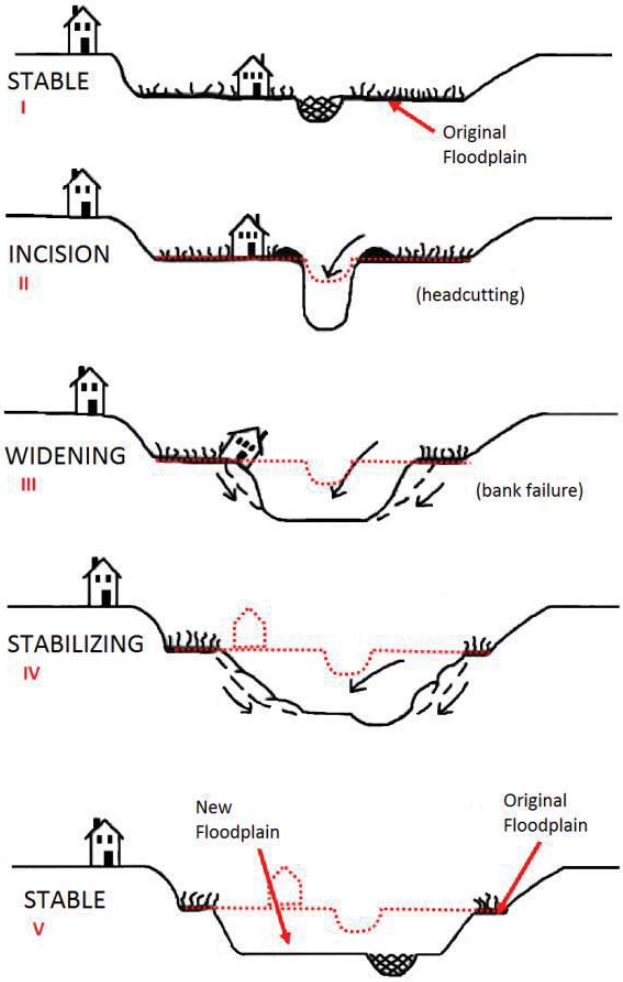


Figure 4: Channel Evolution Process (Source: Schumm, S., 1984).

Understanding fluvial processes is paramount when designing transportation infrastructure that must border, cross, or interact with a riverine system. It is important to recognize the temporal aspect of channel response to change. Fluvial systems are energized by episodic events. Channel adjustment in response to management practices or encroachments may take effect immediately but may also persist for decades depending on the sensitivity and morphology of the stream channel, the magnitude of alteration, and the frequency of high flow events. Consideration of these processes and efforts to maintain stable channel dimension and access to riverine floodplains should be considered during design of permanent and temporary transportation structures within the riverine system.

1.6 The Riparian Zone

Riparian areas are unique vegetation communities that occur adjacent to waterways and wetlands, and provide habitat for numerous floral and faunal species. They generally occupy transitional areas between aquatic and upland habitats, and may function as vegetative buffers for aquatic resources. The riparian zone can be rich with diversity os plant species occupying several vegetative layers. Riparian vegetation composition and

structure is regulated by: (1) frequency, magnitude, duration, and seasonal timing of stream flooding and (2) subsurface moisture conditions.

The condition of the riparian zone adjacent to streams has a critical impact on water quality. Permanent and deeply rooted stream bank vegetation slows run-off of nutrients and pollutants, reduces sedimentation and solar heating, provides wildlife habitat, and overhead cover and organic food supply for aquatic species. Riparian areas typically do not satisfy the USACE regulatory definitions for wetlands (i.e. hydrophytic vegetation, hydric soils, and hydrology) and frequently occur in locations transitional between these jurisdictional wetlands and adjoining uplands. However, riparian areas perform many of the same functions as do wetlands, including maintenance of water quality, storage of floodwaters, and enhancement of biodiversity. Although riparian habitats are often combined with wetlands (as a result of their intimate relationship to the hydrological regime), riparian areas differ from wetlands in that they are generally linear, more terrestrial (less hydric), and are often dependent on a natural disturbance regime relating to flooding and stream dynamics. Figure 5 depicts a conceptual riparian cross section.

In Hawai'i, the coastal nonpoint pollution control program has defined the Hawaii Riparian Zone as *Vegetated ecosystems along a waterbody through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent waterbody. These systems encompass wetlands, uplands, or some combination of these two land forms. They will not in all cases have all of the characteristics necessary for them to be classified as wetlands.*

A healthy riparian zone provides many important benefits including:

- Water Quality Protection;
- Flood Control;
- Streamflow Maintenance;
- Water Temperature;
- Wildlife Habitat;
- Recreation Benefits; and
- Economic Benefits

Riparian vegetation intercepts surface runoff and associated pollutants (sediment, nitrogen, phosphorous, pesticides, heavy metal, etc.) and can buffer their effects on water quality. Loss of riparian areas reduce water quality values, faunal populations, and can result in property damage or loss of lands from bank erosion. Removal of riparian vegetation results in increased water temperatures and decreased dissolved oxygen. The loss of shade exposes soils to drying out by wind and sunlight and reduces the water storage capacity of the riparian area. Loss of riparian vegetation causes streambank erosion. The riparian zone should be considered during project design and efforts made to promote riparian function in project design. Suitable riparian buffer widths are highly variable and are dependent on several variables including slope, soil type, and vegetation mix.

Riparian area health and streambank stability are simply a reflection of the conditions in the surrounding landscape. When studying the river, stream, gulch in your project area, it is important to keep in mind that extensive stretches of eroding streambanks are only symptoms of an unhealthy system and are not the true cause of the problems.

Healthy streams and riparian areas are naturally resilient which allows them to accommodate and recover from natural disturbances such as flood events. Streambank stability is a function of a healthy riparian area. When the riparian area is degraded, the stream health will often degrade in kind and its resiliency to natural disturbances will diminish. Excessive flooding, erosion, and sedimentation will often increase. Degraded riparian areas are less effective for storing floodwaters. As more sediment is deposited, water quality is also diminished. High levels of sediment in a stream suffocate fish, fill in spawning areas and pools, and kill aquatic invertebrates.

As additional sediment is deposited in streams, the streambed may aggrade and become shallower, forcing water to spread out and cause bank erosion. Eroding banks contribute to sedimentation and lead to a wide shallow stream with little habitat value. These factors result in significant reductions in aquatic stream life. Excessive bank erosion causes wider, shallower channels and lowers the water table. A shallower stream also has a lower dissolved oxygen content and a higher temperature, which supports less aquatic life.

In other streams, headcutting may occur, which is the cutting of the streambed to a lower bed elevation. As the streambed lowers, the water table also lowers. This causes riparian vegetation to die-off and be replaced with upland vegetation, which is less successful in stabilizing the streambank. In either case, headcutting or aggradation of the streambed greatly diminishes the natural resiliency of riparian areas.

The first step to designing a transportation project within the riparian zone is to determine the best way to find ways to promote riparian functions while still meeting project needs. By doing so, mitigation for project impacts to aquatic resources can often be completed in close proximity to project impacts. While preservation and conservation of healthy streams and riparian areas should receive high priority, it is clear that restoration of degraded areas is also equally as necessary during the construction of transportation projects.

Prior to roadway construction, rivers and streams generally meandered back and forth along smooth, sinuous paths, with well establish floodplains; the width of these meanders and floodplains varying primarily due to valley slope. However, when man-made structures such as bridges and culverts are placed along stream channels, this natural pattern is interrupted as the streams are forced to flow around tight bends or through narrow constrictions. Quite often, these impacts are unavoidable to meet the transportation needs. Protection of the roadway is usually accomplished through solely traditional engineering practices. Alternatively utilizing solely natural stream/channel design on projects is impracticable due to design requirements. Sometimes plants fail to grow or are replaced by invasive species. Plants and other natural components are harder to model for stability due to buoyancy, decomposition, and other factors. Plants and other natural components may be subject to scouring. Plants can also be uprooted by freezing and thawing, flood flows, and debris loads. Livestock and wildlife often feed on the plants and may destroy them. Because of these variables, utilizing solely bioengineering practices may require the project to receive more frequent maintenance for a period of time, especially early in the project life until vegetation reaches maturity.

However, traditional roadway design principles can be partnered with appropriate bioengineering practices to improve synergy between the roadway and riparian

systems. See Streambank Stabilization BMP in Chapter 5 for more details. Common bioengineering principles that can be evaluated include:

- Fiberschines
- Brush Mattress
- Brush Layering
- Stake Plantings
- Pole Plantings
- Post Plantings
- Brush/Tree Revetment
- Brush Trench
- Vertical Bundles
- Live Wattles or Fascines
- Rootwad Installation
- Living Cribwalls
- Engineered Log Jams
- Boulder Revetments
- Rock Toe Revetments
- Rock/Log Vanes
- Rock/Log Weirs
- Erosion Control Fabric
- Etcetera!!!

1.6.1 Practices to Promote

- Protect or establish native or non-invasive shrubs, trees, or other vegetation along streams to help prevent bank erosion, trap sediment and filter other pollutants.
- Maximize riparian buffer width while balancing sociologic and economic constraints
- Consider riparian functions during project design. Plan land disturbing activities to protect riparian zones.
- Integrate bioengineering concepts where practicable.

1.6.2 Practices to Avoid

- Straightening sections of streams.
- Removing streamside shrubs, trees and other vegetation.
- Excessive hard armoring in riparian zone including the stream channel. [

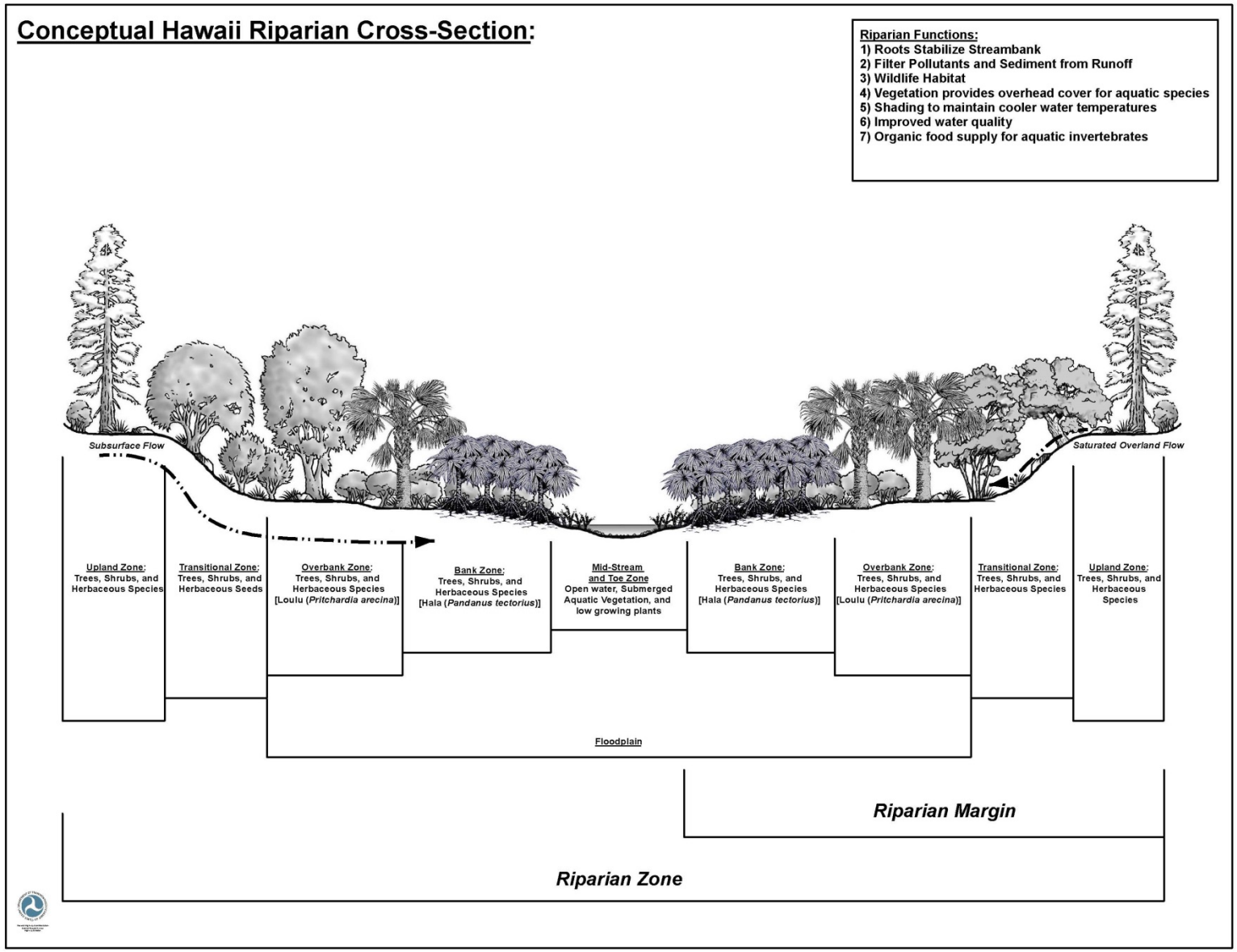


Figure 5: Conceptual Riparian Cross Section

CHAPTER 2:

2 INTEGRATED APPROACH TO STORMWATER MANAGEMENT

In order for site designs to reflect the best stormwater management strategies, it is essential that stormwater be considered early in the site design process—before the site layout is established. Otherwise, the choice/location of stormwater controls will be constrained by prior site design decisions (e.g., predetermined grading contours), and may be limited to more expensive, higher maintenance, and less aesthetically pleasing options.

When stormwater controls are considered early, they can be effectively integrated into site design and planning. There are often opportunities to use existing or proposed site features for stormwater controls and/or repeat small-scale stormwater controls over an entire site. Small-scale controls are typically low-cost and cumulatively very effective.

In some cases, site design necessitates trade-offs among competing goals; however, especially when considered early in the process, stormwater goals can often complement other goals and agency requirements, including those related to vegetation preservation, landscaping, aesthetics, open space, recreational areas, and/or habitat.

2.1 STRATEGIES FOR STORMWATER QUALITY MANAGEMENT INTO PROJECT DEVELOPMENT

2.1.1 ASSEMBLE A COLLABORATIVE TEAM EARLY

In order for site designs to reflect the best stormwater management strategies, stormwater controls must be considered early in the site design process. To do that, involve the project engineer and other design professionals during the conceptual design stage, when the initial site layout is being determined. In the past, only planners and architects may have been involved at this stage of the design.

The collaborative design process may involve the following members of the Project Delivery Team (PDT) or Cross Functional Team (CFT):

- Project Owner
- Project Manager
- Planners
- Designers
- Engineers (Civil, Geotechnical, Etcetera.)
- Hydrologists
- Surveyors
- Landscape Architects
- Arborists
- Environmental Consultants
- Landscape Architects
- Land Management Agencies
- Permitting Agency Staff

It is also helpful to arrange a meeting with the local permitting agency to get agency input at the conceptual design stage; in most jurisdictions, this is referred to as the pre-application meeting.

It is equally important that those involved in site planning and design work collaborate throughout the site design process; that way, stormwater quality features can be optimally integrated into the site and project design. This might be facilitated by periodic meetings of the project team and by routing various designs to the different disciplines for review and comment.

2.1.2 Consider the Site and its Surroundings

Gather information about the following site characteristics, which will greatly influence the type of stormwater quality controls used on your project:

- Climatic region and terrain may lead to design modifications or BMP preferences
- Existing natural hydrologic features and natural resources, including any contiguous natural areas, wetlands, watercourses, seeps, or springs.
- Existing site topography, including contours of any slopes of 4% or steeper, general direction of surface drainage, local high or low points or depressions, and any outcrops or other significant geologic features.
- Zoning, including requirements for setbacks and open space. Location-specific restrictions could impact the selection of BMPs
- Soil types (including hydrologic soil groups) and depth to groundwater, which may determine whether infiltration is a feasible option for managing site runoff. A preliminary determination of infiltration feasibility may be made using maps in hydrology and flood control design manuals published by the local permitting agency. Also, site-specific information (e.g. from boring logs or geotechnical studies) may be required by the permitting agency, depending on the site location and characteristics.
- Existing site drainage. For undeveloped sites, determine drainage patterns by inspecting the site and examining topographic maps and survey data. For previously developed sites, locate site drainage and connections to the municipal storm drain system from a site inspection, municipal storm drain maps, and/or the approved plans for the existing development (typically on file with the local municipality).
- Existing vegetative cover and impervious areas, if any.
- Existing trees and arborists reports, if any.

2.1.3 Identify Opportunities and Constraints

Using the site features information gathered above, identify the principal opportunities and constraints for stormwater quality management on the site.

Opportunities might include existing natural areas, low (depressed) areas, oddly configured or otherwise un-developable parcels, easements, and open space (which potentially can double as locations for stormwater quality controls with the permitting agency's approval). Also look at elevation differences on the site which might provide hydraulic head (difference in water surface elevation between inflow and outflow) for structural treatment control measures.

Constraints might include impermeable soils, high groundwater, contaminated soils or groundwater, steep slopes, geotechnical instability, high intensity land use, expected heavy pedestrian or vehicular traffic, safety concerns, or compatibility with surrounding land uses. Also there might be competing environmental concerns on the project site.

2.1.4 Preserve Valuable Site Features

Consider these techniques to preserve natural and environmentally-sensitive features on your site:

- Define the construction limits and boundaries for protected areas, identifying areas that are most suitable for development and areas that should be left undisturbed.
- Cluster the disturbance, including staging and stockpile areas, to reduce disturbance and conserve natural areas.
- Preserve natural vegetation. Vegetation is an integral part of the natural hydrologic cycle. Vegetation intercepts rainfall, and plant roots take up water that soaks into the ground. Also, roots and decaying organic matter such as leaf litter protect the soil structure and soil permeability, and therefore help preserve the pollutant-removal processes that occur in soil. When designing a site, retain as much natural vegetation as possible.
- Consider preserving trees (consider the number, quality and health and location of existing trees), even if the local jurisdiction would allow their removal, for all the reasons given above.
- Set back the construction from rivers, streams, gulches, wetlands, riparian habitats, and shorelines when practicable, or consider context sensitive solutions when designing permanent and temporary structures in these locations (See Figure 10 versus 11). Check with regulatory agencies for additional permitting requirements when designing in these environments.
- Designate and protect natural buffers for waterways and natural areas. If disturbing buffer areas during construction is unavoidable, make revegetation plans to replant them with plants and trees adapted and suited to the site conditions, preferably low-maintenance plants that are suited to the riparian zone. Such plants have a better chance of survival and adaptation to the site over time without an over reliance on water and fertilizers/pesticides.
- Understand the regulatory status of the receiving water to which the site drains. Depending on the nature of the receiving water, certain BMPs may be promoted, restricted or prohibited, or special design or sizing criteria may apply.
    - Determine if the watershed has characteristics that may require special design considerations or constrain the BMP selection.
    - Determine if the watershed and receiving water characteristics require special design considerations that affect the BMP selection. The BMP design is influenced by the type and condition of the receiving waters downstream. Higher pollutant removal may be needed to protect the downstream resources, leading to a shorter BMP selection list.

2.1.5 Lay Out the Site with Topography and Soils in Mind

To minimize stormwater-related impacts, consider applying the following design principles to the site layout:

- Choose a design that replicates the site's natural drainage patterns as much as possible.
- Where possible, conform the site layout to natural landforms.
- Identify topographic lows that might be suitable for locating stormwater quality treatment features.
- Concentrate construction on portions of the site with less permeable soils, and preserve areas that will actively promote infiltration.
- When possible, avoid disturbing steep slopes and erodible soils.
- When possible, avoid excessive grading and disturbance of vegetation and soils.
- When possible, avoid the use of closed conduit systems.
- When possible, avoid compacting soils in open and/ or landscape areas.
- Include grading notes addressing temporary drainage and phasing for disturbed soil areas.

2.1.6 Put Landscaping to Work

Stormwater quality features can often be integrated into landscape areas such as the site perimeter, ditches, medians, and roadside areas. For example, instead leveling waste material, consider creating depressed areas (i.e. bioretention, biofiltration, bioswales) to accept and filter water before sending it off the site. Using landscape areas for stormwater quality features may require some changes in the conventional approach to landscape designs, and may result in larger/wider disturbance areas.

2.1.7 Stop Pollution at Its Source

Rather than managing stormwater runoff only at the final point of discharge from a site, look for opportunities to manage pollution where it is first generated. Source control measures keep pollutants from entering stormwater to begin with, whereas treatment control measures remove pollutants from stormwater runoff.

Evaluate the site to look for opportunities to prevent pollution sources on the land from becoming mobilized by runoff. Construction sites can be one of the largest sources of nonpoint source pollution, especially sediment, during the period of time when the soil is exposed and susceptible to erosion. Control of these sites during this exposure is essential to proper stormwater management. During this step assess whether any Better Site Design (BSD), Low Impact Development (LID) or temporary sediment control techniques can be applied at the site to prevent erosion and minimize site disturbance during construction.

Many sources of information on the control of construction site runoff are available and are incorporated by reference to this guide. Only general descriptions of the temporary sediment control practices will be given in the Manual because the details associated with these practices are available in many other publications.

- Vegetated buffers
- Access/egress and drainage protection
- Runoff control (sediment control basins)
- Perimeter controls (access and egress, inlet protection)
- Soil and Slope stabilization
- Exposed soil covers and reinforcement
- Inspection and maintenance

Keeping the project site clean of debris, proper storage and application of chemicals, exposure of unprotected soil and adequate air quality regulation are all pollution control elements that should be exercised before the BMP selection process even begins. Specific recommended practices include things such as:

- Good Housekeeping (or other suitable term) including landscaping, street sweeping, pavement maintenance, catch basin maintenance and litter control
- Chemical controls including fertilizer/pesticide management and spill prevention
- Streambank stabilization

2.1.8 Reduce Runoff Close to Its Source

Another way to stop pollution at its source is to reduce runoff wherever possible through the incorporation Low Impact Development (LID) also known as Better Site Design (BSD) or Sustainable Development measures. Reducing site runoff will also reduce the volume and duration of flows to local creeks, thus reducing the potential for downstream erosion and habitat impairment. LID measures can reduce project costs for projects that typically require runoff treatment because this can reduce the need for stormwater quality treatment.

The main ways to reduce runoff are to promote infiltration, minimize impervious surfaces, disconnect impervious surfaces (disconnecting impervious surfaces means to intercept the runoff by draining the roof or pavement to a pervious area and not directly to the storm drain system), and promote planting of trees and shrubs to intercept and slow the runoff.

2.1.9 Promote Infiltration Where Feasible

On undeveloped, undisturbed land, rain slowly percolates into the soil and impurities are filtered out and transformed through natural biological processes. When designing a site, look for ways to promote infiltration by disconnection of impervious surfaces and allowing soil to filter and naturally transform impurities. For example, consider dispersing runoff over a landscaped area rather than concentrating in a ditch. Of course, infiltration is not appropriate where it may pose a threat to groundwater quality or cause other problems such as destabilizing a site.

As part of an amended soil layer, proper mulch can also have a measurable benefit in promoting infiltration by supporting a healthy soil, trapping moisture, and slowing the runoff.

Consider infiltration stormwater quality treatment control measures for your site where feasible including such devices as: the infiltration basin and infiltration trench.

2.1.10 MINIMIZE IMPERVIOUS SURFACES

During design, try to limit overall coverage of pavement. This can be accomplished—where consistent with project purpose and need—by designing narrower streets and sidewalks, smaller parking lots (fewer/smaller stalls where possible, and more efficient lanes), indoor or underground parking, and incorporating porous pavement into the design. Examine site layout and circulation patterns and identify areas where landscaping, porous pavement, or stormwater measures can be substituted for pavement.

2.1.11 WHERE FEASIBLE, AVOID DRAINING IMPERVIOUS AREAS DIRECTLY TO A STORM DRAIN

When the built and landscaped areas are defined on your project plans, look for opportunities to minimize impervious areas that are directly connected to the storm drain system. Several options that can be considered for this, include:

- Direct runoff from impervious areas to adjacent pervious areas or depressed landscaped areas.
- Select porous pavements and surface treatments. Inventory paved areas on the preliminary site plan and identify locations where permeable pavements, such as crushed aggregate, turf block, or unit pavers can be substituted for conventional concrete or asphalt paving. Typically, these materials work best in low-traffic parking areas, rather than high-traffic areas such as drive aisles.

2.1.12 TREAT RUNOFF

Treating runoff is required for projects above certain size thresholds (which vary with respect to project category). As previously noted, providing LID measures can reduce or possibly even eliminate the required treatment.

Treatment is accomplished by either detaining runoff long enough for pollutants to settle out or by filtering runoff through sand, soil, or an engineered soil matrix. Typically, the limiting design factors will be available space, available hydraulic head, and soil permeability. In some cases, a small adjustment of elevations within the design can make a particular treatment option feasible and cost effective.

When developing a drainage and treatment strategy, also consider whether to route most or all drainage through a single detention and treatment control measure or to disperse smaller control measures throughout the site. Directing runoff to a single treatment area may be simpler and easier to design, but designs that integrate smaller techniques such as swales, small landscaped areas, and planter boxes throughout the site are typically more cost-effective, less maintenance intensive, and more attractive. The various treatment control measures that may be acceptable for use are:

Bioretention

- Rain gardens
- Depressed parking lot islands

- Road medians
- Tree pits/stormwater planters

Filtration

- Media filters (surface, underground, perimeter) described by media and function
- Surface flow (vegetative) filters (grass channels dry or wet swales, filter strips)
- Combination media/vegetative filters

Infiltration

- Trenches
- Basins
- Dry wells
- Underground Systems

Stormwater Ponds (design based upon components needed to fulfill the desired function)

- Components include pre-treatment, various storage volumes (detention needed), and biologic character.
- Functions include water quality (including thermal impact) and flow control (rate and volume), which determine whether they are wet/dry or some combination

Constructed Wetlands (selection criteria similar to ponds)

- Components include pre-treatment (see also next section), various storage volumes (detention needed), biologic character
- Functions include primarily water quality and flow control, but could also include ecological factors

2.1.13 HYDROMODIFICATION MANAGEMENT

Urbanization, vegetation removal, agricultural practices will often cause an increase in peak flow as well as runoff duration. Hydromodification Management addresses changes to runoff characteristics from urbanization and other sources that would otherwise result in the artificially altered rate of erosion or sedimentation within downstream natural channels. Hydromodification control measures should be provided (as required) to mitigate this effect. These measures function through attenuation, infiltration, and dispersion of runoff.

2.2 CONSTRUCTION SITES AND POTENTIAL POLLUTANTS

Stormwater runoff contains numerous natural constituents. However, activities such as construction, if not adequately managed, can increase these constituent concentrations to levels that may impact water quality. Pollutants associated with stormwater may

include sediment, nutrients, pesticides, metals, pathogens, litter, petroleum products and chemicals.

There are a number of potential storm water pollutants that are common to Transportation construction sites. The soil-disturbing nature of construction activities and the use of a wide range of construction materials and equipment are the sources of contaminants with the potential to pollute storm water discharges.

Common construction activities that increase the potential for polluting storm water with sediment include:

- Clearing and grubbing operations
- Demolition of existing structures
- Grading operations
- Soil importing and stockpiling operations
- Clear water diversions and Isolation Technique BMPs (Refer to Chapter 5)
- Landscaping operations
- Excavation operations
- Concrete placement and finishing operations

Common construction materials with the potential to contribute pollutants, other than sediment, to storm water include the following:

- Vehicle fluids, including oil, grease, petroleum, and coolants
- Asphalt concrete and Portland cement concrete materials and wastes
- Joint seal materials, form oil, and concrete curing compounds
- Paints, solvents, and thinners
- Wood products
- Metals and plated products
- Fertilizers, herbicides, and pesticides

Construction-related waste must also be managed to prevent its introduction into storm water. Typical waste on construction sites includes:

- Used vehicle fluids and batteries
- Wastewater from vehicle cleaning operations
- Green waste from vegetation removal
- Non-storm water from dewatering operations
- Trash from materials packaging, employee lunch/meal breaks, etc.
- Contaminated soils
- Slurries from sawing and grinding operations

- Wastewater/waste from concrete washout operations
- Hazardous materials waste
- Sanitary waste
- Partially empty buckets and drums improperly sealed

Erosion and sedimentation during construction are perhaps the most visible water quality impacts due to construction activities. Other less visible impacts are associated with offsite discharge of pollutants such as metals, nutrients, soil additives, pesticides, construction chemicals, and other construction waste. After the construction project is complete, the changes to the landscape due to the project may alter the existing runoff regime or introduce new sources of pollutants that continue to impact water quality into the future. The magnitude of stormwater impacts depends on construction activities, climatic conditions, and site conditions. Development of a comprehensive SWPPP requires a basic understanding of the impacts, pollutant sources and other contributing factors, as well as suitable BMPs which can eliminate or reduce these impacts. A brief summary of common stormwater pollutants associated with transportation facilities and their impact on water quality are described below.

2.3 Potential Pollutants

2.3.1 Total Suspended Solids (TSS) AKA Sediment and Soil

Sediment or TSS is considered a pollutant when it significantly exceeds natural concentrations and can have a detrimental effect on the beneficial uses designated for the receiving water. Possible sources of TSS include natural erosion, runoff from construction sites, and other operations where the surface of the ground is disturbed. In addition, increased runoff from new impervious surfaces can accelerate the process of channel erosion, which in turn can increase TSS in runoff.

Sediment from soil erosion is made up of soil particles and gravel washed into rivers, lakes, streams and marine environments. It is the major pollutant in surface waters. Excessive sediment in waterbodies impairs aquatic ecosystems, reduces public water storage and increases drinking water treatment costs. These sediment particles are also a vehicle to transport other pollutants including nutrients, metals, petroleum products and bacteria to surface waters.

Runoff from construction sites is the major source of sediment in urban areas under development. Another major source of sediment is off-site streambank and streambed erosion. Though part of natural processes as described in the last section, this erosion can be by product caused from higher peak runoff flow rates and volumes in modified landscapes.

2.3.2 Nutrients

Excessive inputs of nutrients such as phosphorus and nitrogen to receiving waters can overstimulate the growth of aquatic plants to the detriment of other aquatic life and to some beneficial uses of the receiving water. Nutrients generally have more adverse effects in water bodies with slow flushing rates, such as slow moving streams and lakes. Also, nutrients attached to TSS in storm water runoff can cause problems where they settle out downstream.

Sources of phosphorus that may be present in highway runoff include tree leaves, surfactants and emulsifiers, and natural sources such as the mineralized organic matter in soils. Phosphorus may be present in storm water discharges as dissolved or particulate orthophosphate, polyphosphate, or organic phosphorous.

Potential sources of nitrogen in highway runoff include atmospheric fallout, nitrite discharges from automobile exhausts, fertilizer runoff, and natural sources such as mineralized soil organic matter. Nitrogen may be present in storm water discharges as nitrate, nitrite, ammonia/ammonium, or organic nitrogen.

Phosphorus and nitrogen are the primary forms of nutrients that can cause water pollution. Lawn fertilizers used to establish and maintain vegetation can be significant sources of phosphorus. Nitrogen comes from fertilizer, too, but is also found in animal wastes, grass clippings and effluent from leaking septic systems.

Phosphorus and nitrogen are sources of food for the algae and bacteria that live in lakes, streams, rivers and marine environments. Waters polluted with these nutrients develop large numbers of algae and bacteria that can deplete available oxygen, causing fish and other beneficial organisms to die (Hypoxic and Anoxic conditions).

Nutrient pollution can be prevented by composting grass clippings and animal wastes, and repairing leaking septic systems. Nutrient pollution from construction sites can be minimized by applying fertilizer at the rate recommended by a soil test, or conserving topsoil to reduce or eliminate the need for fertilizer soil amendments.

2.3.3 PESTICIDES

A pesticide is a chemical agent designed to control pest organisms. The most common forms of pesticides are organic chemicals designed to target insects (insecticides) or vascular plants (herbicides). Pesticides have been repeatedly detected in surface waters and precipitation in the United States. Water is one of the primary media in which pesticides are transported from targeted applications to other parts of the environment. As the use of pesticides has increased, concerns about the potential adverse effects of pesticides on the environment and human health have also increased.

2.3.4 METALS (PARTICULATE AND DISSOLVED)

Metals in storm water runoff may be in a dissolved phase or a particulate form attached to TSS. Some Treatment BMPs are effective for removing specific particulate metals, but not for removing dissolved metals. If there are special requirements to remove dissolved metals (e.g., to address a TMDL or other site-specific requirement), then the designer should contact the DOH-CWB to identify the appropriate BMP requirements. Metals in the particulate phase may be removed through sedimentation or biofiltration.

Possible sources of metals in highway runoff include the combustion products from fossil fuels, the wearing of brake pads, and the corrosion of metals, paints and solder. Metals can also reach receiving waters through the natural weathering of rock and soil erosion.

2.3.5 PATHOGENS

Pathogenic microorganisms including viruses, bacteria, protozoa, roundworms, tapeworms, and flatworms (aka flukes) are of concern in storm water runoff. The direct measurement of specific pathogens in water is extremely difficult. For that reason, the

coliform group of organisms is commonly used as an indicator of the potential presence of pathogens of fecal origin.

Sources of total and fecal coliforms in storm water runoff are ubiquitous (e.g., soil particles, droppings of wild and domestic animals, etc.). Human sources could include illicit sewer connections and seepage from septic tanks.

2.3.6 TRASH

Trash in storm water is defined as manufactured objects made from paper, plastic, cardboard, glass, metal, etc. This definition does not include materials of natural origin such as gravel or vegetation. Trash in surface waters can inhibit the growth of aquatic vegetation, harm aquatic organisms by ingestion or entanglement, convey other pollutants, such as toxic substances, and cause aesthetic problems on shorelines.

2.3.7 PETROLEUM PRODUCTS

Petroleum products float on water and are visible. The hydrocarbons in petroleum have a strong characteristic for attaching to sediment particles. Hydrocarbons are known to be toxic to aquatic organisms. Common sources of petroleum products at the construction site are oil storage, fuel facilities, leaks from crankcases and improper disposal of drain oil.

2.3.8 CHEMICALS

Paints, solvents, sealants, cleaning agents and caulks may be found on construction sites. These chemicals along with chemically composed or treated construction materials may enter the runoff water. Water quality is easily degraded by these chemicals and removal during water treatment processes may be feasibly, fiscally, and logistical difficult.

2.4 WATER CHEMISTRY

Pollutants in stormwater can be affected by multiple chemical factors including pH, hardness, salinity, and temperature.

2.4.1 PH

pH is a measure of hydrogen ion concentration, with low pH (pH<7) being acidic, pH = 7 being neutral, and high pH (7<pH<14) being basic or alkaline. In addition to direct impact on fish and other wildlife, pH also significantly affects other chemical characteristics of stormwater. Lowering pH increases the solubility of metals, resulting in a higher fraction of metals present in the dissolved state. Raising pH increases the levels of the more toxic form of ammonia.

2.4.2 HARDNESS

Water hardness measures the presence of multivalent cations (positively charged ions) dissolved in water, particularly calcium and magnesium divalent cations (ions with a charge of +2). Increased water hardness typically decreases the toxicity of metals for fish. Hardness does not have a substantial effect on the toxicity of metals for fish in marine waters.

2.4.3 SALINITY AND TEMPERATURE

Salinity is the dissolved salts content of a body of water. Increases in salinity of surface waters can reduce the amount of oxygen that can be dissolved in the water. Increased

temperature has a similar effect on dissolved oxygen. Salinity also affects metal toxicity, frequently increasing it.

2.5 Transport of Stormwater Pollutants

Stormwater pollutants enter receiving waters through many routes. The following sections describe what happens to stormwater pollutants when these substances come into contact with stormwater.

2.5.1 Initial Transport

Pollutants are deposited on road surface as particulates (e.g., brake pad dust, dirt, and salt) and liquids (e.g., oil, antifreeze, gasoline), then washed off the undercarriage of vehicles during storm events (e.g., rusted metal, hydrocarbons), or washed onto roads from adjacent exposed soils or landscaping. Pollutants on the roadway surface may coat or bind to soil particles, or may remain unbound on the road surface.

When precipitation hits impervious surfaces such as roadways, roofs, and sidewalks, contaminants may be picked up and transported in stormwater runoff, whether bound to particulate matter, dissolved in solution, or in suspension. Particulate material may be transported as suspended load or as bed load (bumping along the bottom or "bed" of the channel).

2.5.2 During "First Flush"

First flush describes the elevated pollutant concentrations that are often experienced during the initial part of a storm. Pollutant concentrations may peak during the "first flush" of a storm, but concentration peaks may or may not coincide with the load peaks since that is a factor of both concentration and volume of runoff. Different pollutants may also have peaks at different times during a storm, depending on how easily they are entrained. The prominence of the first flush varies considerably between storms and between locations. Factors influencing the magnitude of the first flush include the availability of pollutants on the road surface, and the form of the drainage area. The simpler and shorter a drainage area is, the more likely it is that the first flush will be clearly expressed.

Along with the storm event first flush, there may be a seasonal first flush when pollutants that have accumulated during an extended dry period are collected during the first storms of the season. Larger pollutant loads and higher median concentrations are often observed during the first storms of the season than storms later in the wet season or those closely following a series of storms. A seasonal first flush is not always present.

2.5.3 After Entry into a Water Body

Once stormwater carrying pollutants enters a receiving water body, several things can happen to the pollutant load. Compounds bound to soil and other solids may settle out of the water column or be filtered out by vegetation. Chemicals can be removed from the water column by biological uptake (i.e., plants and aquatic animals), or become attached to sediment and organic matter. Pollutants also may be degraded biologically (e.g., by microbes), chemically, or with sunlight (photodegradation). Compounds that are not removed from the water column may be transported to other water bodies. Pollutants

that are deposited and removed from the water column may be re-entrained later, either by erosion, or by reentering a dissolved state if the chemical environment changes.

2.5.4 During Downstream Transport

During transport downstream, the concentration of pollutants from a discharge of highway runoff will decrease through three mechanisms. The first is dilution by increased flow in the stream from tributaries and additional base flow. Second is pollutant removal as described above. Finally, dispersion as the plume of stormwater becomes elongated due to mixing and irregular flow within the stream. This last effect means that the peak concentration in the plume will decrease, while the extent of the plume will increase.

2.6 Impacts of Water Quality Pollution on Aquatic Organisms

Fisheries are an important resource in Hawaii. However, despite the abundance of fresh water and hundreds of streams, the only freshwater fishes native to Hawai'i are four gobies and an eleotrid, collectively known as o'opu. Two marine fishes, aholehole and mullet, are transient inhabitants of lower stream reaches. While these species have differing habitat requirements and tolerances, all are vulnerable to increased pollutant loads and concentrations.

Anthropogenic (human-caused) pollution via stormwater can harm fish by reaching lethal levels of toxicity, by affecting the health and viability of fish populations, by damaging or changing food sources (such as macorinvertebrates), and by physical changes to the aquatic habitat. To protect this dwindling resource, stormwater must be treated based on both pollutants generated and vulnerability of species in receiving waters.

The toxicity to fish of a given chemical is often not directly related to chemical concentration. Instead, toxicity to fish is affected by the bioavailability of the compound. Bioavailability of a compound to fish can be affected by water temperature, pH, dissolved organic carbon, suspended sediment, and hardness (pH and hardness are discussed in water chemistry section of this chapter); other water quality parameters are discussed below.

2.6.1 Water Temperature

Elevated temperatures can have lethal or non-lethal effects to aquatic organisms, depending on the temperature and duration of exposure. Acute non-lethal effects of temperature include behavior adjustments such as reduced feeding and relocation to cooler waters. Chronic non-lethal effects of elevated temperatures include reduced growth and development, both of which can affect survival and reproduction of aquatic species.

2.6.2 Sediment

Sediment can affect fish both directly (when suspended) and indirectly (when settled and accumulating). In suspended form, sediment may damage gill tissue, particularly if the sediment particles are angular. Several fish species are sight feeders, and murky waters can decrease their ability to find food. Suspended solids also can increase the stress response in fish, which in time can disrupt the proper functioning of other systems and alter fish behavior. Suspended solids may have a substantial effect on the

bioavailability of other pollutants. Contaminants can absorb or bond to the surface of the particles, preventing them from being absorbed by fish and becoming toxic.

When sediments settle and accumulate they can degrade fish habitat, including sensitive spawning habitat which may requires clean gravel. Changes in a water body's substrate due to excessive sedimentation can also lead to a change in the benthic macroinvertebrate community, and thus food sources for fish. Impairment of habitat can have long-term or delayed adverse effects on fish populations.

2.6.3 METALS

Stormwater from roadways contains metals in concentrations that may be toxic to fish, particularly copper, zinc, lead, and cadmium. The three known physiological pathways of metal exposure and uptake in fish species are gill surfaces, olfactory receptor neurons, and the digestive system. Dissolved metals are the most bioavailable form, and can be taken up by the fish directly through the gills.

Toxicity is affected by water's pH, hardness and salinity, and by other chemicals in the water.

2.6.4 NUTRIENTS

Nutrients consist of chemicals that stimulate growth, particularly nitrogen and phosphorus. The largest concern about nutrients is their overstimulation of algal growth in receiving waters, particularly stagnant waters such as ponds, lakes or sloughs. Algae may affect the food chain by competing for surfaces with organisms that fish use as a food source, or in more extreme cases, cause eutrophication. Eutrophic waters experience explosive growth in algae populations, followed by a crash as nutrients are depleted. The algal die-off and decomposition uses up the dissolved oxygen in the water, causing fish and other aquatic life to suffocate.

Different forms of nitrogen and phosphorous exhibit different degrees of algal growth, with orthophosphates typically having the highest potential to cause eutrophication, usually because phosphorus is the nutrient limiting plant growth—many algae can fix their own nitrogen from the atmosphere. Stagnant waters and slow moving streams are particularly vulnerable to these hazards.

2.6.5 ORGANIC POLLUTANTS

Many different organic pollutants are toxic to salmonids, including pesticides, herbicides, pthalates, phenols, and poly aromatic hydrocarbons (PAHs). Typical levels of these pollutants in roadway runoff are not clearly defined, and in many cases may be below toxic concentrations.

2.6.6 ACUTE AND CHRONIC EFFECTS

Acute (limited duration) and chronic (longer duration) exposure of fish to contaminants can result in various non-lethal effects. Physiological effects include altered respiration rate, blood chemistry (glucose levels, cortisol levels, etc.), swimming speed, breathing rate, and oxygen consumption. Numerous chemicals act as endocrine-disrupting compounds (EDCs), including estrogenic compounds, PAHs, flame retardants, and metal compounds. Chronic exposure to these compounds can affect fish behaviorally, resulting in altered hormone-dependent behaviors (e.g., spawning, migration), and

physiologically, resulting in physical changes (e.g., intersex, the presence of both male and female reproductive organs in an individual).

2.6.7 Indirect Impacts to Water Quality

The placement and design of highway facilities can modify elements of the landscape that have beneficial hydrologic and water quality functions. Those modifications can affect the hydrology and water quality of receiving waters, even if no highway runoff reaches them. The most important of these landscape elements are riparian zones and wetlands.

2.6.7.1 Riparian Zones

Riparian zones can, when in good condition, provide several water quality benefits. Trees and shrubs produce shading, which is important for regulating temperature in smaller streams. They also act as sources of food and nutrients for the biotic community of the stream, including macroinvertebrates, fish, and amphibians. During high flow events, the same trees and shrubs slow down overbank floodwaters and provide refugia for fish. Vegetation on the stream bank is important for controlling lateral erosion. Riparian zones can also be effective at removing nutrients, sediment and other pollutants carried by runoff from adjacent developed or agricultural lands.

Destruction of riparian vegetation can therefore lead to the following adverse impacts:

- Increased stream temperature
- Increased pollutant loads derived from adjacent land use
- Reduced food supply for aquatic animals
- Increased bank erosion, which in turn leads to increased turbidity, and potentially sediment deposits on spawning gravels and modified stream geometry
- Loss of high flow refugia for fish.

2.6.7.2 Wetlands

Wetlands provide both water quality and hydrologic benefits. Even degraded wetlands can effectively provide those functions. The wetlands usually perform these functions for the drainage area as a whole, not just for highway runoff. Impacts to wetland can reduce the capability and the capacity of the wetland to perform certain water resources functions. Loss of capability could result from changes in vegetation composition, structure or density, or from altered hydrology. Loss of capacity would result from a reduction of size, diversion of water away from the wetland, or other modification of the hydrology.

Loss of wetlands can lead to the following adverse impacts:

- Increased pollutant loads discharged to streams and lakes
- Higher flood peaks downstream of the wetland
- Reduced low flow discharges downstream of the wetland
- Loss of aquatic habitat.

2.6.7.3 Development

Induced or facilitated development may also be considered a secondary or indirect impact of a project on water resources. In Hawaii, highway projects support the designated land uses, so it is rare that a highway project can be said to cause development, but they do support planned and approved development. The result of development is that expected from the addition of impervious area with new roads, buildings and landscape modifications. It is not the responsibility of the PDT to analyze the impacts from associated development in any depth, but they should be addressed in NEPA analysis if reasonably foreseeable.

2.7 Step by Step Process for SWPPP/IWPPP Development and Implementation.

2.7.1 Internal Roles and Responsibilities

NPDES compliance clearly requires an interdisciplinary approach. However, roles and responsibilities for the various NPDES requirements need to be defined and responsibility/accountability for the overall program needs to be assigned. The following recommendations are made to promote consistency within FLH and thereby facilitate development and maintenance of an FLH NPDES Program. In general:

- Environmental staff should be responsible and accountable for defining the NPDES processes required for program compliance, as well as monitoring and refining those processes for adequacy and continuous improvement.
- Project Management staff should be responsible and accountable for ensuring that all program level processes are addressed and executed to the appropriate degree on the project development and delivery level.
- Environmental staff should be responsible for compiling the stand-alone SWPPP/IWPPP, as well as preparing and submitting the NOI and NOT.
- Design staff should be responsible for development of the Erosion and Sediment Control (ESC) plans and specifications included in the PS&E package.
- Construction staff should be responsible for implementing and maintaining the SWPPP/IWPPP during the life of the construction project.
- Technical Services staff should act as a program and/or project resource to provide necessary support information, such as custom analysis, design, or evaluation of standard drawings, SCRs, and new products.

2.7.2 External Roles and Responsibilities

It is recommended that FHWA and HDOT use program agreements to define general agency roles and responsibilities associated with the NPDES Program. Project Agreements should be used to clearly define project-specific partner roles and responsibilities early in the project development process. Partner agencies should be considered for one or more of the following roles and responsibilities:

- Providing re-vegetation design and specifications

- Removing temporary erosion and sediment control devices that need to be left in place until final stabilization is achieved
- Submitting an NOI and assuming the NPDES responsibilities when construction work is complete but final stabilization has not yet been achieved.

Assigning these roles and responsibilities to the local FHWA or HDOT partner agencies is considered appropriate for three primary reasons:

- The owning agency or the land management agency has intimate local knowledge of the climatic, soil conditions and ground cover type and density that can be supported. This knowledge allows them to identify and develop the most appropriate final stabilization strategy and design.
- The owning agency has responsibility for maintenance of the roadside and thereby, a vested interest in ensuring that final stabilization can be achieved and maintained.
- The brief, contractual nature of the FHWA or HDOT presence makes it very difficult to address NPDES requirements between the end of the construction contract and final stabilization. This is especially true in arid to semi-arid regions of the country where final stabilization may take time to achieve.

2.7.3 Step By Step Process Description and Recommendations

The 2007 EPA Guide included in Appendix C is a reference that can be used by the PDT as basic guidance for project-level compliance. Additional State and local requirements apply for compliance in Hawaii and these have been included in the IWPPP sample found in Appendix G.

The EPA guidance describes seven steps for developing and implementing project-specific SWPPPs. Recommendations for improving the SWPPP development and implementation practices within FLH are listed below in the context of EPA's 7-step process.

2.7.3.1 Step 1: Site Assessment and Planning (Chapter 3 in 2007 EPA Guide (Appendix C)

- **Environment** staff should be responsible for identifying, documenting, and communicating the applicable NPDES requirements and other related environmental issues. This includes identifying the governing construction general permit (CGP), applicable state and local ordinances, and sensitive resources such as impaired waters, presence of aquatic ESA species or critical habitat.
- **Environment** staff should conduct a site assessment jointly with Design, whenever appropriate, to evaluate and document site conditions, risks, and opportunities associated with erosion and sediment control. The EPA SWPPP Template should be used as a checklist when conducting this review. This review should be conducted early in the project development process as part of the early coordination field review or other planned review.

2.7.3.2 Step 2: SWPPP Development - Selecting Erosion and Sediment Control BMPs (Chapter 4 in 2007 EPA Guide.)

- **Design** staff should develop an erosion and sediment control plan as part of the contract package. The plan should include standard drawings, details, quantities, and specifications for all structural BMPs. BMPs should be selected from the approved BMPs listed within this manual. Wherever possible, rely on erosion controls to keep sediment in place. Back up those erosion controls with sediment controls to ensure that sediment doesn't leave the site.
- **Design** staff should include contract specifications and pay items for non-structural BMPs to address unique site conditions, requirements or risks as needed. Examples include water quality monitoring or an onsite Erosion and Sediment Control Supervisor.
- **Environment** staff should provide progress reviews of the plans and specifications (typically 30, 50, 70, and 95%) to ensure compliance with the NPDES CGP requirements and to facilitate development of the stand-alone SWPPP described in Step 4 and the Notice of Intent (NOI) described in Step 5.

2.7.3.3 Step 3: SWPPP Development – Selecting Good Housekeeping BMPs (Chapter 5 in 2007 EPA Guide)

- **Design** staff should be responsible for selecting good housekeeping BMPs and providing appropriate contract language in the specifications. EPA defines good housekeeping BMPs as those designed to prevent contamination of stormwater from a wide range of materials and wastes at the construction site.

2.7.3.4 Step 4: SWPPP Development - Inspections, Maintenance, and Recordkeeping (Chapter 6 in 2007 EPA Guide.)

- **Design** staff should include contract specifications for inspection, maintenance, and recordkeeping required during construction. Contract specifications should identify the government provided SWPPP as a key project record and require appropriate care and maintenance throughout the life of the construction project including disposition of the SWPPP at the end of construction.

  EPA and many state general permits require that a sign be posted near the main entrance of construction sites. It is common for the permits to require that the sign contain a copy of the NOI, the location of the SWPPP, and a contact person for viewing the SWPPP.
- **Environment** staff should be responsible for compiling a stand-alone SWPPP that will be provided to Construction for directing and documenting the implementation of the SWPPP as described in Step 6. Elements of the stand-alone SWPPP include the CGP, erosion and sediment control plan from the contract package, associated narrative, contract specifications, NOI, inspection forms, and any other information required to comply with the CGP.

2.7.3.5 Step 5: Certification and Notification (Chapter 7 in 2007EPA Guide)

- **Environment** staff should be responsible for preparing the NOI, obtaining an authorized signature on the certification, and submitting the NOI in accordance with the CGP.

2.7.3.6 Step 6: SWPPP Implementation (Chapter 8 in 2007 EPA Guide.)

- **Construction** staff is responsible for ensuring inspections, maintenance, and recordkeeping are performed in accordance with the CGP and the SWPPP.
- **Construction** staff is responsible for reviewing and approving contractor requested modifications to SWPPP.
- **Construction** staff is responsible for directing changes to the SWPPP as needed to ensure compliance with the CGP.
- **Construction** staff is responsible for requesting support from Environment, as needed. As the lead office, Environment should be the single point of contact for managing such requests and enlist the assistance of Design, Tech Services, or others, as needed.
- **Construction Operations Engineer** (COE) or **Project Engineer** (PE) should conduct a Quality Assurance (QA) review of NPDES compliance during every project site visit. The QA review should include inspection of the SWPPP to ensure that it is properly maintained. The QA review should also include an inspection of site conditions to ensure that site conditions match the SWPPP and that erosion and sediment control is effective. The COE's QA reviews should be documented in the SWPPP.
- **Construction** staff should be responsible for submitting the final post-construction SWPPP to Environment when construction work is complete.

2.7.3.7 Step 7: Final Stabilization and Permit Termination (Chapter 9 in EPA guidance.)

- If the owner agency is responsible for final stabilization, Construction should submit the final as-built SWPPP to Environment. Environment should prepare and submit the NOT, and transfer the SWPPP to the owner agency. The owner agency would then be responsible for filing an NOI and assuming all of the NPDES requirements through final stabilization in accordance with the program or project agreement. This is a practice successfully applied in CFL.
- If FLH is responsible for final stabilization, Construction should remain responsible for all NPDES requirements until final stabilization is achieved and the final SWPPP is submitted to Environment. Environment should prepare and submit the NOT and archive all SWPPP related records with the construction records.

2.7.3.8 Task -Specific Recommendations

The following recommendations are provided to assist with the details of completing various tasks associated with SWPPP/IWPPP development and implementation in accordance with the 2007 EPA Guide and state specific requirements.

2.7.3.8.1 Develop Site Plan Design

- Include topographic mapping in SWPPP document to better show drainage patterns and discharge points.
- Show "clearing limits" on Erosion and and Sediment Control plans.
- Determine if a pay item for Erosion Control Supervisor is appropriate,

2.7.3.8.2 Measure Area of Disturbance

- Area of disturbance should be based on clearing limits, not slope stake limits.
- Where no definition is provided by the CGP, consider defining "disturbance" as any erodible surface of 1 acre or more, except travel ways of gravel or better surface type.

2.7.3.8.3 Determine Drainage Area

- Calculate area draining to all non-standard, structural BMP devices. An example is a sediment basin.
- Provide sediment basin(s) when the area of disturbance within a given drainage area is ten acres or more. (EPA sediment basin sizing criteria – lesser of 3600 cu. ft. per acre or volume of Q2 runoff from drainage area.)

2.7.3.8.4 Determine Runoff Coefficient

- Required for sediment basin design in drainage areas of 200 acres or less.

2.7.3.8.5 Construction/Implementation

- Consider paying for maintenance of ESC items with equipment and labor hours, or prorating a lump sum amount over the life of the contract..

CHAPTER 3:

3 STORMWATER TREATMENT PROGRAM - BEST MANAGEMENT PRACTICES AND SELECTION MATRIX

3.1 SUMMARY

The FHWA and HDOT are proposing refinements to the Stormwater Management Program (Program) to streamline the stormwater, 404 and 401 permitting process, while continuing to meet their missions as transportation agencies. Under the Program, the goal is to reduce the amount of runoff generated to the extent practicable before relying on engineered stormwater facilities to meet water quantity and water quality requirements. Through this process, FHWA and HDOT are working internally with management, project delivery and maintenance teams, as well as with representatives from regulatory agencies to define the improvement areas. The key outcomes from the Program include advancement in the following areas:

1. Stormwater treatment guidance: Best Management Practice (BMP) Selection Tool and User's Guide
2. Expedited Clean Water Act Section 404 and 401 permitting for Transportation projects.

This manual focuses on the stormwater treatment guidance component of the Program (item 1 above). The impetus for developing the BMP Selection Tool is to have a transparent and technically based BMP selection process that documents the decisions and streamlines overall stormwater management and permitting with the regulatory agencies. The BMP Selection Tool is one component of an overall "Stormwater Treatment Design Process." The Stormwater Treatment Design Process integrates pollution prevention and minimization techniques, low impact development and other practices to reduce the runoff generated by the project once the project goals and objectives have been defined and site characterization has occurred.

Generally, the BMP Selection Tool uses metrics and ratings for treatment suitability (effectiveness) for pollutants of concern, site suitability and physical constraints, maintenance needs and constraints, and costs to document the decision-making process for selecting among a suite of potential BMPs for a project. However, the BMP Selection Tool prioritizes the use of "preferred" BMPs, which include infiltration-focused technologies and those BMPs that have a soil-amendment feature. Input and review by the regulatory agencies can be minimized and streamlined when the "preferred" BMPs are selected.

Finally, the BMP Selection Tool uses "primary treatment mechanisms" rather than removal efficiency data reported for specific BMPs to determine the treatment suitability for pollutants of concern (POC). Primary treatment mechanism refers to the prevailing unit operations that result in the removal or chemical breakdown of a given compound. If a BMP employs a given treatment mechanism, then by definition the BMP is considered effective at treating the pollutant of concern.

The goal is to promote integrated stormwater design and LID in its project development and design process. Under the Program, consideration is given to these approaches at the project development and definition phase and throughout the preliminary and final design phases. The goal for FHWA and HDOT, which is consistent with the regulatory agencies' position, is to reduce the amount of runoff generated to the extent practicable before relying on engineered stormwater facilities to meet water quantity and water quality requirements. The "traditional" POC for roadway projects (e.g., suspended solids, oil and grease, and particulate metals) are addressed in this process, while extra focus may be given to BMPs that address other POCs of concern to other regulatory agencies.

The project designer usually provides layout sheets showing the suggested locations of structural BMPs. The purpose of these sheets is to show the contractor the designer's anticipated placement of these BMPs covering activities such as contractor staging areas, approximate location of concrete washouts, approximate locations for storage of materials, and preferred locations for vehicle and equipment maintenance. These are not intended to be highly detailed drawings. Typically, these layouts can be drawn on l:200 and l:500 scale drawings. Where multiple stages of construction are anticipated, the designer should show how deployment of the BMPs is expected to change over time. These locations and layouts will be, in most cases, subject to the contractor's phasing of the work and timing of operations. As a result, many of the suggested locations will be modified by the contractor in the SWPPP/IWPPP. If these draft layouts are provided, the layout sheet usually contain a disclaimer stating that the temporary BMP locations are suggested, and that the Contractor is ultimately responsible for developing a SWPPP/IWPPP that complies with the Permit. Refer to Appendix C for the EPA's guide to developing a SWPPP/IWPPP.

This section presents a flexible approach to BMP selection that allows a stormwater manager to select those BMPs most able to address an identified POC. Selecting an inappropriate best management practice (BMP) for a site could lead to adverse resource impacts, friction with regulators if a BMP does not work as anticipated, misperceptions about stormwater control success, and wasted time and money. Careful selection of BMPs will prevent negative impacts from installing the wrong BMP at the wrong location. Regulators can similarly use these matrices to check on the efficiency of proposed BMPs.

3.2 Stormwater Treatment Guidance and BMP Selection Matrix

The "Stormwater Treatment Design Process" is a comprehensive process that starts with problem definition and continues through development of the conceptual design of the selected stormwater treatment system. Under this process, stormwater management begins with simple methods that minimize the amount of runoff that occurs from a site and methods that prevent pollution from accumulating on the land surface and becoming available for wash-off. Even though we know that we will never be able to fully accomplish either of these goals, we can make substantial progress using BSD/LID techniques and the pollution prevention, volume minimization, temporary construction erosion control and structural BMP techniques.

After all of the efforts possible are made to minimize runoff and surface wash-off, we must recognize that some potential for runoff will occur. The next major category of BMPs focuses on the collection and treatment of runoff locally and regionally, either as stand-alone practices or in treatment train combinations. Some of the available BMPs are best used to reduce or manage runoff volume, while others focus on water quality protection. Some planning and construction BMPs are easy to implement, while others involve more extensive engineering and design. Figure 6 illustrates the conceptual stormwater treatment design process, of which the "BMP Selection Tool" is one part. Through the process, the project delivery team integrates pollution prevention and minimization techniques, LID, BSD and other practices to reduce the runoff generated by the project once the project goals and objectives have been defined and site characterization has occurred.

The process includes the development of key decision documents that will be used by HDOT to assist in the permitting process for their projects. One of the key decision documents is the "output" from the BMP Selection Tool. The BMP Selection Tool is used to:

- Evaluate the engineered, post-collection and conveyance facilities used to treat stormwater runoff and protect water quality during construction.
- Document design and BMP decisions made by FHWA and/or HDOT's project development team in a decision support framework.

As Figure 6 illustrates, the BMP Selection Tool is applied after the project objectives and treatment goals have been defined and after the preliminary conceptual site layout and integrated stormwater design considerations have been developed. At this point, the Project Team has considered appropriate LID/BSD options to reduce runoff and the design process is at the point where "end-of-pipe" stormwater treatment options are needed.

The BMP Selection Tool was initially developed by the Oregon Department of Transportation (ODOT) and is based on the information from the key references and literature reviewed by their interagency team. These primary references were also used to develop BMP Summary Reports that include the basis for ratings assigned to the metrics in the BMP Selection Tool. Figure 7 shows the components (or metrics) of the selection process, key "check-in" points within the PDT and the regulatory agencies, and the "streamlining benefits" of the BMP selection process.

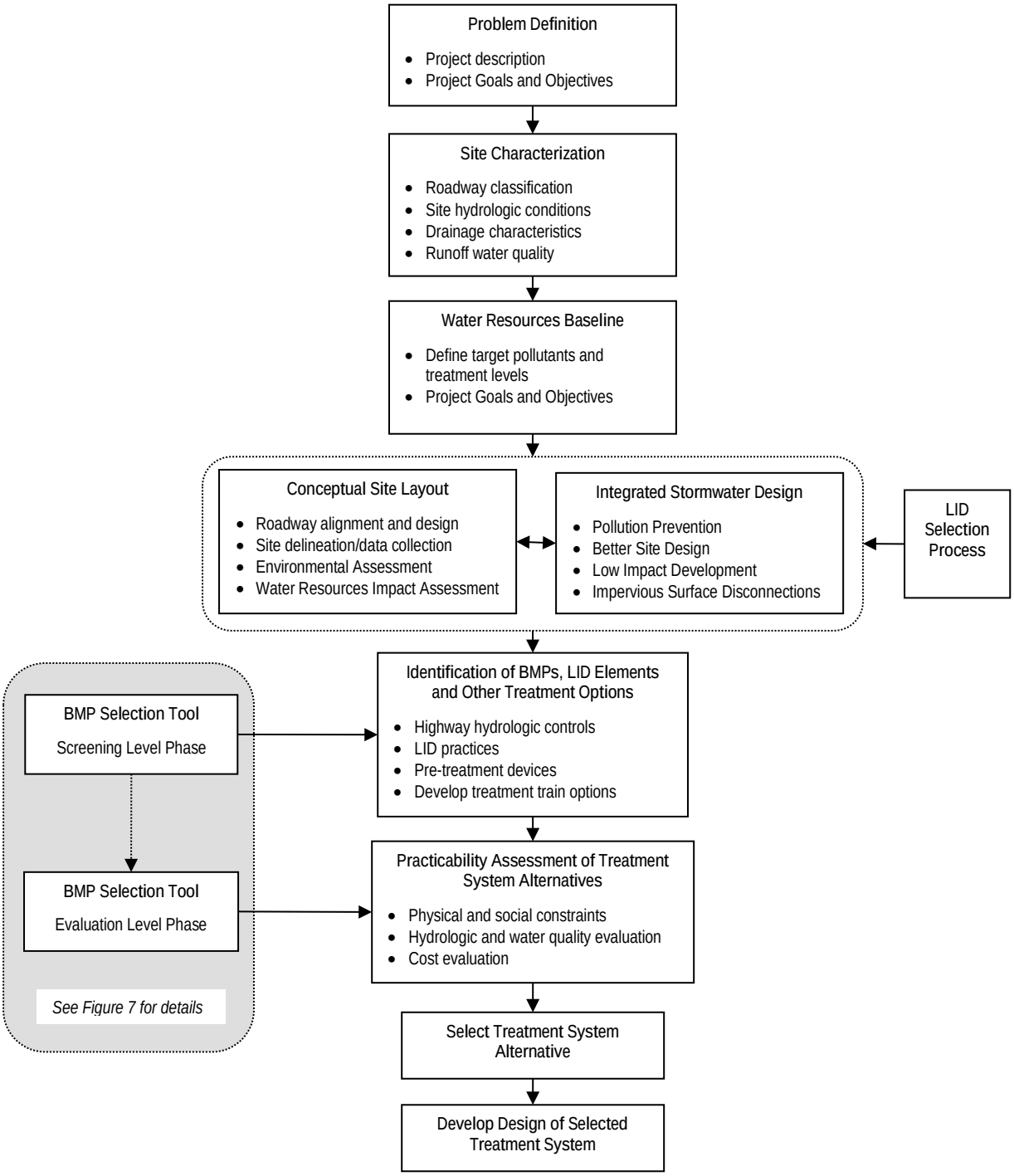


Figure 6. Conceptual Stormwater Treatment Design Process

The BMP Selection Tool includes metrics and ratings for treatment suitability (effectiveness) of pollutants of concern, site suitability and physical constraints, maintenance needs and constraints, and costs. The selection process is generally applied in two steps: (i) BMP screening level; and (ii) treatment train alternatives evaluation. The BMP screening step in the selection process evaluates individual BMPs and is used to identify the most appropriate BMPs for the project. Those BMPs that are screened through are used to develop treatment train alternatives. These alternatives are evaluated further and in more detail with respect to conceptual design layouts for the individual components of the treatment train. The alternatives are evaluated using similar metrics from the screening step. As Figure 7 shows, there are at least two opportunities for the regulatory agencies and the Project Team to discuss documented decisions in the selection process.

"Preferred" Permanent BMPs have been identified as part of the literature review for treatment effectiveness. If "preferred" BMPs for the target pollutants are feasible and appropriate for the project site, streamlining of the BMP selection process is possible and the formal evaluation and scoring process can be by-passed, as illustrated in Figure 7. While the stormwater/hydraulics engineer still needs to design the system and ensure that the BMP is feasible and meets design standards, input and review by the regulatory agencies can minimized and streamlined when the preferred BMPs are selected. Preferred Permanent BMPs fall into the following categories:

- Pretreatment
- Infiltration
- Filtration
- Pool and Ponds
- Soil Amendment Features

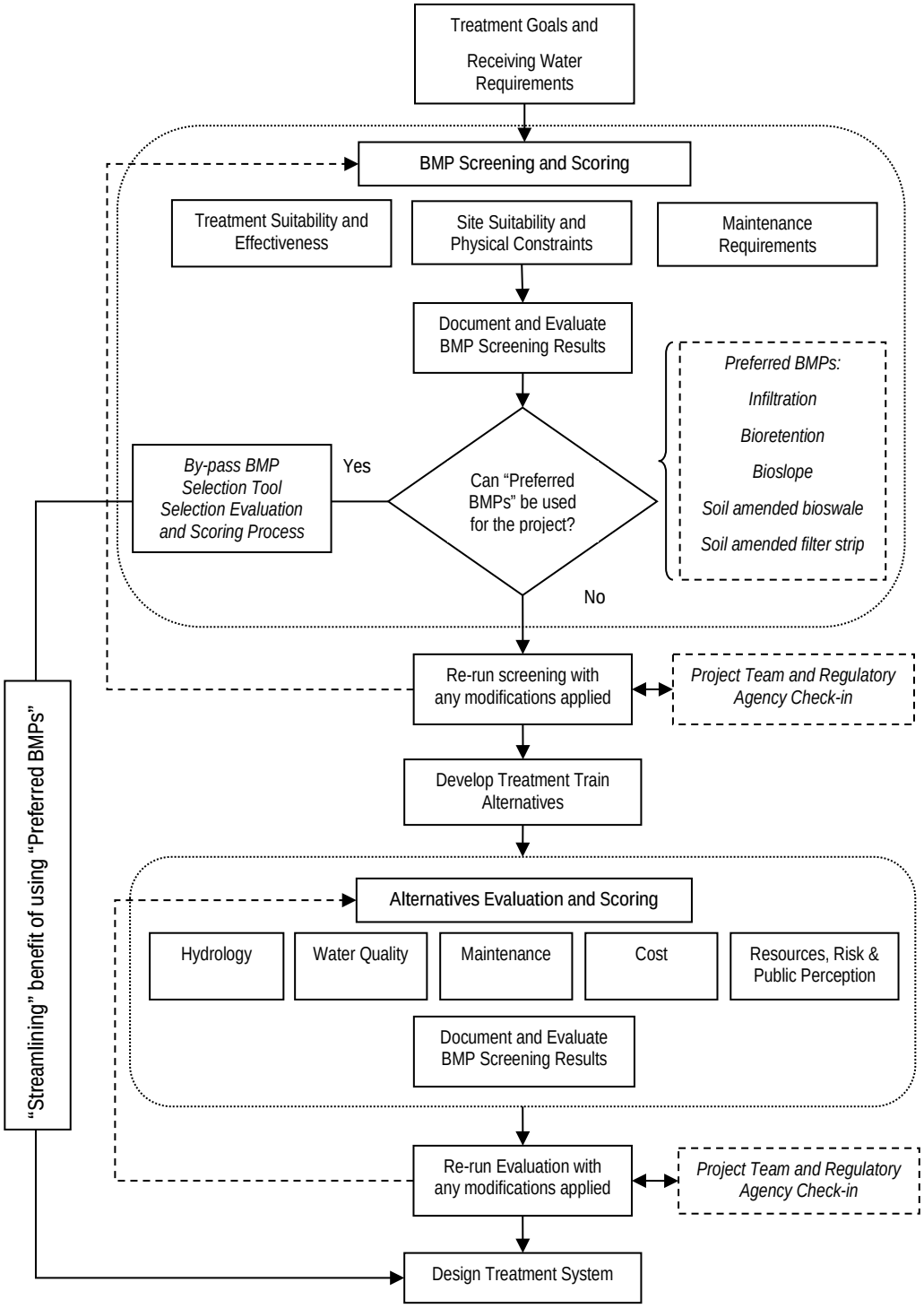


Figure 7. Schematic of BMP Selection Tool

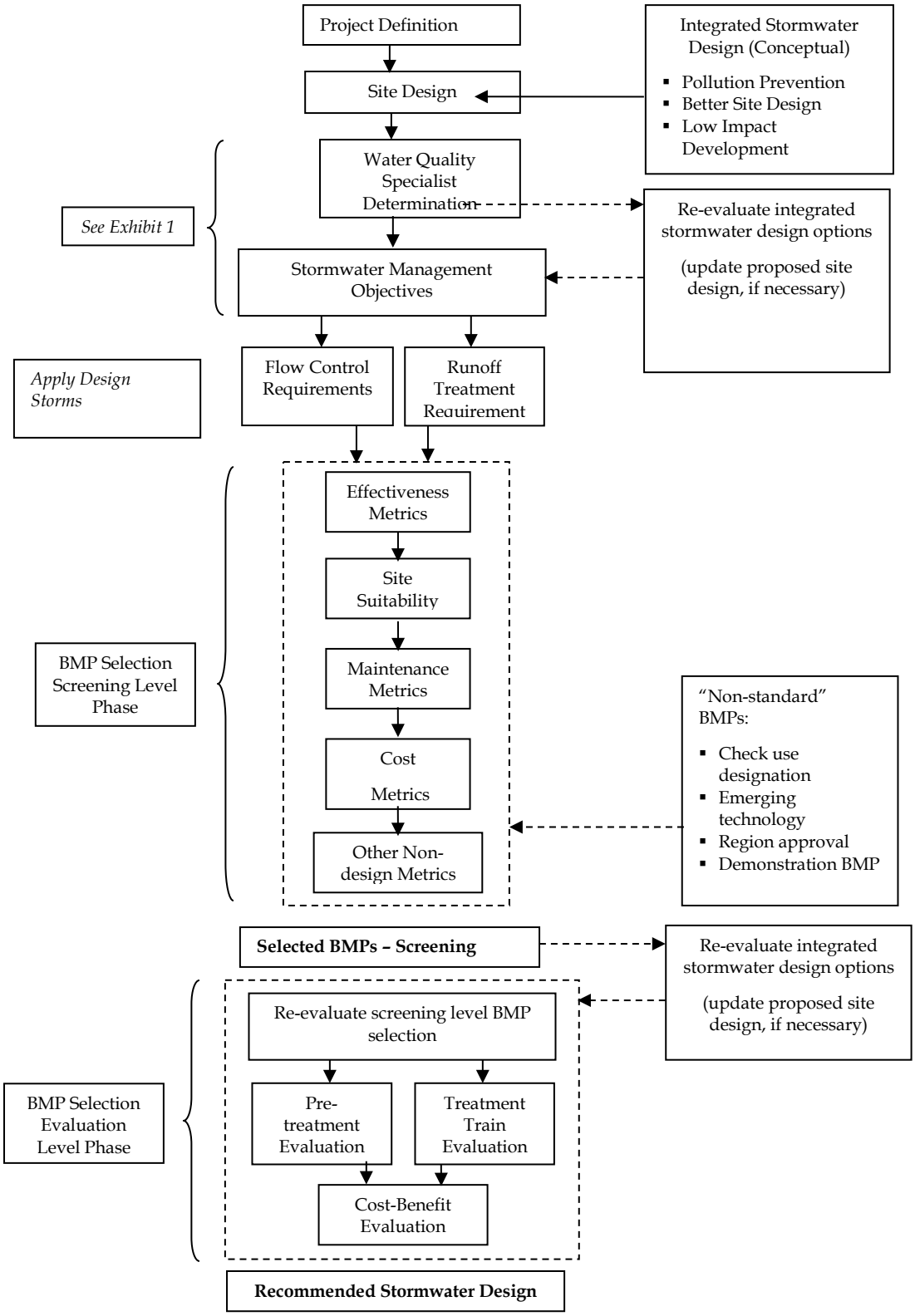


Figure 8. BMP Selection Process

3.3 BMPS IN THE SELECTION TOOL

This manual provides a focused effort on incorporating the commonly utilized BMPs by FHWA and HDOT, most identified in the HDOTs construction BMP Field Manual and Stormwater Permanent BMP Manual covering structural BMPs currently implemented on FHWA/HDOT projects. This effort hopes to build off of these BMP guidance manuals with additional suitable construction BMPs to promote consistent implementation of BMPs on transportation projects.

In addition to the structural BMPs, there are also non-structural, pollution prevention, and BSD/LID type BMPs, which essentially act to reduce the amount of pollution generation or pollution-carrying runoff. These BMPs are to be considered prior to the BMP Selection Tool step (see Figure 8).

FHWA and HDOT expects that the preferred BMPs included in the BMP Selection Tool will change as new technologies are developed and evaluated for their performance to meet HDOT standards and water quality treatment requirements. For the purposes of developing the guidance and tool, only these existing non-structural and structural BMPs, including engineered facilities are included in the BMP Selection Tool.

Other methods of treating stormwater runoff may be proposed but must be evaluated on a project-by-project basis to determine if the proposed treatment methods are adequate. A hydraulic design deviation request must be submitted to the hydraulics engineer for consideration. After an experimental BMP or Emerging Technology is approved for use on a specific FHWA/HDOT project it is placed on an evaluation list. The performance of all BMPs or Emerging Technologies placed on the evaluation list will be assessed and only the approved stormwater management approaches would be added to future revisions summarizing preferred BMPs utilized by FHWA and HDOT. In the interim, technical bulletins or memorandum may be published for the experimental emerging technologies for use by FHWA and HDOT engineers and consultants.

3.4 DEFINING TREATMENT EFFECTIVENESS USING TREATMENT MECHANISMS

The key issue with rating the "treatment effectiveness" of BMPs in the BMP Selection Tool is the wide range of removal efficiencies reported for the BMPs. One approach is to rate a BMP's treatment effectiveness based on the removal efficiencies reported in literature. However, the reported efficiencies vary greatly (e.g., at times from 20-80 percent removal by concentration). The wide range in removal efficiencies is a result primarily of the varying site conditions, influent concentrations, flow rates, and specific BMP designs. In addition, the number of studies reported in the literature for each BMP is still relatively limited, despite the development of such databases as the International BMP Database. Efforts to add to the dataset have so far not resulted in any clear increase in the precision of effectiveness data.

In an attempt to address this issue, FHWA, is proposing that treatment effectiveness be defined in terms of their "primary treatment mechanisms" rather than by removal efficiency data reported for specific BMPs. Primary treatment mechanism refers to the prevailing unit operations or processes (borrowing the term from the wastewater treatment field) that results in the removal or chemical breakdown of a given compound. The approach defines a given treatment mechanism as effectively treating a

specific target pollutant, and if a BMP employs that treatment mechanism, then by definition the BMP would be considered effective at treating for the POC. Ratings of "high, medium, low" are used.

Types of Treatment Mechanisms. In general, a limited set of unit processes exist that different BMPs rely on to remove constituents from water. The reality of stormwater treatment is that the more complex unit processes, such as ultraviolet disinfection or chemical precipitation/flocculation, will generally not be used because of the economics of treating such large volumes of water.

The treatment effectiveness of a BMP is essentially related to which processes are actually utilized by the BMP and the ability of the BMP to maximize the process(es). Six primary treatment mechanisms are considered most appropriate for stormwater. The descriptions of these mechanisms are summarized below:

- **Hydrologic attenuation –** Hydrologic attenuation achieves pollutant reduction through runoff volume reduction. Infiltration is the primary means of hydrologic attenuation for the purposes of the types of BMPs used in stormwater management. Attenuation reduces the pollutant load discharged to surface waters, but does not necessarily reduce pollutant concentrations. Infiltration includes several different treatment mechanisms. Processes such as sorption, filtration, and microbial degradation occur as runoff infiltrates through the soil matrix.
- **Sedimentation/density separation** - Density separation refers to the unit processes of sedimentation and flotation that are dependent on the density differences between the pollutant and the water to effect removal. Sedimentation is the gravitational settling of particles having a density greater than water. Flotation is similar to gravitational sedimentation except in the opposite direction. Typically, floatable materials such as trash, debris, and hydrocarbons are removed through treatment processes that utilize the location of these pollutants on the water surface for removal. Stormwater treatment that incorporates vegetation and or permanent water bodies usually has a diverse microbial population, and it is not possible to optimize conditions for all beneficial species.
- **Sorption** - Sorption refers to the individual unit processes of both absorption and adsorption. Absorption is a physical process whereby a substance of one state is incorporated into another substance of a different state (e.g., liquids being absorbed by a solid or gases being absorbed by water). Adsorption is the physiochemical adherence or bonding of ions and molecules (ion exchange) onto the surface of another molecule. In stormwater treatment application, particularly for highway runoff, the primary pollutant types targeted with absorption unit processes are petroleum hydrocarbons, while adsorption processes typically target dissolved metals, nutrients, and organic toxicants such as pesticides and polycyclic aromatic hydrocarbons (PAHs). Different types of filter media may provide either or both of these unit processes.
- **Filtration** - Filtration can encompass a wide range of physical and chemical mechanisms, depending on the filtering media, typically some sand media,

natural soil, grassy vegetation, or mixes of chemically active ingredients such as perlite, zeolite, and granular activated carbon. Filtration removes particulate matter either on the surface of the filter or within the pore space of the filter. Filtration such as a sand filter can provide the added benefit of removing stormwater constituents that may be attached to solids such as metals and bacteria. Filtration can also provide opportunities for sorption processes to occur, reducing dissolved and fine suspended constituents. Filtration can often be an effective preliminary treatment for stormwater, by increasing the longevity of downstream BMPs and reducing maintenance frequency.

- **Uptake/Storage** - Uptake and storage refer to the removal of organic and inorganic constituents by plants and microbes through nutrient uptake and bioaccumulation. Nutrient uptake converts required micro- and macro-nutrients into living tissue. In addition to nutrients, various algae and wetland and terrestrial plants accumulate organic and inorganic constituents in excess of their immediate needs (bioaccumulation). The ability of plants to accumulate and store metals varies greatly. Significant metal uptake by plants will not occur unless the appropriate species are selected.
- **Microbially mediated transformation –** Microbial activity promotes or catalyzes redox reactions and transformations including degradation of organic and inorganic pollutants and immobilization of metals. Bacteria, algae, and fungi present in the soil or water column are primarily responsible for the transformations. Stormwater treatment that incorporates vegetation or permanent water pools usually has a diverse microbial population. These transformations can remove dissolved nitrogen species, metals, and simple and complex organic compounds. Soils may be inoculated with desirable microbes to promote specific reactions.

Table 1 summarizes the stormwater-related pollutants of concern considered to be effectively removed by each treatment mechanism.

Table 1. Treatment Mechanism- Target Pollutant Matrix		Mechanism					
		Hydrologic Attenuation [1]	Density Separation	Sorption (Chemical Activity)	Filtration	Uptake/Storage [2]	Microbial Transformation [3]
Target Pollutant	Sediment/Particulate (Suspended Solids)	■	■		■		
	Nutrients [4]	■	□	■		■	■
	Oil and Grease	■	■	■	■		■
	Polycyclic Aromatic Hydrocarbons (PAH)	■	□	■	□	■	■

	Metals (Particulate)	■	■		■		
	Metals (Dissolved)	■		■	□	□	□

■= Treatment mechanism effective for target pollutant removal

□= Depending on chemical activity or filter media

1 Refers to infiltration which is credited for overall pollutant mass load reduction of all target pollutants primarily through volume reduction; pollutant removal is also achieved through filtering, sorption, and microbial transformation in the soil column.

2 Dependent on plant species

3 Dependent on types of microbes present (in soil and water column)

4 May not be considered a highway target pollutant but included for completeness

3.5 Treatment Effectiveness Matrix

Based on information compiled in Table 2 relates the treatment mechanisms utilized by each of the BMPs included in the BMP Selection Tool. The table indicates whether the treatment mechanism is a key (or main) pollutant removal mechanism of the BMP, or whether it is a secondary (or "associated") mechanism.

The lower portion of Table 3 cross references Table 2 with the current list of BMPs to identify which target pollutants are addressed by each BMP. The table indicates whether the BMP has high, moderate, or low capability of removing a target pollutant. The rating is largely a function of whether the BMP employs the key treatment mechanism identified to be effective at removing that particular pollutant. A BMP may be rated moderate or low for a target pollutant if the key treatment mechanism is a secondary process within the BMP. Alternatively, a BMP may be rated high for a target pollutant if at least one key treatment mechanism occurs as part of the BMP treatment process.

In application, this approach indicates that all of the BMPs included in the BMP Selection Tool are considered highly capable of removing particulates and total suspended solids, while infiltration, bioretention, bioslope, and constructed wetlands are the BMPs with high capability to remove dissolved metals. Porous pavements are also considered effective at removing dissolved metals, but are not considered to be stand-alone BMPs and will require the approval of the Pavement Engineer prior to use on a project. Soil-amended grass swales and filter strips, extended dry detention ponds and wet ponds, proprietary filtration facilities and media filters may also be moderately effective for dissolved metals. Similarly, the matrix can be used to identify which BMPs are considered effective in removing the other target pollutants.

Table 2. Treatment Mechanism-BMP Matrix

		Best Management Practice																
		Pre-treatment		Infiltration				Filtration				Pool-Ponds			Space-Constrained or Urban Application			
		Oil Control Facilities	Sediment Control	Infiltration Pond	Bioretention	Bioslope	Porous Pavement (Not stand-alone)	Grass Swale (soil amended)	Filter Strip (soil amended)	Grass Swale (no soil amendment	Filter Strip (no soil amendment)	Constructed wetlands	Extended Detention Dry Pond	Wet Pond	Wet Vaults	Media Filters (non-proprietary)	Proprietary Separation	Proprietary Filtration Facilities
Treatment Mechanism	Hydrologic Attenuation			■	■	■	■	□	□	□	□	□	■	□				
	Density Separation (Sedimentation or Flotation)	■	■	□	□	□		□	□	□	□	■	■	■	■		■	
	Sorption	□		□	■	■		■	■	□	□	■	□	□		□	□	■
	Filtration	□	□	■	■	■		■	■	■	■	□	□	□		■	□	■
	Uptake/Storage[1]			□	■	□		□	□	□	□	■	□	□				
	Microbial Transformation[1]			□	■	□		□	□	□	□	■	□	□		□		□
Target Pollutant	Sediment/Particulate (TSS)	○	●	●	●	●	○	●	●	●	●	●	●	●	○	●	●	●
	Nutrients	□	□	●	●	●	○	○	○	○	○	●	○	○		-		
	Oil and Grease	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○
	Polycyclic Aromatic Hydrocarbons (PAH)	□	□	●	●	●	○	○	○	○	○	●	○	○		○		
	Metals (Particulate)	○	○	●	●	●	○	●	●	●	●	●	●	●	○	●	●	●
	Metals (Dissolved)	□		●	●	●	-	●	●	○	○	●	○	○		○		●

■ = Key treatment mechanism for BMP

□ = Associated treatment mechanism for BMP; dependent on plant species/ microbes present.

● = High capability to remove target pollutant

○ = Moderate capability to remove target pollutant

- = Low capability to remove target pollutant

1 Dependent on types of plant species or microbes (in soil and water column) present

Using "treatment mechanisms" (or unit processes) to define a BMP's effectiveness at removing target pollutants circumvents the need to rely strictly on the wide-ranging removal efficiency data for this purpose. It also allows for new BMPs to be easily integrated into the framework.

3.6 BMP Selection Tool – Metric Ratings

As noted above, the BMP Selection Tool includes metrics and ratings for treatment suitability (effectiveness) for POC, site suitability and physical constraints, maintenance needs and constraints, and costs. The draft ratings for the BMPs included in the BMP Selection Tool are summarized in Table 3.

Table 3. BMP Performance Summary Table		Best Management Practice																
		Pretreatment		Infiltration				Filtration				Pool-Ponds			Space-Constrained or Urban Application			
		Oil Control Facilities	Sediment Control	Infiltration Pond	Bioretention	Bioslope	Porous Pavement (Not stand-alone)	Grass Swale (soil amended)	Filter Strip (soil amended)	Grass Swale (no soil amendment	Filter Strip (no soil amendment)	Constructed wetlands	Extended Detention Dry Pond	Wet Pond	Wet Vaults	Media Filters (non-proprietary)	Proprietary Separation (pretreatment)	Proprietary Filtration Facilities
Rank: ●=High ○=Medium - =Low blank=none/not applicable																		
Application to Stormwater Management Objectives [1]	Water Quality	-	-	○	●	●	○	●	●	●	●	●	○	○	○	●	●	●
	Channel Protection	□	□	●	●	○	●	-	-	-	-	●	●	○	●		□	
	Peak Discharge	□	□	●	●	○	●	-	-	-	-	●	●	●	●	-	□	□
	Recharge	□	□	●	○	●	●	-	-	-	-	-	-	-		□	□	□
Receiving Water Application [2]	Drinking Water Protection	-	-	-	○	○	-	○	○	○	○	●	○	●	●	●	●	●
	Aquatic Species Protection	-	-	●	○	●	●	○	○	○	○	●	○	○	○	○	-	-
	Water Quality Protection	-	-	●	●	●	●	○	○	○	○	●	○	●	-	○	●	●
	Wetlands Protection	-	-	○	○	●	○	○	○	○	○	●	○	●	-	-	-	-
	Sensitive Water Protection	-	-	○	○	●	○	-	-	-	-	○	○	●	-	-	-	-
Water Quality Treatment Effectiveness [3]	Sediment/Particulate (Suspended Solids)	○	●	●	●	●	○	●	●	●	●	●	●	●	○	●	●	●
	Nutrients [4]	□	□	●	●	●	○	○	○	○	○	●	○	○		-		
	Oil and Grease	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○
	Polycyclic Aromatic Hydrocarbons (PAH)	□	□	●	●	●	○	○	○	○	○	●	○	○		○		

	Metals (Particulate)	○	○	●	●	●	○	●	●	●	●	●	●	●	○	●	●	●
	Metals (Dissolved)	□		●	●	●	-	●	●	○	○	●	○	○		○		●
Rank: ⇧=large ⇔=medium ⇩=small blank=none/not applicable																		
Physical Site Suitability [4]	Surface Area (large is greater area)	⇩	⇩	⇔	⇩	⇔	⇩	⇔	⇔	⇔	⇔	⇧	⇧	⇧	⇩	⇔	⇩	⇩
	Drainage Area (large is greater area)	⇩	⇩	⇧	⇩	⇔	⇩	⇔	⇔	⇔	⇔	⇧	⇧	⇧	⇩	⇩	⇩	⇩
	Soil Infiltration Rate (large is higher rate)	□	□	⇧	⇧	⇧	⇧	⇔	⇔	⇔	⇔	⇩	⇩	⇩	□	□	□	□
	Slope (gradient)(large is steeper)	□	□	⇩	⇔	⇩	⇩	⇔	⇔	⇔	⇔	⇩	⇔	⇩	□	⇩	□	□
	Groundwater depth (large is deeper)	□	□	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇧	⇧	⇧	□	⇧	□	□
	Confined space/safety (large is greater required)	⇧	⇔	⇩	⇩	TBD	TBD	⇩	⇩	⇩	⇩	⇩	⇔	⇔	⇧	⇩	⇧	⇧
	Dependency on Soil Characteristics	□	⇩	⇧	⇧	⇔	⇧	⇔	⇔	⇔	⇔	⇧	⇧	⇧	□	□	□	□
Rank: H=High M=medium L=Low blank=none/not applicable																		
Maintenance Factors	Maintenance Level of Effort	M	M+	M+	M	TBD	TBD	L	L	L	L	L	M	M+	H	M	H+	H
	Frequency of Maintenance	M	M+	M+	M+	TBD	TBD	L	L	L	L	L	M	M+	H	M	H	H
	Reliability/Durability (Appurtenances)	M	L	L	L	TBD	TBD	L	L	L	L	L	L	M+	H	L	H	H
	Need for "Specialized" equipment	M	L	H	L	TBD	TBD	L	L	L	L	L	L	M	H	L	H+	H
	Operation and Maintenance Cost (Including Waste Disposal)	H	M+	H	M	TBD	TBD	L	L	L	L	H	M+	H	H	M	H+	H
Rank: +=Favorable /=Neutral -=Unfavorable blank=none/not applicable																		
Non-Design Factors	Community Acceptance	/	/	/	+	+	/	/	/	/	/	+	/	/	/	/	/	/
	Construction Cost	/	/	-	/	/	-	+	+	+	+	-	-	-	-	/	/	/
	Wildlife Habitat			/	+	/		/	/	/	/	+	/	+				

*See notes below for Rating Categories

Assumes soil amendments (compost; organic materials) are used to enhance pollutant removal and effectiveness

Assumes appropriate plantings (e.g. metal hyper-accumulating species) are used.

Notes:

1. Application to Stormwater Management Objectives

Water Quality – Objective for sites subject to water quality goals or requirements (see Matrix Receiving Water Application Component). In almost all cases, water quality objective is applicable. Specific water quality objectives are addressed further under Matrix Reciving Water Application Component.
Channel Protection – Objective for sites subject to channel protection requirements to protect streams.
Peak Discharge – Objective for sites subject to flood control. In almost all cases, flood control objective is applicable.
Recharge – Objective for sites subject to a recharge requirement to infiltrate runoff.
(1) Ratings (low, medium, high) are qualitative in nature and are based on a compilation of design criteria and effectiveness factors. These rating are to be applied in the context of comparing BMPs within the BMP selection process.

2. Receiving Water Application

Drinking water Protection – For groundwater; use the sensitive lakes category to define BMP design restrictions for surface water drinking supplies.

Aquatic Species Protection – minimizes channel erosion; provides channel protection; promotes baseflow; stream temperature.
Water Quality Protection – provides enhanced pollutant removal for TMDL/303(d) listed pollutants of concern (corresponds with Matrix Water Quality Treatment Effectiveness Component).
Wetlands Protection – maintains wetland hydroperiods and provides enhanced removal of nutrient (phosphorus) loads.
Sensitive Lakes Protection – provides enhanced removal of nutrient loads (primarily phosphorus).
***Rating Notes:*
High – provides positive benefits to meet needs under receiving water category.
Medium – provides limited benefit or is not a detriment to receiving water category.
Low – Potentially detrimental to receiving water category.

3. Water Quality Treatment Effectiveness

Based on treatment mechanisms documented in Table 2.
Data Sources:
NCHRP. 2006. Evaluation of Best Management Practices and Low Impact Development for Highway Runoff Control.
Portland Bureau of Environmental Services. 2006. Effectiveness Evaluation of Best Management Practices for Stormwater Management in Portland, Oregon.
Water Environment Research Federation. Undated. International Stormwater BMP Database. www.bmpdatabase.org

4. Physical Site Suitability

Surface Area – size of surface area BMP requires in terms of percentage total contributing surface area.
Surface Area Rating: Small <5%; Medium <10%, Large >10% of impervious area
Drainage Area – size of drainage area generally acceptable for the "conventional" application of the BMP.
Drainage Area Rating: Small < 2 acres; Medium <10 acres, Large >10 acres of drainage area
Soil Infiltration Rate – acceptable soil infiltration rates for optimum BMP performance.
Soil Infiltration Rate Rating: Small < 0.5 in/hr; Medium <2.5 in/hr; Large >2.5 in/hr
Slope (gradient) – acceptable site slopes/topography to construct BMP and allow proper function.
Slope Rating: Small <2%; Medium <5%; Large >5% slope
Groundwater level – depth to groundwater allowable for proper function of BMP
Groundwater Level Rating: Shallow/Small <10 ft below ground surface; Medium <50 ft bgs; Deep/Large >50 feet bgs
Dependency on Soil Characteristics – Dependency as it relates to maintaining treatment effectiveness.

5. Maintenance Factors

Based on data provided by ODOT staff and consideration of literature.
Data Sources:
NCHRP. 2006. Evaluation of Best Management Practices and Low Impact Development for Highway Runoff Control.

6. Non-Design Factors
Community acceptance – accounts for general sense of visual preference, reported nuisance problems, vegetative management; subjective in nature.
Construction Cost – general cost rating to construct the BMP. Rating should not preclude preparing design-level engineering cost estimates when evaluating the preferred alternative.
Wildlife Habitat – provides potential habitat for wildlife.
***Ratings (favorable, neutral, unfavorable) are qualitative in nature and are based on a compilation of information from references on these factors. The rating is to be applied in the context of comparing BMPs within the BMP selection process.*

CHAPTER 4:

4 CONSTRUCTION SITE BEST MANAGEMENT PRACTICES

A critical next step in protecting water quality is the implementation of stormwater, non stormwater, and waste management control BMPs during construction. Construction Site BMPs are applied during construction activities to reduce the pollutants in storm water discharges throughout construction. These Construction Site BMPs provide both temporary erosion and sediment control. There are six categories of BMPs suitable for temporary erosion and sediment control on construction sites. They are:

- Soil Stabilization Practices;
- Sediment Control Practices;
- Tracking Control Practices;
- Wind Erosion Control;
- Non-storm Water Controls; and
- Waste Management and Material Pollution Controls.

It is generally accepted that practices that perform well by themselves can be complemented by other practices to raise the collective level of erosion control effectiveness and sediment retention. Effective erosion and sediment control planning relies on a system of BMPs (e.g., mulches for source control, fiber rolls on slopes for reducing runoff velocities, silt fence at the toe of slopes for capturing sediment, etc.) which is commonly referred to as a treatment train.

The greatest water pollution threat from soil-disturbing activities is the introduction of sediment from the construction site into storm drain systems or natural receiving waters. Soil-disturbing activities such as clearing, grading, grubbing, and earthwork increase the exposure of soils to wind, rain, and concentrated flows that cause erosion. A three-pronged approach is necessary to combat this storm water threat:

- Temporary soil stabilization practices reduce erosion associated with disturbed soil areas (DSAs).
- Temporary run-on control practices prevent storm water flows (sheet and concentrated) from contacting DSAs.
- Temporary sediment control practices reduce sediment caused by erosion from entering a storm drain system or receiving water.

Soil stabilization BMPs reduce the erosive impact of rain on exposed soil. Run-on control practices reduce the erosive impacts by preventing storm water flows from contacting DSAs. Sediment control BMPs remove sediment from storm water by ponding and settling, and/or filtering prior to discharge offsite. It is imperative that soil stabilization and sediment control BMPs are implemented together to reduce the discharge of sediment from the construction site.

The following conditions on construction sites contribute to erosion caused by storm water flows:

- Larger areas of impermeable structures and surfaces reduce natural infiltration resulting in increased storm water flow volume and velocity.
- Changes to surface flow patterns cause storm water flows to be more erosive.
- Concentration of flows to areas that are not naturally subjected to such runoff volume increases erosion.

Proper management of a construction project minimizes or prevents soil erosion and sediment discharges. Good construction management for soil conservation requires an understanding of the following basic principles:

Soil Erosion Control – The First Line of Defense

Soil stabilization is a key component in the control of erosion. By stabilizing DSAs with covers or binders, the exposed soils are less likely to erode from the effects of wind or rain.

Prevent Storm Water Flows from Contacting DSAs – The Second Line of Defense

Another key component in the control of erosion is the diversion of storm water flows around DSAs or the conveyance of flows through DSAs in a non-erosive manner.

Sediment Control – The Last Line of Defense

Storm water runoff may originate from active or inactive DSAs whether or not proper erosion and/or run-on controls have been implemented. Implementing proper sediment control BMPs can reduce sediment amounts in storm water discharges.

Combine Soil Erosion and Sediment Control – Effective Protection

An effective combination of soil erosion and sediment controls should be implemented to prevent sediment from leaving the site and/or entering a storm water drainage system or receiving water.

Soil stabilization and other erosion control BMPs are not 100 percent effective at preventing erosion. Soil erosion control BMPs must be supported by sediment control BMPs to capture sediment on the construction site.

Sediment control BMPs alone are not 100 percent effective primarily due to their capacity limits. To be effective for storm water protection, the amount of sediment must be reduced at the source using soil erosion control BMPs, and then sediment control BMPs are used to further reduce the sediment that leaves the site or enters the storm drain system.

Inspection and Maintenance – Ensure Protection for the Duration of the Project

Inspection and maintenance are required for all BMPs (soil stabilization, run-on control, and sediment control) to maintain effectiveness for reducing or eliminating the amount of sediment that leaves a site.

Post Construction

The key to getting the post-project site to function (from a stormwater runoff standpoint) similar to a natural, undisturbed site is to restore the functionality that has been removed. In general, the successful and sustainable erosion control solution addresses:

1. Soil Cover:

   Bare soil requires the protective cover provided by a mulch product (bark mulch, compost blanket, pine needles, straw, duff) or hydroseeding. These products protect the soil surface from erosion due to raindrop impact and sheet flow.

2. Healthy Soil:

   Healthy soils maintain stormwater quality and control erosion by their open structure that facilitates infiltration of runoff, and by providing the nutrients and soil biota necessary to support long-term sustainable vegetative cover. To maintain stormwater quality, disturbed roadsides that feature highly compacted sterile soils typically require de-compaction and/or incorporation of organics such as compost to restore soil health.

3. Sustainable Vegetation:

   Sustainable vegetation is dependent upon selecting the proper mixture of plant types (grass, annual, perennial, forb, cutting, sod, liner, woody shrub) and species for specific site environmental conditions (geographic location, elevation, exposure, soil type). The short-term goal is to quickly establish vegetative cover to provide protection from raindrop impact and sheet-flow erosive forces. The long-term goal is to establish healthy mature vegetation that requires minimal replanting, supplemental water, or maintenance.

An erosion control solution that ensures that well drained soil including organic material and healthy soil biota, a surface mulch layer of duff/mulch, together with regionally appropriate plant material mimics the functionality of the natural environment, and with time should perform in a similar manner - protecting water quality and managing the runoff rate and volume.

4.1 Construction Operations and Applicable Best Management Practices Matrix

Prior to any ground disturbing activities, the physical condition of the construction site and adjacent areas should be reviewed by members of the PDT and Contractor Construction Staff. A project design package showing what is being constructed, limits of construction, avoidance areas/ sensitive areas, project schedule, and contract requirements will be provided to contractor. Site characteristics including drainage patterns, soils, vegetation, surface water bodies, and steep or unstable slopes should be noted. If available, the hydrology report, soils report, and a grading/drainage plan should also be consulted. Physical conditions at the site will change as construction progresses; BMP application should change accordingly to ensure effective protection is maintained throughout construction milestones.

To meet regulatory requirements and protect the site resources, every project must include an effective combination of erosion and sediment control measures within the SWPPP/IWPPP. These measures must be selected from all of the BMP categories presented in this section: soil stabilization practices, sediment control practices, tracking control practices, and wind erosion control practices. Additionally, the project plan must include non-storm water controls, waste management and material pollution controls. These practices are identified in the erosion control plan, also known as the SWPPP.

The SWPPP/IWPPP is more than just and erosion control plan. A SWPPP is a tool that aids in managing pollution during construction. A SWPPP is a written documents that describe the pollution prevention practices and activities that will be implemented on the site. It includes descriptions of the site and of each major phase of the planned activity, the roles and responsibilities of contractors and subcontractors, procedures that will be implemented to comply with the terms and conditions of the construction general permit and the inspection schedule and logs. It is also a place to document changes and modifications to the construction plans and associated stormwater pollution prevention activities.

Also, SWPPPs are designed to be amended whenever there is a change in design, construction, operation, or maintenance, which has a significant effect on the potential for discharge of pollutants to surface WUS, state or a MS4. The SWPPP is also amended if BMPs prove to be ineffective in managing POCs from sources identified during inspection, or when any new contractor and/or subcontractor will implement any measure of the SWPPP. All amendments are signed, dated, and kept as attachments to the original SWPPP. This ensures that SWPPPs are kept up to date with changes on the construction site.

However, historically many key construction permit applications (including the 404 and 401-water quality certifications) have required that a list of appropriate BMPs proposed for a specific project, along with the required site plan, description, and location of those BMPs be provided. A common issue with this approach is that a construction contractor has not been selected at the time of issuance for these permits. To address this, the project designer provides layout sheets showing the suggested locations of Construction Site BMPs. The purpose of these sheets is to show the contractor the designer's anticipated placement of Construction Site BMPs such as contractor staging areas, approximate location of concrete washouts, approximate locations for storage of materials, and preferred locations for vehicle and equipment maintenance. However, the contractors input into the layout are unavailable during development. Typically, these layouts are not highly detailed drawings and are commonly drawn on l:200 and l:500 scale. Where multiple stages of construction are anticipated, the designer attempts to show the various stages of construction and how the deployment of the BMPs is expected to change over time. These locations and layouts will be, in most cases, subject to the contractor's phasing of the work and timing of operations. As a result, many of the suggested locations are immediately modified by the contractor in the SWPPP/IWPPP as construction phasing is identified.

Contractors and designers need to carefully think through many factors to choose the most appropriate, effective and feasible practice(s) at a construction site that will best

meet Federal, state and local stormwater and water quality objectives. Rather than relying on the suggested temporary BMP locations, and acknowledging the Contractor is ultimately responsible for developing a SWPPP that complies with the Permit, FHWA is attempting to factor in more flexibility into BMP selection.

Proper BMP selection requires that a stormwater manager select those BMPs most able to address an identified pollution source. Selecting an inappropriate BMP for a site could lead to adverse resource impacts, friction with regulators if a BMP does not work as anticipated, misperceptions about stormwater control success, and wasted time and money. Careful selection of BMPs will prevent negative impacts from installing the wrong BMP at the wrong location. .

The number, location and type of applicable BMPs is variable and depends on project design and generally must be determined on a case by-case basis. There is no minimum number of practices that are appropriate to various projects. Following permit approval, it is common that BMPs need to be modified as a contractor develops their methods and means of construction on the project. This commonly requires that BMPs be modified, moved, or substituted to ensure they continue to meet project goals. The SWPPP is a living document and must be developed or amended to address conditions as activities change at the site. The utilization of preferred construction BMPs from six control categories allows improved coordination with the contractor during the development of the SWPPP and adaptive management of BMPs during construction as one preferred construction BMPs is substituted for another in the SWPPP/IWPPP rather than being static.

The goal of the below matrices is to allow a suite of preferred construction BMPs to be identified during the permitting process. Following permit approvals, the PDT including contractors can then use the project design specifications to refine the BMP list in the project site plan of the SWPPP/IWPPP. This approach allows projects to adaptively manage project BMPs as site conditions change, construction phasing changes or construction milestones are reached.

The BMP Matrices in this section cross-reference individual BMPs with the most common construction activities that can release pollutants. Therefore, in Table 4 the horizontal axis of the matrix (across the top) lists typical highway construction activities. The BMPs appropriate for those construction activities are listed on the vertical axis (down the left hand side of the page). This table groups BMPs with major construction operations which will assist with BMP management during construction phasing.

The matrix in Table 5 further refines the construction BMPs by grouping BMPs into BMP categories including: soil stabilization practices, sediment control practices, tracking control practices, and wind erosion control practices, non-storm water controls, waste management and material pollution controls. These BMP categories are cross referenced against typical highway construction activities.

Detailed descriptions and guidance regarding implementation of these BMPs may be found in the Construction BMP Field Manual (Appendix A), CFLHD Design Standards (Appendix E) or the Clear Water Diversion and Isolation Techniques (Chapter 5) which summarizes additional BMPs suitable for construction activities in, over or adjacent to

water or when water diversion and isolation techniques are required to complete the necessary construction activities.

The BMP Matrix includes the best information available to the FHWA and HDOT at this time regarding practices known to be appropriate for transportation projects. It is anticipated that this manual will be revised and supplemented in subsequent reviews of available BMP technologies. The list of BMPs provided in the matrix is not intended to be exhaustive. Rather, it is intended that members of the PDT may select BMPs other than those included in the BMP Matrix, so long as they treat the same POC and are an appropriate BMP for the particular construction activity.

The matrix format in Table 4 and 5 reflects the fact that there are a variety of BMPs that may be appropriate for a given project and that each project's circumstances are unique. The matrix identifies the most likely BMPs appropriate for different types of projects and for different types of pollutant scenarios. It also assists the PDT in determining if a specific BMP is not appropriate to a specific scenario. The individual BMPs designated by an "X" in Table 5 have been identified as applicable to a particular typical construction activity, but will not necessarily be appropriate for all projects involving the noted activity. For example, not all projects will have on-site vehicle fueling and maintenance operations; however, those that do will be required to conduct those operations in a manner consistent with the intent of the BMP description (Appendix A, Appendix E). These tables can assist construction staff to determine if a proposed practice is actually applicable to the desired pollution prevention or environmental protection outcome. It is intended to be a flexible tool.

Table 4. Storm Water BMPs for Construction Operations

Construction Operation	BMP Category	BMPs
Mobilization	Sediment Control	Street Sweeping and Vacuuming
	Tracking Control	Stabilized Construction Entrance/Exit
		Stabilized Construction Roadway
		Entrance/Outlet Tire Wash
	Non-Stormwater Control	Illicit Connection / Illegal Discharge Detection and Reporting
	Waste Management and Materials Pollution Control	Material Delivery and Storage
		Material Use
		Spill Prevention and Control
		Solid Waste Management
		Hazardous Waste Management
		Sanitary/Septic Waste Management
Clearing/Grubbing	Soil Stabilization	Scheduling
		Preservation of Existing Vegetation
		Hydraulic Mulch
		Hydroseeding
		Soil Binders
		Straw Mulch
		Geotextiles, Plastic Covers & Erosion Control Blankets/Mats
		Wood Mulching
		Earth Dikes/Drainage Swales & Lined Ditches
		Outlet Protection/Velocity Dissipation Devices
		Slope Drains
	Sediment Control	Silt Fence
		Desilting Basin
		Sediment Trap/ Filter bags
		Check Dam
		Fiber Rolls
		Gravel Bag Berm
		Street Sweeping and Vacuuming
		Sandbag Barrier
		Straw Bale Barrier
		Storm Drain Inlet Protection
	Wind Erosion Control	Wind Erosion Control
	Non-Stormwater Management	Water Conservation Practices
		Vehicle and Equipment Cleaning
		Vehicle and Equipment Fueling
		Vehicle and Equipment Maintenance
	Waste Management and Materials Pollution Control	Stockpile Management
		Solid Waste Management
		Contaminated Soil Management

Table 4. Storm Water BMPs for Construction Operations

Construction Operation	BMP Category	BMPs
Earthwork	Soil Stabilization	Scheduling
		Preservation of Existing Vegetation
		Hydraulic Mulch
		Hydroseeding
		Soil Binders
		Straw Mulch
		Geotextiles, Plastic Covers & Erosion Control Blankets/Mats
		Wood Mulching
		Earth Dikes/Drainage Swales & Lined Ditches
		Outlet Protection/Velocity Dissipation Devices
		Slope Drains
	Sediment Control	Silt Fence
		Desilting Basin
		Sediment Trap / Filter bags
		Check Dam
		Fiber Rolls
		Gravel Bag Berm
		Street Sweeping and Vacuuming
		Sandbag Barrier
		Straw Bale Barrier
		Storm Drain Inlet Protection
	Tracking Control	Stabilized Construction Entrance/Exit
	Wind Erosion Control	Wind Erosion Control
	Non-Stormwater Management	Temporary Stream Crossing
		Vehicle and Equipment Cleaning
		Vehicle and Equipment Fueling
		Vehicle and Equipment Maintenance
	Waste Management and Materials Pollution Control	Contaminated Soil Management
Portland Cement Concrete and Asphalt / Concrete Operations	Sediment Control	Street Sweeping and Vacuuming
	Tracking Control	Stabilized Construction Entrance/Exit
	Non-Stormwater Management	Paving and Grinding Operations
	Waste Management and Materials Pollution Control	Material Delivery and Storage
		Material Use
		Stockpile Management
		Solid Waste Management
		Concrete Waste Management
Drainage Work	Sediment Control	Desilting Basin
		Sediment Trap / Filter bags
		Check Dam
		Storm Drain Inlet Protection
	Soil Stabilization	Earth Dikes/Drainage Swales & Lined Ditches

Table 4. Storm Water BMPs for Construction Operations

Construction Operation	BMP Category	BMPs
		Outlet Protection/Velocity Dissipation Devices
Dewatering Operations	Non-Stormwater Management	Dewatering Operations
Bridge Construction	Non-Stormwater Management	Water Conservation Practices
		Paving and Grinding Operations
		Temporary Stream Crossing
		Clear Water Diversion and Isolation Techniques
		Vehicle and Equipment Cleaning
		Vehicle and Equipment Fueling
		Vehicle and Equipment Maintenance
	Waste Management and Materials Pollution Control	Material Delivery and Storage
		Material Use
		Stockpile Management
		Spill Prevention and Control
		Solid Waste Management
		Hazardous Waste Management
		Concrete Waste Management
		Liquid Waste Management
	Non-Stormwater Control	Paving and Grinding Operations
		Temporary Stream Crossing
		Clear Water Diversion and Isolation Techniques
Roadway Construction	Waste Management and Materials Pollution Control	Material Delivery and Storage
		Material Use
		Stockpile Management
		Solid Waste Management
		Hazardous Waste Management
		Concrete Waste Management
		Liquid Waste Management
Mobile Operations	Sediment Control	Street Sweeping and Vacuuming
		Storm Drain Inlet Protection
	Tracking Control	Stabilized Construction Entrance/Exit
	Non-Stormwater Control	Vehicle and Equipment Cleaning
		Vehicle and Equipment Fueling
		Vehicle and Equipment Maintenance
	Waste Management and Materials Pollution Control	Material Delivery and Storage
		Material Use
		Stockpile Management
		Solid Waste Management
		Hazardous Waste Management
		Concrete Waste Management
Trenching Operations	Sediment Control	Street Sweeping and Vacuuming
		Storm Drain Inlet Protection

Table 4. Storm Water BMPs for Construction Operations

Construction Operation	BMP Category	BMPs
	Waste Management and Materials Pollution Control	Stockpile Management
Erosion Control, Highway Planting and Landscaping	Soil Stabilization	Scheduling
		Preservation of Existing Vegetation
		Hydraulic Mulch
		Hydroseeding
		Soil Binders
		Straw Mulch
		Geotextiles, Plastic Covers & Erosion Control Blankets/Mats
		Wood Mulching
		Earth Dikes/Drainage Swales & Lined Ditches
		Outlet Protection/Velocity Dissipation Devices
	Sediment Control	Silt Fence
		Street Sweeping and Vacuuming
		Sandbag Barrier
		Straw Bale Barrier
		Storm Drain Inlet Protection
	Wind Erosion Control	Wind Erosion Control
	Non-Stormwater Control	Potable Water/Irrigation
		Vehicle and Equipment Cleaning
	Waste Management and Materials Pollution Control	Material Delivery and Storage
		Material Use

Table 5: Construction Site BMPs By Construction Activity

	Typical Highway Construction Activities																											
	Demolish Pavement/Structure	Clear and Grub	Construct Access Roads	Grading (including cut and fill slopes)	Channel Excavation	Channel Paving	Trenching/ Underground Drainage	Underground Drainage Facility Installation	Drainage Inlet Modification	Utility Trenching	Utility Installation	Subgrade Preparation	Base Paving	Asphalt Concrete Paving	Concrete Paving	Saw Cutting	Joint Sealing	Grind/Groove	Structure Excavation	Erect Falsework	Bridge/Structure Construction	Remove Falsework	Striping	Miscellaneous Concrete Work	Sound Walls/Retaining Walls	Planting and Irrigation	Contractor Activities	Treatment BMP Construction
Best Management Practices																												
Temporary Sediment Control																												
Silt Fence	X	X	X	X	X		X			X		X							X		X					X		X
Sandbag Barrier	X	X	X	X	X		X			X		X							X		X					X		X
Straw Bale Barrier	X	X	X	X	X		X			X		X							X		X					X		X
Fiber Rolls	X	X	X	X	X		X			X											X					X		X
Gravel Bag Berm	X	X	X	X	X		X			X											X					X		X
Check Dam	X	X		X	X		X																					X
Desilting Basin	X	X	X	X	X																X					X		X
Sediment Trap / Filter Bags	X	X	X	X	X		X			X		X							X		X					X		X
Sediment Basin		X		X	X																X					X		X
Temporary Soil Stabilization																												
Hydraulic Mulch	X	X		X	X																X					X		X
Hydroseeding	X	X		X	X																X					X		X
Soil Binders	X	X		X	X														X		X					X		X
Straw Mulch	X	X	X	X	X		X	X		X		X							X		X					X		X
Geotextiles, Mats/Plastic Covers and Erosion Control	X	X	X	X	X		X	X		X		X							X		X					X		X

Table 5: Construction Site BMPs By Construction Activity

	Typical Highway Construction Activities																									
	Demolish Pavement/Structure	Clear and Grub	Construct Access Roads	Grading (including cut and fill slopes)	Channel Excavation	Channel Paving	Trenching/ Underground Drainage	Underground Drainage Facility Installation	Drainage Inlet Modification	Utility Trenching	Utility Installation	Subgrade Preparation	Base Paving	Asphalt Concrete Paving	Concrete Paving	Saw Cutting	Joint Sealing	Grind/Groove	Structure Excavation	Erect Falsework	Bridge/Structure Construction	Remove Falsework	Striping	Miscellaneous Concrete Work	Sound Walls/Retaining Walls	Planting and Irrigation	Contractor Activities	Treatment BMP Construction
Best Management Practices																												
Scheduling	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X
Preservation of Existing Vegetation		X	X	X			X	X		X									X	X		X			X			
Temporary Concentrated Flow Conveyance Controls																												
Earth Dikes/Drainage Swales & Lined Ditches		X	X	X																	X							
Outlet Protection/Velocity Dissipation Devices		X	X	X																	X							
Slope Drains				X																	X							
Temporary Stream Crossing			X				X	X		X	X									X	X	X		X				
Clear Water Diversion and Isolation Techniques	X		X		X	X														X	X	X			X			X
Wind Erosion Control		X	X	X	X		X			X		X	X	X	X											X		X
Sediment Tracking Control	X	X	X	X	X		X	X		X	X	X	X	X	X	X		X	X		X				X	X	X	X

Table 5: Construction Site BMPs By Construction Activity

	Typical Highway Construction Activities																											
	Demolish Pavement/Structure	Clear and Grub	Construct Access Roads	Grading (including cut and fill slopes)	Channel Excavation	Channel Paving	Trenching/ Underground Drainage	Underground Drainage Facility Installation	Drainage Inlet Modification	Utility Trenching	Utility Installation	Subgrade Preparation	Base Paving	Asphalt Concrete Paving	Concrete Paving	Saw Cutting	Joint Sealing	Grind/Groove	Structure Excavation	Erect Falsework	Bridge/Structure Construction	Remove Falsework	Striping	Miscellaneous Concrete Work	Sound Walls/Retaining Walls	Planting and Irrigation	Contractor Activities	Treatment BMP Construction
Best Management Practices																												
Street Sweeping and Vacuuming	X	X	X	X	X		X	X		X	X	X	X	X	X	X		X	X		X				X	X	X	X
Stabilized Construction Roadway		X	X	X																								
Entrance/Outlet Tire Wash		X	X	X																						X	X	
Waste Management																												
Spill Prevention and Control	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Solid Waste Management	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hazardous Waste Management	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Contaminated Soil Management	X	X		X			X	X		X	X									X								
Concrete Waste Management	X		X			X		X			X		X		X	X		X	X		X			X	X	X	X	X
Sanitary/Septic Waste Management	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Liquid Waste Management														X		X	X		X		X		X				X	X

Table 5: Construction Site BMPs By Construction Activity

	Typical Highway Construction Activities																									
	Demolish Pavement/Structure	Clear and Grub	Construct Access Roads	Grading (including cut and fill slopes)	Channel Excavation	Channel Paving	Trenching/ Underground Drainage	Underground Drainage Facility Installation	Drainage Inlet Modification	Utility Trenching	Utility Installation	Subgrade Preparation	Base Paving	Asphalt Concrete Paving	Concrete Paving	Saw Cutting	Joint Sealing	Grind/Groove	Structure Excavation	Erect Falsework	Bridge/Structure Construction	Remove Falsework	Striping	Miscellaneous Concrete Work	Sound Walls/Retaining Walls	Planting and Irrigation	Contractor Activities	Treatment BMP Construction
Best Management Practices																												
Materials Handling																												
Material Delivery, and Storage	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Material Use	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Vehicle and Equipment Operations																												
Vehicle and Equipment Cleaning	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Vehicle and Equipment Fueling	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Vehicle and Equipment Maintenance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Paving Operations			X			X			X				X	X	X	X	X	X			X							
Stockpile Management	X		X					X		X	X		X	X	X			X										
Water Conservation Practices	X	X	X	X	X	X	X	X	X	X		X				X	X	X	X		X			X		X	X	X

Table 5: Construction Site BMPs By Construction Activity

	Typical Highway Construction Activities																										
	Demolish Pavement/Structure	Clear and Grub	Construct Access Roads	Grading (including cut and fill slopes)	Channel Excavation	Channel Paving	Trenching/ Underground Drainage	Underground Drainage Facility Installation	Drainage Inlet Modification	Utility Trenching	Utility Installation	Subgrade Preparation	Base Paving	Asphalt Concrete Paving	Concrete Paving	Saw Cutting	Joint Sealing	Grind/Groove	Structure Excavation	Erect Falsework	Bridge/Structure Construction	Remove Falsework	Striping	Miscellaneous Concrete Work	Sound Walls/Retaining Walls	Planting and Irrigation	Contractor Activities	Treatment BMP Construction
Best Management Practices																											
Potable Water/Irrigation																											
Dewatering Operations	X			X	X	X	X	X	X	X	X								X		X			X	X	X		X
Illicit Connection/Illegal Discharge Detection and																											
Storm Drain Inlet Protection	X	X	X	X	X		X	X	X	X		X	X			X	X	X	X								X	X
Stabilized Construction Entrance/Exit		X	X	X																						X		X

X BMP may be applicable to activity

4.2 CONSTRUCTION BMPS

Specifications for construction BMPs can be found in FHWA FP 14 Standard Specifications and HDOT Construction BMP Field Manual (Appendix A) and CFLHD Standard Details (Appendix E).

4.2.1 SOIL STABILIZATION BMPS

Examples of Temporary Soil Stabilization BMPs include:

- Scheduling;
- Preservation of Existing Vegetation;
- Hydraulic Mulch;
- Hydroseeding;
- Soil Binders;
- Straw Mulch;
- Geotextiles, Plastic Covers and Erosion Control Blankets;
- Wood Mulching;
- Earth Dikes/Drainage Swales and Ditches;
- Outlet Protection/Velocity Dissipation Devices; and
- Slope Drains.

Provided on Table 5 are selection criteria information and ratings for temporary soil stabilization BMPs. The BMPs are described in detail following Table 6.

Table 6: Temporary Soil Stabilization Criteria Matrix

CLASS	TYPE	TEMPORARY SOIL STABILIZATION CONTROL CRITERIA													
		Antecedent Moisture	Availability	Ease of Clean-Up	Installed Cost Per Ha	EC Effectiveness (%)	Degradability	Length of Drying Time (hrs)	Time to Effectiveness (days)	Longevity	Mode of Application	Residual Impact	Native	Runoff Effect	Water Quality Impact
CATEGORY: STANDARD BIODEGRADABLE MULCHES (SBM)															
Straw Mulch	Wheat Straw	D	S	H	$5,200	90-95	B	0	1	M	L/M	M		+	M
	Rice Straw	D	S	H	$5,200	90-95	B	0	1	M	L/M	M		+	L
Wood Fiber Mulch	Wood Fiber	D	S	H	$2,200	50-60	B	0-4	1	M	H	L		+	M
Recycled Paper Mulch	Cellulose Fiber	D	S	H	$2,100	50-60	B	0-4	1	S	H	L		+	L
Bonded Fiber Matrix	Biodegradable	D	S	H	$13,600	90-95	B	12-18	1	M	H	M		+	H
CATEGORY: ROLLED EROSION CONTROL PRODUCTS (RECP)															
Biodegradable	Jute Mesh	D	S	H	$16,000	65-70	B		1	M	L	M		+	UNK
	Curled Wood Fiber	D	S	H	$26,000	85-90	P/B		1	M	L	M		+	L
	Straw	D	S	H	$22,000	85-90	P/B		1	M	L	M		+	H
	Wood Fiber	D	S	H	$22,000	85-90	P/B		1	M	L	M		+	L
	Coconut Fiber	D	S	H	$32,000	90-95	P/B		1	L	L	M		+	L
	Coconut Fiber Mesh	D	S	H	$77,000	85-90	B		1	L	L	M		+	UNK
	Straw Coconut Fiber	D	S	H	$27,000	90-95	P/B		1	L	L	M		+	M
Non-Biodegradable	Plastic Netting	D	M	H	$5,000	<50	P		1	L	L	H		+	UNK
	Plastic Mesh	D	M	H	$8,000	75-80	P		1	L	L	H		+	UNK
	Synthetic Fiber with Netting	D	M	H	$86,000	90-95	P		1	L	L	H		+	UNK
	Bonded Synthetic Fibers	D	M	H	$121,000	90-95	P		1	L	L	H		+	UNK
	Combination with Biodegradable	D	M	H	$79,000	85-90	P		1	L	L	H		+	UNK
CATEGORY: TEMPORARY SEEDING (TS)															
High-Density	Ornamentals		S-M	H	$1000 - $4000	50-60			28	M-L	H	L-M	N/E	+	UNK

	Turf species		S	H	$900	50-60			28	L	H	M-H	N/E	+	UNK
	Bunch grasses		S-M	H	$750 - $3200	50-60			28	L	H	L-M	N	+	UNK
Fast-Growing	Annual		S	H	$900 - $1,600	50-60			28	L	H	L-H	N/E	+	UNK
	Perennial		S	H	$800 - $2000	50-60			28	L	H	M	N/E	+	UNK
Non-Competing	Native		S-M	H	$700 - $4000	50-60			28	L	H	L-M	N	+	UNK
	Non-Native		S-M	H	$1000 - $1200	50-60			28	L	H	L-H	E	+	UNK
Sterile	Cereal Grain		S	H	$1,200	50-60			28	L	H	L	E	+	UNK
CATEGORY: IMPERVIOUS COVERS (IC)																
Plastic	Rolled Plastic Sheeting		S		$17,000	100	P		1	M	L	H		-	UNK
	Geotextile (Woven)		S		$14,800	90-95	P		1	M	L	H		-	UNK
CATEGORY: HYDRAULIC SOIL STABILIZERS (HSS)																
(PBS) Plant Material Based- Short Lived	Guar	D	S	H	$1,000	80-85	B	12-18	Same as Length of	S	B	L		0/+	M/L
	Psyllium	P	S	H	$1,000	25-35	B	12-18		M	B	L		0	L/H
	Starches	D	S	H	$1,000	25-30	B	9-12		S	H	L		0	L
(PBL) Plant Material Based- Long Lived	Pitch/ Rosin Emulsion	D	S	M	$3,000	60-75	B	19-24		M	B	M		-	H
(PEB) Polymeric Emulsion Blends	Acrylic polymers and copolymers	D	S	M	$3,000	35-70	P/C	19-24		L	B	M		+/-	L/M
	Methacrylates and acrylates	D	M	M	$1,000	35-40	P/C	12-18		S	W	L		0/+	L
	Sodium acrylates and acrylamides	D	M	M	$1,000	20-70	P/C	12-18		S	H	L		+/-	L/M
	Polyacrylamide	D	M	M	$1,000	55-65	P/C	4-8		M	H	L		0/+	L
	Hydro-colloid polymers	D	M	H	$1,000	25-40	P/C	0-4		M	H	L		0/+	L/M
(PRB) Petroleum/ Resin-Based Emulsions	Emulsified Petroleum Resin	D	M	L	$3,000	10-50	P/C	0-4		M	B	M		0/-	H
(CBB) Cementitious Based Binders	Gypsum	D	S	M	$2,000	75-85	P/C	4-8		M	H	L		-	M/H

Antecedent Moisture	D P	Soil should be relatively dry before application Soil should be pre-wetted before application
Availability	S M	A short turn-around time between order and delivery, usually 3-5 days A moderate turnaround time, between 1-2 weeks
Ease of Clean-Up	L M H	Require pressure washing, a strong alkali solution, or solvent to clean up Requires cleanup with water while wet; more difficult to clean up once dry May be easily removed from equipment and overspray areas by a strong stream of water
Installed Cost		Dollars per hectare
Degradability	C P B	Chemically degradable Photodegradable Biodegradable
Length of Drying Time		Estimated hours
Time to Effectiveness		Estimated days
Erosion Control Effectiveness		Percent reduction in soil loss over bare soil condition.
Longevity	S M L	1 - 3 months 3 – 12 months > than 12 months

Application Mode	L W H B M	Applied by hand labor Applied by water truck Applied by hydraulic mulcher Applied by either water truck or hydraulic mulcher Applied by a mechanical method other than those listed above (e.g., straw blower)
Residual Impact	L M H	Projected to have a low impact on future construction activities Projected to have a moderate impact on future construction activities Projected to have a significant impact on future construction activities
Native	N E	Plant or plant material native to the State of Hawaii Exotic plant not native to the State of Hawaii
Runoff Effect	+ 0 -	Runoff is decreased over baseline (bare soil) No change in runoff from baseline Runoff is increased over baseline
Water Quality Impact	L M H	Low potential to impact water quality Moderate potential to impact water quality Higher potential to impact water quality

4.2.1.1 Scheduling

This BMP involves developing, for every project, a schedule that includes sequencing of construction activities with the implementation of Construction Site BMPs such as temporary soil stabilization (erosion control) and temporary sediment control measures. The purpose is to reduce the amount and duration of soil exposed to erosion by wind, rain, runoff and vehicle tracking, and to perform the construction activities and control practices in accordance with the planned schedule.

4.2.1.2 Preservation of Existing Vegetation

Preservation of existing vegetation is the identification and protection of desirable vegetation that provides erosion and sediment control benefits. Whenever practical, existing vegetation should be preserved. Plants and trees act as effective soil stabilization and sediment control devices, particularly around the perimeter of construction sites. Areas that will not be disturbed as part of construction activities should be clearly marked on plans and protected in the field with fencing prior to clearing and grubbing. Access limitations should also be shown on the plans and described in the Special Contract Requirements (SCR). Any damage to preservation areas should be repaired immediately.

Items to consider when preserving existing vegetation include:

- Preserve existing vegetation to provide effective erosion control;
- Consider the age, life expectancy, health, aesthetic value, and habitat benefits of vegetation to be preserved;
- Areas containing vegetation to be preserved must be shown on the plans; and
- Preserve native plants on the site wherever possible.

4.2.1.3 Hydraulic Mulch

Hydraulic mulch consists of applying a water-based mixture of wood or paper fiber and stabilizing emulsion with hydro-mulching equipment. This will protect disturbed soil from erosion by raindrop impact or wind.

4.2.1.3.1 Type: Wood Fiber

Wood fiber mulch is generally used as a component of hydraulic applications. It is usually used in combination with seed, fertilizer and other materials, and is typically applied at the rate of 2,250 to 4,500 kilograms per hectare (kg/ha).

Wood fiber mulch can be specified with or without a tackifier. Data shows that wood fiber mulches with tackifiers have better erosion control performance.

4.2.1.3.2 Type: Recycled Paper

Recycled paper mulch is generally used in hydraulic applications. It is usually used in combination with seed and fertilizer and is typically applied at the rate of 2,250 to 4,500 kg/ha.

4.2.1.3.3 Type: Cellulose Fiber

Cellulose fiber mulch contains fibers of shorter length than wood fiber mulches and is typically made from recycled newsprint, magazine, or other waste paper sources. It can be specified with or without a tackifier.

4.2.1.3.4 Type: Bonded Fiber Matrix

A bonded fiber matrix (BFM) is a hydraulically applied system of fibers and adhesives that upon drying forms an erosion-resistant blanket that promotes vegetation, and prevents soil erosion. BFMs are typically applied at rates from 3,400 to 4,500 kg/ha based on the manufacturer's recommendation.

The biodegradable BFM is composed of materials that are 100% biodegradable. The binder in the BFM should also be biodegradable and should not dissolve or disperse upon re-wetting. Typically, biodegradable BFMs should not be applied immediately before, during or immediately after rainfall so that the matrix will have an opportunity to dry for 24 hours after application.

4.2.1.4 Hydro seeding

Hydro seeding consists of applying a water-based mixture of wood or paper fiber, stabilizing emulsion, and seed with hydro-mulching equipment. This is usually a multi-step process with a layer of straw. Often fertilizer and compost are added to the hydraulic mixture. This will protect disturbed soil from erosion by raindrop impact or wind. Hydraulic mulches are typically combined with a seed mixture for achieving longer term temporary soil stabilization than by hydraulic mulching alone. The selection of plant materials to be included in the seed mixture can be based, in part, on the length of time temporary stabilization is required.

4.2.1.5 Soil Binders

Soil binders, also known as soil stabilizers, are adhesives that stabilize soil by binding soil particles together. This will protect disturbed soil from erosion by raindrop impact or wind. Soil binders can also be used in combination with hydraulic mulches to improve their erosion control effectiveness.

There are five types of soil binders:

- Plant Material-Based (Short-Term);

- Plant Material-Based (Long-Term);
- Polymeric Emulsion Blends;
- Petroleum or Resin-Based Emulsions; and
- Cementitious-Based Binders.

4.2.1.5.1 Type: Plant-Material Based (Short-Term)

4.2.1.5.1.1 Guar

Guar is a non-toxic, biodegradable, natural galactomannan-based hydrocolloid treated with dispersant agents for easy field mixing. It should be applied at the rate of 1.2 to 1.8 kg per 1,000 liters of water, depending on application machine capacity. Recommended minimum application rates are as follows:

Application Rates for Guar Soil Stabilizer

Slope (V:H):	Flat	1:4	1:3	1:2	1:1
Kg/ha:	45	50	56	67	78

4.2.1.5.1.2 Psyllium

Psyllium is composed of the finely ground muciloid coating of plantago seeds that is applied as a dry powder or in a wet slurry to the surface of the soil. It dries to form a firm but re-wettable membrane that binds soil particles together but permits germination and growth of seed. Psyllium requires 12 to 18 hours drying time. Application rates are generally 90 to 225 kg/ha, with enough water in solution to allow for a uniform slurry flow.

4.2.1.5.1.3 Starch

Starch is non-ionic, cold-water soluble (pre-gelatinized) granular cornstarch. The material is mixed with water and applied at the rate of 170 kg/ha. Approximate drying time is 9 to 12 hours.

4.2.1.5.2 Type: Plant-Material Based (Long-Term)

4.2.1.5.2.1 Pitch and Rosin Emulsion

Generally, a non-ionic pitch and rosin emulsion has a minimum solids content of 48%. The rosin should be a minimum of 26% of the total solids content. The soil stabilizer should be non-corrosive, water-dilutable emulsion that upon application cures to a water insoluble binding and cementing agent. For soil erosion control applications, the emulsion is diluted as follows:

- For clayey soil: 5 parts water to 1 part emulsion
- For sandy soil:10 parts water to 1 part emulsion

Application can be by water truck or hydraulic seeder with the emulsion/product mixture applied at the rate specified by the manufacturer.

4.2.1.5.3 Type: Polymeric Emulsion Blends

4.2.1.5.3.1 Acrylic Copolymers and Polymers

Polymeric soil stabilizers should consist of a liquid or solid polymer or copolymer with an acrylic base that contains a minimum of 55% solids. The polymeric compound should be handled and mixed in a manner that will not cause foaming or should contain an anti-foaming

agent. The polymeric emulsion should have a minimum shelf life of one year. Polymeric soil stabilizer should be readily miscible in water, non-injurious to seed or animal life, non-flammable, should provide surface soil stabilization for various soil types without totally inhibiting water infiltration, and should not re-emulsify when cured. The applied compound should air cure within a maximum of 36 to 48 hours. Liquid copolymer should be diluted at a rate of 10 parts water to 1 part polymer and applied to soil at a rate of 11,000 liters/hectare.

4.2.1.5.3.2 Liquid Polymers of Methacrylates and Acrylates

This material consists of a tackifier/sealer that is a liquid polymer of methacrylates and acrylates. It is an aqueous 100% acrylic emulsion blend of 40% solids by volume that is free from styrene, acetate, vinyl, ethoxylated surfactants or silicates. For soil stabilization applications, it is diluted with water and applied with a hydraulic seeder at the rate of 190 liters per hectare. Drying time is 12 to 18 hours after application.

4.2.1.5.3.3 Copolymers of Sodium Acrylates and Acrylamides

These materials are non-toxic, dry powders that are copolymers of sodium acrylate and acrylamide. They are mixed with water and applied to the soil surface for erosion control at rates that are determined by slope gradient:

Slope Gradient (V:H)	**Kg/ha**
Flat to 1:5	3.4 – 5.6
1:5 to 1:3	5.6 – 11.2
1:2 to 1:1	11.2 – 22.4

4.2.1.5.3.4 Poly-Acrylamide and Copolymer of Acrylamide

Linear copolymer poly-acrylamide is packaged as a dry-flowable solid. When used as a stand-alone stabilizer, it is diluted at a rate of 1.2 kg/1,000 liters of water and applied at the rate of 5.6 kg/ha.

4.2.1.5.3.5 Hydro-Colloid Polymers

Hydro-colloid polymers are various combinations of dry-flowable poly-acrylamides, copolymers and hydro-colloid polymers that are mixed with water and applied to the soil surface at rates of 60 to 70 kg/ha. Drying times are 0 to 4 hours.

4.2.1.5.4 Type: Petroleum or Resin-Based Emulsions

4.2.1.5.4.1 Emulsified Petroleum Resin

This material is a concentrated petroleum hydrocarbon emulsion that is mixed with water and applied to the soil surface at a rate of 23,000 liters per hectare. Dilution rates vary with the type of soil and other site conditions, and should be provided by the manufacturer. They typically range from 12:1 to 20:1 parts water to emulsion.

4.2.1.5.5 Type: Cementitious-Based Binders

4.2.1.5.5.1 Gypsum

This is a formulated gypsum-based product that readily mixes with water and mulch

to form a thin protective crust on the soil surface. It is composed of high purity gypsum that is ground, calcined and processed into calcium sulfate hemihydrate with a minimum purity of 86

percent. It is mixed in a hydraulic seeder and applied at rates 4,500 to 13,500 kg/ha. Drying time is 4 to 8 hours.

4.2.1.6 Straw Mulch

Straw mulch consists of placing a uniform layer of straw and incorporating it into the soil with a studded roller, or anchoring it with a tackifier. Straw mulch is used for soil stabilization, as a temporary surface cover, on disturbed areas until soils can be prepared for re-vegetation. It is also used in combination with temporary and/or permanent seeding strategies to enhance plant establishment.

Loose straw is the most common mulch material used in conjunction with direct seeding of soil. Straw mulching is generally the second part of multi-step process where seed and fertilizer are first applied, then straw mulch is applied as the second step. The final step of the process involves holding the loose straw in place by a) using netting, b) applying a liquid tackifier, or c) punching it into the soil by a process known as "crimping" or "incorporating."

4.2.1.6.1 Type: Wheat or Rice Straw

Straw can be hand applied or machine applied. The fiber length of the straw should be typically greater than 150 millimeters (mm) (6 inches [in]).

4.2.1.7 Geotextiles, Mats/Plastic Covers and Erosion Control Blankets

This BMP involves the placement of geotextiles, plastic covers, or erosion control blankets/mats to stabilize DSAs and protect soil from erosion by wind or water. These measures are typically used when DSAs are particularly difficult to stabilize, around Environmentally Sensitive Areas (ESAs), and as a temporary quick stopgap measure.

4.2.1.7.1 Type: Biodegradable Rolled Erosion Control Products

Biodegradable Rolled Erosion Control Products (RECPs) are typically composed of jute fibers, curled wood fibers, straw, coconut fiber, or a combination of these materials. For an RECP to be considered 100% biodegradable, the netting, sewing or adhesive system that hold the biodegradable mulch fibers together must also be biodegradable.

4.2.1.7.1.1 Jute Mesh

Jute is a natural fiber that is made into a yarn that is loosely woven into a biodegradable mesh. It is designed to be used in conjunction with vegetation and has longevity of approximately one year. The material is supplied in rolled strips, which should be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.

4.2.1.7.1.2 Curled Wood Fiber

Excelsior (curled wood fiber) blanket material should consist of machine produced mats of curled wood excelsior with 80% of the fiber 150 mm (6 in) or longer. The excelsior blanket should be of consistent thickness. The wood fiber should be evenly distributed over the entire area of the blanket. The top surface of the blanket should be covered with a photodegradable extruded plastic mesh. The blanket should be smolder resistant without the use of chemical additives and shall be non-toxic and non-injurious to plant and animal life. Excelsior blanket should be furnished in rolled strips, a minimum of 1,220 mm (48 in) wide, and should have an average weight of 0.5 kilograms per square meter (Kg/m2), +/-10 percent, at the time of manufacture. Excelsior blankets should be secured in place with wire staples. Staples should be made of 3.05-mm (0.12 in) steel wire and should be U-shaped with 200-mm (7.9 in) legs and 50-mm (2 in) crown.

4.2.1.7.1.3 Straw

Straw blanket should be machine-produced mats of straw with a lightweight biodegradable netting top layer. The straw should be attached to the netting with biodegradable thread or glue strips. The straw blanket should be of consistent thickness. The straw should be evenly distributed over the entire area of the blanket.

The straw blanket should be furnished in rolled strips a minimum of 2 meters (m) (6.6 feet [ft]) wide, a minimum of 25 m (82 ft) long and a minimum of 0.27 kg/m2. Straw blankets should be secured in place with wire staples. Staples should be made of 3.05-mm (0.12 in) steel wire and should be U-shaped with 200-mm (7.9 in) legs and 50-mm (2 in) crown.

4.2.1.7.1.4 Wood Fiber

Wood fiber blanket is composed of biodegradable fiber mulch with extruded plastic netting held together with adhesives. The material is designed to enhance revegetation. The material is furnished in rolled strips, which should be secured to the ground with U-shaped staples or stakes in accordance with manufacturers' recommendations.

4.2.1.7.1.5 Coconut Fiber

The coconut fiber blanket should be machine-produced mats of 100% coconut fiber with biodegradable netting on the top and bottom. The coconut fiber should be attached to the netting with biodegradable thread or glue strips. The coconut fiber blanket should be of consistent thickness. The coconut fiber should be evenly distributed over the entire area of the blanket. The coconut fiber blanket should be furnished in rolled strips with a minimum of 2 m (6.6 ft) wide, a minimum of 25 m (82 ft) long and a minimum of 0.27-kg/m2. Coconut fiber blankets should be secured in place with wire staples. Staples should be made of 3.05-mm (0.12 in) steel wire and should be U-shaped with 200-mm (7.9 in) legs and 50-mm (2 in) crown.

4.2.1.7.1.6 Coconut Fiber Mesh

Coconut fiber mesh is a thin permeable membrane made from coconut or corn fiber that is spun into a yarn and woven into a biodegradable mat. It is designed to be used in conjunction with vegetation and typically has longevity of several years. The material is supplied in rolled strips, which should be secured to the soil with U- shaped staples or stakes in accordance with manufacturers' recommendations.

4.2.1.7.1.7 Straw Coconut Fiber

The straw coconut fiber blanket should be machine-produced mats of 70% straw and 30% coconut fiber with a biodegradable netting top layer and a biodegradable bottom net. The straw and coconut fiber should be attached to the netting with biodegradable thread or glue strips. The straw coconut fiber blanket should be of consistent thickness. The straw and coconut fiber should be evenly distributed over the entire area of the blanket. The straw coconut fiber blanket should be furnished in rolled strips a minimum of 2 m (6.6 in) wide, a minimum of 25 m (82 ft) long and a minimum of 0.27 kg/m2. Straw coconut fiber blankets should be secured in place with wire staples. Staples should be made of 3.05-mm (0.12 in) steel wire and should be U-shaped with 200-mm (7.9 in) legs and 50-mm (2 in) crown.

4.2.1.7.2 Type: Non-Biodegradable Rolled Erosion Control Products

Non-biodegradable RECPs are typically composed of polypropylene, polyethylene, nylon or other synthetic fibers. In some cases, a combination of biodegradable and synthetic fibers is used to construct the RECP. Netting used to hold these fibers together is typically non-biodegradable as well.

4.2.1.7.2.1 Plastic Netting

Plastic netting is a lightweight biaxially-oriented netting designed for securing loose mulches like straw or paper to soil surfaces to establish vegetation. The netting is photodegradable. The netting is supplied in rolled strips, which should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

4.2.1.7.2.2 Plastic Mesh

Plastic mesh is an open-weave geotextile that is composed of an extruded synthetic fiber woven into a mesh with an opening size of less than 0.5 centimeters (cm) (0.2 in). It is used with re-vegetation or may be used to secure loose fiber such as straw to the ground. The material is supplied in rolled strips, which should be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.

4.2.1.7.2.3 Synthetic Fiber with Netting

Synthetic fiber with netting is a mat that is composed of durable synthetic fibers treated to resist chemicals and ultraviolet light. The mat is a dense, three-dimensional mesh of synthetic (typically polyolefin) fibers stitched between two polypropylene nets. The mats are designed to be vegetated and provide a permanent composite system of soil, roots, and geomatrix. The material is furnished in rolled strips, which should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

4.2.1.7.2.4 Bonded Synthetic Fibers

This type of product consists of a three-dimensional, geomatrix nylon (or other synthetic) matting. Typically it has more than 90% open area, which facilitates root growth. It's tough root-reinforcing system anchors vegetation and protects against hydraulic lift and shear forces created by high volume discharges. It can be installed over prepared soil, followed by seeding into the mat. Once vegetated, it becomes an invisible composite system of soil, roots, and geomatrix. The material is furnished in rolled strips that should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

4.2.1.7.2.5 Combination Synthetic and Biodegradable

Combination synthetic and biodegradable RECPs consist of biodegradable fibers, such as wood fiber or coconut fiber, with a heavy polypropylene net stitched to the top and a high-strength continuous-filament geomatrix or net stitched to the bottom. The material is designed to enhance re-vegetation. The material is furnished in rolled strips, which should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

4.2.1.7.2.6 Rolled Plastic Sheeting

Plastic sheeting should have a minimum thickness of 6 mm (0.24 in), and should be firmly held in place with sandbags or other weights placed no more than 3 m (9.8 ft) apart. Seams are typically taped or weighted down their entire length, and there should be at least a 300 mm (12 in) to 600 mm (24 in) overlap of all seams. Edges should be embedded a minimum of 150 mm (6 in) in native soil.

All sheeting should be inspected periodically after installation and after significant rainstorms to check for erosion and undermining. Any failures shall be repaired immediately. If washout or breakages occurs, the material should be re-installed after repairing the damage to the slope.

4.2.1.7.2.7 Geotextile (Woven)

Woven geotextile material should be a woven polypropylene fabric with a minimum thickness of 15 mm (0.6 in), a minimum of 3.7 m (12ft) wide and should have a minimum tensile strength of 0.67 KN (warp) 0.36 KN (fill) in conformance with the requirements in American Society of Testing and Materials (ASTM) Designation: D 4632. The permittivity of the fabric shall be approximately 0.07 sec –1 in conformance with the requirements in ASTM Designation: D 4491. The fabric should have an ultraviolet (UV) stability of 70% in conformance with the requirements in ASTM designation: D 4355. Geotextile blankets should be secured in place with wire staples or sandbags and by keying into tops of slopes and edges to prevent infiltration of surface waters under geotextile. Staples should be made of 3.05-mm (0.12 in) steel wire and shall be U-shaped with 200-mm (7.9 in) legs and 50-mm (2 in) crown.

4.2.1.7.2.8 Geotextile (Non-Woven)

Non-woven geotextile shall be manufactured from polyester, nylon, or polypropylene material, or any combination thereof. The fabric shall be permeable, non-woven, shall not act as a wicking agent. The fabric shall weigh a minimum of 135 grams per square meter (per ASTM Designation: D 3776), have a minimum grab tensile strength of 0.22 KN in each direction (per ASTM Designation: D 4632), have a minimum elongation at break of 10% (per ASTM Designation: D 4632), have a minimum toughness of 13 KN (percent elongation x grab tensile strength), and a minimum permittivity of 0.5 sec-1 (per ASTM Designation: D 4491).

4.2.1.8 Wood Mulching

Wood mulching consists of applying shredded wood, bark, or green material. The primary function of wood mulching is to reduce erosion by protecting bare soil from raindrop impact and reducing runoff. Use is limited to slopes that are less than 1:3 and depth of the mulch blanket is typically 8 to 10 cm (3 – 4 inches). The material is typically spread by hand, although pneumatic methods are available. Wood mulching is primarily applicable for landscape projects.

4.2.1.9 Earth Dikes/Drainage Swales and Ditches

The primary function of earth dikes, drainage swales and ditches is to prevent erosion and reduce pollutant loading. They are structures that intercept, divert, and convey surface runoff in a controlled, non-erosive manner. Top, toe, and mid-slope diversion ditches, berms, dikes, and swales should be used to intercept runoff and direct it away from critical slopes without allowing it to reach the roadway.

Typically, mid-slope diversion ditches should have a cross-slope of at least 2%, and should be concrete or rock-lined. Top of slope diversions should be paved along cut slopes where the slope length above the cut is greater than 12.2 m (40 ft). Earthen diversion ditches, berms, dikes, and swales channelize flow and should be stabilized with vegetation or other materials to prevent erosion.

Alternatively, drop structures can be placed along the diversion to maintain a grade sufficiently mild to prevent erosive velocities, or a paved chute can be placed down the side of the fill before the accumulated runoff in the diversion is sufficient to cause erosive velocities.

Design guidelines include:

- Select design flow and safety factor based on careful evaluation of the risk due to erosion of the measure, over topping, flow backups, or wash out;

- Examine the site for run-on from off-site sources. These off-site flows should be diverted from the right-of-way;
- Select flow velocity limit of unlined conveyance systems based on soil types and drainage flow patterns for each project site. Establish a maximum flow velocity for using earth dikes and swales, above which a lined ditch must be used. Consider use of rip-rap, engineering fabric, vegetation or concrete lining;
- Consider outlet protection where localized scour is anticipated;
- Consider order of work provisions early in the construction process to effectively install and use the permanent ditches, berms, dikes, and swales; and
- A sediment-trapping device should be used in conjunction with conveyances where sediment-laden water is expected.

4.2.1.10 Outlet Protection/Velocity Dissipation Devices

Outlet protection/velocity dissipation devices are rock, riprap, or other materials placed at pipe outlets to reduce flow velocity and the energy of exiting storm water flows and to prevent scour. They are used where localized scouring is anticipated, such as outlets of pipes, drains, culverts, slope drains, diversion ditches, swales, conduits, or channels. They are also used where lined channels or ditches discharge to unlined conveyances.

Appropriate applications include:

- Outlets of pipes, drains, culverts, slope drains, diversion ditches, swales, conduits, or channels;
- Outlets located at the bottom of mild to steep slopes;
- Discharge outlets that carry continuous flows of water;
- Outlets subject to short, intense flows of water, such as from flash floods; and
- Where lined conveyances discharge to unlined conveyances.

4.2.1.11 Slope Drains

A slope drain is a pipe used to intercept and direct surface runoff or groundwater into a stabilized watercourse, trapping device, or stabilized area. Slope drains are used with lined ditches to intercept and direct surface flow away from slope areas to protect cut or fill slopes.

Slope drains should be sized to convey large, infrequent storms down or around the slope. Design the top and toe of slope diversion ditches/berms/dikes/swales to direct flow into the drain. Provide for outlet protection/velocity dissipation devices at the outlet of the drain, as needed

4.2.2 Sediment Control Practices

Sediment control is required along the site perimeter at all operational internal inlets and at all times during the rainy season.

Sediment control devices function by:

- Slowing water velocities, thereby allowing soil particles to settle out; and

- Attenuating the flood peak by detaining flow and releasing water at a slower rate.

All sediment control devices require continued maintenance to function properly. Excess sediment not removed reduces capacity and efficiency.

Examples of sediment control practices include:

- Silt Fence
- Desilting Basin
- Sediment Trap / Filter Bags
- Check Dam
- Fiber Rolls
- Gravel Bag Berm
- Street Sweeping and Vacuuming
- Sand Bag Barrier
- Straw Bale Barrier
- Storm Drain Inlet Protection

4.2.2.1 Silt Fence

A silt fence is a temporary linear sediment barrier of permeable fabric designed to intercept and slow the flow of sediment-laden sheet flow runoff. Silt fences allow sediment to settle from runoff before water leaves the construction site.

Silt fences are placed below the toe of exposed and erodible slopes, downslope of exposed soil areas, around temporary stockpiles and along streams and channels. Silt fences should not be used to divert flow or in streams, channels or anywhere flow is concentrated.

4.2.2.2 De-silting Basin

A de-silting basin is a temporary basin formed by excavation and/or constructing an embankment so that sediment-laden runoff is temporarily detained under quiescent conditions, allowing sediment to settle out before the runoff is discharged.

De-silting basins shall be considered for use:

- On construction projects with disturbed areas during the rainy season;
- Where sediment-laden water may enter the drainage system or water courses; and
- At outlets of disturbed soil areas between 2 ha and 4 ha (5 acres and 10 acres).

4.2.2.3 Sediment Trap / Filter Bags

A sediment trap is a temporary basin with a controlled release structure, formed by excavating or constructing an earthen embankment across a waterway or low drainage area. As a supplemental control, sediment traps provide additional protection for a water body or for reducing sediment before it enters a drainage system.

Sediment traps may be used on construction projects during the rainy season when the contributing drainage area is less than 2 ha (5 acres). Traps would be placed where sediment laden storm water may enter a storm drain or watercourse, and around and/or up-slope from storm drain inlet protection measures.

Filter bags may be used in place of sediment traps. Sediment filter bags consist of a non-woven geotextile fabric that can catch and contain sediment during dewatering and pumping operations.

4.2.2.4 Check Dam

A check dam is a small device constructed of rock, sand bags, or fiber rolls, placed across a natural or man-made channel or drainage ditch. Check dams reduce scour and channel erosion by reducing flow velocity and encouraging sediment dropout.

Check dams may be installed:

- In small open channels that drain 4 ha (10 acres) or less;
- In steep channels where storm water runoff velocities exceed 1.5 meters per second (m/s) (5 feet per second [ft/s]);
- During the establishment of grass linings in drainage ditches or channels; and
- In temporary ditches where a short length of services does not warrant establishment of erosion-resistant linings.

4.2.2.5 Fiber Rolls

A fiber roll consists of straw, flax or other similar materials inserted into a tube of netting. Fiber rolls are placed on the face of slopes at regular intervals and/or at the toe of slopes to intercept runoff, reduce its flow velocity, release the runoff as sheet flow, and provide some removal of sediment from the runoff. Fiber rolls may be used along the top, face and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.

4.2.2.6 Gravel Bag Berm

A gravel bag berm consists of a single row of gravel bags that are installed end-to-end to form a barrier across a slope to intercept runoff, reduce runoff velocity, release runoff as sheet flow and provide some sediment removal. The gravel bag berm should be installed along a level contour with the bags tightly abutted.

4.2.2.7 Street Sweeping and Vacuuming

Street sweeping and vacuuming are practices to remove tracked soil particles from paved roads to prevent the sediment from entering a storm drain or watercourse. Street sweeping and vacuuming are implemented anywhere sediment is tracked from the project site onto public or private paved roads, typically at points of egress.

4.2.2.8 Sand Bag Barrier

A sand bag barrier is a temporary linear sediment barrier consisting of stacked sand bags, designed to intercept and slow the flow of sediment-laden sheet flow runoff. Sand bag barriers allow sediment to settle from runoff before water leaves the construction site.

Sand bags can also be used:

- Where flows are moderately concentrated to divert and/or detain flows;
- Along the perimeter of a site;
- Along streams and channels;
- Below the toe of exposed and erodible slopes; and
- Around stockpiles.

4.2.2.9 Straw Bale Barrier

A straw bale barrier is a temporary linear sediment barrier consisting of straw bales, designed to intercept and slow sediment-laden sheet flow runoff. Straw bale barriers allow sediment to settle from runoff before water leaves the construction site.

Typical applications for straw bale barriers include:

- Along the perimeter of a site;
- Along streams and channels;
- Below the toe of exposed and erodible slopes;
- Downslope of exposed soil areas; and
- Around stockpiles.

4.2.2.10 Storm Drain Inlet Protection

Storm drain inlet protection is a practice to reduce sediment from storm water runoff discharging from the construction site prior to entering the storm drainage system. Effective storm drain inlet protection allows sediment to settle out of water or filters sediment from the water before it enters the drain inlet. Storm drain inlet protection is the last line of sediment control defense prior to storm water leaving the construction site.

Storm drain inlet protection is used:

- Where ponding will not encroach into highway traffic;
- Where sediment-laden surface runoff may enter an inlet;
- Where disturbed drainage areas have not yet been permanently stabilized; and
- Where the drainage area is 0.4 ha (1 acre) or less.

4.2.3 Tracking Control Practices

Tracking control practices prevent or reduce off-site tracking of sediment by vehicles. Tracking is a common source of complaints, and can result the discharge of sediment to storm drains or watercourses. These measures include:

- Stabilized Construction Entrance;
- Stabilized Construction Roadway; and
- Entrance/Outlet Tire Wash.

Tracking controls shall be implemented, as needed, to reduce the tracking of sediment and debris from the construction site. At a minimum, entrances and exits shall be inspected daily, and controls implemented as needed.

4.2.3.1 Stabilized Construction Entrance

A stabilized construction entrance is a designated point of access (ingress and egress) to a construction site that is stabilized to reduce tracking of sediment (mud and dirt) onto public roads by construction vehicles. Stabilized construction entrances are an effective method to limit the migration of sediment from the construction site, especially when combined with

street sweeping and vacuuming. The stabilized entrance is typically composed of a crushed aggregate layer over a geotextile fabric or constructed of steel plates with ribs.

4.2.3.2 Stabilized Construction Roadway

A stabilized construction roadway is a temporary access road connecting existing public roads to a remote construction area. It is designed for the control of a dust and erosion created by vehicular traffic. A stabilized construction roadway may be constructed of aggregate, asphalt concrete, or concrete based on the desired longevity.

4.2.3.3 Entrance/Outlet Tire Wash

A tire wash is an area located at stabilized construction access points to remove sediment from tires and undercarriages, and to prevent tracking of sediment onto public roads. The tire wash typically includes a wash rack on a pad of coarse aggregate. The runoff water from the wash area must be conveyed to a sediment trap or basin.

4.2.4 Wind Erosion Control

Wind erosion controls shall be considered for all disturbed soil areas on the project site that are subject to wind erosion and when significant wind and dry conditions are anticipated during construction of the project. Wind erosion control consists of applying water or other dust palliatives as necessary to prevent or alleviate wind-blown dust. Dust control must be applied in accordance with FHWA/HDOT standard practices. Water or dust palliatives should be applied so no runoff occurs.

The Hawaii General Construction Permit (Appendix D) requires that special attention be paid to stockpiles. Stockpiles may be covered with plastic, mats, blankets, mulches, or sprayed with water or soil binders. It may also be prudent to surround the base of a stockpile with a row of fiber rolls, silt fence, or other sediment barrier.

Another means to reduce the potential for wind erosion of stockpiles is to keep the height of stockpiles low, and to adjust the shape and orientation of the stockpiles to reduce the area of exposure to the prevailing wind.

4.2.5 Non-Storm Water Controls

The objective of the construction site management (non-stormwater and waste management and materials pollution controls) is to reduce the discharge of materials other than stormwater to the stormwater drainage system or to receiving waters. These controls shall be implemented year-round for all applicable activities, material usage, and site conditions.

The National Pollutant Discharge Elimination System (NPDES) storm water regulations for construction sites also require that BMPs be included in the project plans for control of non-storm water discharges. Non-storm water management measures are source controls that prevent pollution by limiting or reducing potential pollutants at their source before they come in contact with storm water. These BMPs are also known as "good housekeeping practices." These BMPs must be in place throughout the grading and construction phases. The measures include:

- Water Conservation Practices
- Dewatering Operations
- Illicit Connection/Illegal Discharge Detection and Reporting
- Potable Water/Irrigation

- Paving and Grinding Operations
- Temporary Stream Crossing
- Clear Water Diversion
- Vehicle and Equipment Cleaning
- Vehicle and Equipment Fueling
- Vehicle and Equipment Maintenance

During preparation of the project plans, it is not always possible to know where a contractor will be performing certain activities. To provide the contractor with flexibility, but to assure that proper control measures are implemented, it is appropriate to identify in the project plans that specific BMPs will be implemented for certain activities regardless of where on the site those activities are performed.

4.2.5.1 Water Conservation Practices

Water conservation practices are activities that use water during the construction of a project in a manner that avoids erosion caused by runoff and the transport of pollutants off the site. If less water is used, the potential for erosion decreases and the transport of construction-related pollutants off site is less likely. Water conservation practices must be implemented on all construction sites wherever water is used. It includes preventing water leaks, avoid vehicle washing on site, sweeping in lieu of hosing areas, and applying water for dust control to minimize runoff.

4.2.5.2 Dewatering Operations

This BMP is intended to prevent the discharge of pollutants from construction site dewatering operations associated with storm water (accumulated rain) and non-storm water (groundwater, water from a diversion or cofferdam, etc.). Dewatering effluent that is discharged from the construction site to a storm drain or receiving water is subject to the requirements of the applicable NPDES permit.

4.2.5.3 Paving and Grinding Operations

Procedures that minimize pollution of storm water runoff during paving operations include new paving and preparation of existing paved surfaces for overlays. Paving and grinding operations include handling materials, wastes and equipment associated with pavement removal, paving, surfacing, resurfacing, pavement preparation, thermoplastic striping and placing pavement markers.

4.2.5.4 Temporary Stream Crossing (Discussed further in Chapter 5)

A temporary stream crossing is a structure placed across a waterway that allows vehicles to cross the waterway during construction without contacting the water, thus reducing erosion and the transport of pollutants into the waterway. Temporary stream crossings are typically conditions of regulatory permits for work near live streams. Installation may require dewatering or temporary diversion of the stream. Types of temporary stream crossings include culverts, fords, and bridges. Their design requires knowledge of stream flows, soils, and wildlife.

4.2.5.5 Clear Water Diversion (Discussed further in Chapter 5)

Clear water diversion consists of a system of structures and measures that intercept clear surface water runoff upstream of a construction site, transport it around the site, and discharge it downstream with minimal water quality impact. A common example is a temporary creek diversion system that consists of a sandbag cofferdam and a flexible plastic pipe to divert the water around the construction site. Structures commonly used as part of this system include diversion ditches, berms, dikes, slope drains, drainage, and interceptor swales.

4.2.5.6 Illicit Connection/Illegal Discharge Detection and Reporting

These procedures and practices are designed for construction contractors to recognize illicit connections or illegally dumped or discharged materials on a construction site and report incidents to the Project Engineer (PE).

4.2.5.7 Potable Water/Irrigation

Potable water/irrigation consists of practices and procedures to reduce the discharge of potential pollutants generated from irrigation water lines, landscape irrigation, lawn or garden watering, potable water sources, water line flushing, and hydrant flushing. These practices include reusing discharges for landscaping, automatic shut-off valves, prevention of impacts to downstream drainage systems, leak detection, inspection of equipment and lines, and repair of broken pipes.

4.2.5.8 Vehicle and Equipment Cleaning

This BMP consists of procedures and practices used to minimize or eliminate the discharge of pollutants from vehicle and equipment cleaning operations to storm drains or watercourses. On most construction sites, vehicle and equipment cleaning on site should be discouraged.

If vehicle or equipment cleaning is allowed, then soap, solvents, or steam shall not be used unless approved by the PE. Vehicle and equipment wash water must be contained for percolation or evaporation, and must not be discharged off site.

4.2.5.9 Vehicle and Equipment Fueling

This BMP consists of measures and practices to minimize or eliminate the discharge of fuel spills and leaks into the storm drain system or to watercourses. These measures include containment of fueling areas, spill prevention and control, drip pans or absorbent pads, automatic shut-off nozzles, vapor recovery nozzles, topping off restrictions, and leak inspection and repair.

4.2.5.10 Vehicle and Equipment Maintenance

This BMP consists of procedures and practices to minimize or eliminate the discharge of pollutants to the storm drain system or to watercourses from vehicle and equipment maintenance procedures. Practices include drip pans or absorbent pads, spill kits, dedicated maintenance areas, proper waste disposal, leak repair, and secondary containment.

4.2.5.11 Pile Driving Operations

The construction of bridges and retaining walls often includes driving piles for foundation support. Piles are typically constructed of cast in place concrete, steel, or timber. Driven sheet piles are also used for shoring and cofferdam construction. Proper control and use of equipment, materials, and waste products from pile driving operations will reduce the discharge of potential pollutants to the storm drain system or watercourses. These procedures apply to all construction sites where permanent and temporary pile driving operations take place.

4.2.5.12 Concrete Curing

This BMP consists of procedures that minimize pollution of storm water runoff during concrete curing. Concrete curing includes the use of both chemical and water methods. Concrete curing is used for the construction of structures such as bridges, retaining walls, and pump houses. Any element of the structure (i.e., footings, columns, abutments, stem and soffit, decks) may be subject to curing requirements.

4.2.5.13 Material and Equipment Use Over Water (Discussed Further in Chapter 5)

This BMP consists of procedures for the proper use, storage, and disposal of materials and equipment on barges, boats, temporary construction pads, or similar locations that minimize or eliminate the discharge of potential pollutants to a watercourse. These procedures shall be implemented for construction materials and wastes (solid and liquid), soil or dredging materials, or any other materials that may be detrimental if released and apply where equipment is used over or adjacent to a watercourse.

4.2.5.14 Concrete Finishing

This BMP consists of procedures to minimize the impact that concrete finishing methods may have on storm water runoff. Methods include sand blasting, lead shot blasting, grinding, or high pressure water blasting. Concrete finishing methods are used for bridge deck rehabilitation, paint removal, curing compound removal, and final surface finish appearances.

4.2.5.15 Structure Demolition/Removal Over Water (Discussed Further in Section ////)

This BMP consists of procedures to protect water bodies from debris and wastes associated with structure demolition or removal over or adjacent to watercourses. These procedures shall be implemented for full bridge demolition and removal, partial bridge removal (i.e., barrier rail, edge of deck) associated with bridge widening projects, concrete channel removal, or any other structure removal that could potentially affect water quality.

4.2.6 Waste Management and Materials Pollution Control

The NPDES storm water regulations for construction sites also require that BMPs be included in the project plans for waste management and materials pollution control. These are source control BMPs that prevent pollution by reducing pollutants at their source, and require a clean, well-kept site. The measures include:

- Material Delivery and Storage
- Material Use
- Stockpile Management
- Spill Prevention and Control
- Solid Waste Management
- Hazardous Waste Management
- Contaminated Soil Management
- Concrete Waster Management
- Sanitary/Septic Waste Management
- Liquid Waste Management

As with the non-storm water management measures, it is important to provide the contractor with flexibility, but to identify that in the plans, that specific BMPs will be implemented for certain activities regardless of where on the site those activities are performed.

4.2.6.1 Material Delivery and Storage

This BMP consists of procedures and practices for the proper handling and storage of materials in a manner that minimizes or eliminates the discharge of these materials to the storm drain system or to watercourses. These procedures include secondary containment, spill prevention and control, product labeling, quantity reduction, proper storage, material covering, training, and inventory control.

4.2.6.2 Material Use

This BMP consists of procedures and practices for use of construction material in a manner that minimizes or eliminates the discharge of these materials to the storm drain system or watercourses. These procedures include proper waste disposal, product labeling, proper

cleaning techniques, recycling materials, reducing quantities, and application rates, spill prevention and control, training, and reduction of exposure to storm water.

4.2.6.3 Stockpile Management

This BMP consists of procedures and practices to eliminate pollution of storm water from stockpiles of soil and paving materials (such as concrete rubble, aggregate, and asphalt concrete). These procedures include locating stockpiles away from drainages, providing perimeter sediment barriers, and wind erosion control measures.

4.2.6.4 Spill Prevention and Control

This BMP consists of procedures and practices implemented to prevent and control spills in a manner that minimizes or prevents the discharge of spilled material to storm drain systems or watercourses. Spill prevention and prompt appropriate spill response reduce the potential for polluting receiving waters with spilled contaminants. Spills of concern include chemicals and hazardous wastes such as soil stabilizers/binders, dust palliatives, herbicides, growth inhibitors, fertilizers, de-icing products, fuels, lubricants, paints, and solvents. Spill prevention practices include education as well as cleanup and storage procedures that address small spills, semi- significant spills, and significant/hazardous spills. A Spill Prevention Control and Countermeasure (SPCC) Plan may be required to document the anticipated procedures and protocols to be implemented on the project.

4.2.6.5 Solid Waste Management

This BMP consists of procedures and practices to minimize or eliminate the discharge of pollutants to storm drain systems or watercourses as a result of the creation, stockpiling or removal of construction site wastes. Solid wastes include such items as used brick, mortar, timber, steel, vegetation/landscaping waste, empty material containers, and litter. Measures include education as well as collection, storage, and disposal practices.

4.2.6.6 Hazardous Waste Management

This BMP consists of procedures and practices to minimize or eliminate the discharge of pollutants from construction site hazardous waste to the storm drain system or watercourses. Hazardous wastes should be collected, stored, and disposed of using practices that prevent contact with storm water. The following types of wastes are considered hazardous; petroleum products, concrete curing compounds, palliatives, septic wastes, paints, stains, wood preservatives, asphalt products, pesticides, acids, solvents, and roofing tar. There may be additional wastes on the project that are considered hazardous. It is also possible that non-hazardous waste could come into contact with these hazardous wastes, such that they become contaminated and are therefore considered hazardous waste. Measures include education, storage procedures, and disposal procedures.

4.2.6.7 Contaminated Soil Management

This BMP consists of procedures and practices to minimize or eliminate the discharge of pollutants to the storm drain system or watercourses from contaminated soil. Typical soil contamination is due to spills, illicit discharges, and underground storage tank leaks, or aerially deposited lead (ADL). Contaminated soils tend to occur on projects in urban or industrial areas. Soil contaminants and locations are often identified in the project plans and specifications. Measures include identifying contaminated areas, education, handling procedures for material with ADL, handling procedures for contaminated soils, procedures for underground storage tank removals, and water control.

4.2.6.8 Concrete Waste Management

This BMP consists of procedures and practices that are implemented to minimize or eliminate the discharge of concrete waste materials to the storm drain system or to watercourses. These measures include education, concrete slurry waste handling procedures, on-site concrete washout facility, transit truck washout procedures, and procedures for removal of temporary concrete washout facilities.

4.2.6.9 Sanitary/Septic Waste Management

This BMP consists of procedures and practices to minimize or eliminate the discharge of construction site toilet facilities to the storm drain system or watercourse. Measures include education, and storage and disposal procedures.

4.2.6.10 Liquid Waste Management

This BMP includes procedures to prevent pollutants related to non-hazardous liquid wastes from entering storm drains or receiving waters. Liquid wastes include drilling slurries, drilling fluids, wastewater that is free from grease and oil, dredging's, and other non-storm water liquid discharges not covered by separate permits. This BMP does not apply to the following:

- Dewatering operations;
- Solid wastes;
- Hazardous wastes ;
- Concrete slurries;
- Liquid wastes covered by specific laws or permits; and
- Non-storm water discharges permitted by any FHWA/HDOT NPDES permit unless FHWA/HDOT determines that the discharge contains pollutants.

4.3 Monitoring and Inspection Program

The Project Engineer (PE) or Resident Engineer (RE) is responsible for ensuring that construction personnel monitor the contractor's water pollution control practices and maintain compliance with the approved project SWPPP. This includes reviewing the contractor's SWPPP, reviewing written inspection reports, and conducting field inspections. All construction personnel should also be aware of the water pollution control requirements and participate in the monitoring program. Key steps to a successful monitoring and inspection program are summarized below.

Step 1. Do your Homework

a. Review the Current FHWA and HDOT Storm Water Quality Handbooks included in Appendix A, B and E of this manual.

   Construction personnel with storm water responsibilities should familiarize themselves with BMP requirements. In particular, become familiar with (1) the rainy season dates for your geographical area, (2) the definitions of DSA, active DSA, and non-active DSA, and (3) the requirements for soil stabilization and sediment control BMPs for the season and specific Rainfall Area.

b. Review the Project Plans.

Review the Project Plans in the context of storm water pollution control. Visualize storm water run-on and runoff flow patterns when reviewing the plans. Review the general layout and existing drainage courses. Identify potential problem areas where storm water may run onto the site or discharge off site.

Identify the locations where structures are being constructed or modified. Be familiar with the right-of-way and easement limits. Determine the limits of clearing and grubbing activities (i.e. Construction Limits). Identify the project phase or stage. Try to determine DSAs and Environmentally Sensitive Areas (ESAs). Is the next phase going to include soil-disturbing activities and is it scheduled within the rainy season? Do the DSAs have provisions in the plans for permanent erosion control? Determine if permanent erosion control can be placed when activity in the DSA is complete.

c. Review the SCRs

Review the SCRs for site-specific water pollution control requirements such as:

(1) permits for the construction project, (2) limits on active DSAs, (3) rainy season dates and requirements, (4) minimum BMP requirements, (5) BMP maintenance and inspection requirements, and (6) final erosion control requirements. Final erosion control requirements include (1) required products, (2) application process, (3) application rate, (4) seeding window, and (5) planting requirements.

The SCRs also include a section on water pollution control permits or requirements imposed on the project by other agencies. Typical agencies include the USACE, DOH-CWB, USFWS, NMFS, local flood control agencies, and others. There may be special requirements for water bodies or ESAs that need special water pollution control consideration.

Review the SCRs bid items related to water pollution control. There may be lump sums or unit prices for water pollution control items including SWPPP/WPCP preparation, permanent erosion control, and temporary erosion and sediment controls.

Review the section of the SCRs for site-specific activities such as: (1) dewatering, (2) sampling and analysis, (3) BMP maintenance cost allocation between FHWA/HDOT and the contractor, and (4) sanctions against the contractor in the event of non- compliance with the water pollution control requirements.

d. Review the SWPPP/IWPPP.

The SWPPP or IWPPP for the project is the contractor's plan to ensure conformance with FHWA/HDOT water pollution control requirements on the construction site. The SWPPP/IWPPP contains conceptual details about the BMPs to be used on the site, their locations, implementation timeframes, and inspection and maintenance schedules. The contractor must comply with the approved SWPPP/WPCP. If conditions change on the construction site that impact storm water pollution controls, the contractor must amend the SWPPP/IWPPP.

The SWPPP/IWPPP contains the approval signature, lists any amendments, describes unique features of the construction site, and contains the construction and water pollution control schedules. It also identifies the BMPs selected for soil stabilization, sediment control, non-storm water controls, waste management, and materials disposal controls and references locations on the vicinity map and water pollution control drawings.

e. Review the Schedule.

The accepted Baseline schedule as well as the monthly updates and three-week "look-ahead" schedules are important references to better anticipate which BMPs will be implemented or needed. A project schedule is required in both SWPPPs and must show how the rainy season relates to soil-disturbing and re-stabilization activities and must also show major activities sequenced with implementation of BMPs.

Step 2. Establish an Inspection Schedule

a. Prior to the rainy season, inspect the site to ensure that the contractor has the necessary materials to stabilize required DSAs and to implement the necessary sediment controls.

b. Year round, inspect the construction site prior to a forecast storm, after a rain event that causes runoff from the construction site, and at 24-hour intervals during an extended rain event. Refer to Section 4.4, Rain Event Action Plan.

c. Conduct inspections at other frequencies as required by the Special Provisions.

d. Work with the PE, and Inspectors during site inspections and to receive assistance when necessary.

Step 3. Conduct the Inspection

a. Document the Inspection in a Construction Site Inspection Checklist.

b. Encourage the contractor to participate in the inspection. This provides the opportunity for verbal feedback and discussion.

c. If the project involves significant structures work, encourage the Structures representative or inspector to participate in the inspection. Take a copy of the most current and approved site plan(s) and SWPPP on the inspection for identification of site features and for taking notes at specific areas.

d. Fill out the Inspection Checklist and add findings in writing. Use clear and concise language and give specific locations where problems were observed.

e. Take photographs during the inspection to document the existing conditions. This is especially important if the contractor does not attend the inspection. When photos of problem areas are taken, try to follow up with photos showing corrections.

f. Inspect the entire site, including the perimeter, especially where there is potential for run-on or discharge from the site. Look for areas of potential concentrated flows and for adjacent water bodies or drainage facilities that may be affected by discharges from the site. Start the inspection at the lowest point, or the area with

the highest potential for discharge. Inspect all potential discharge points. The SWPPP should identify discharge points; however, there may be areas with discharge potential that were not identified in the SWPPP.

g. Inspect the contractor's yard(s), where required.

h. Look for changes in construction or site conditions that may require an amendment to the SWPPP.

i. Inspect for proper implementation of non-storm water management BMPs and waste management and materials pollution control BMPs.

j. For inspections during the rainy season, evaluate active and non-active DSAs. (The PE or RE should periodically evaluate the classification of construction areas as active DSAs or non-active DSAs.) Determine the total area of DSA and compare it to the limit for DSAs in the Special Provisions. If the existing DSA exceeds the limit, identify areas that can be stabilized to reduce the amount. Active DSAs require protection prior to the onset of rain. Evaluate erosion and sediment control BMPs based on the requirements related to Rainfall Area, season and active/non-active status as defined in the SWPPP and BMP Manual. Be sure to inspect the entire site during a rain event, especially when run-off from the site occurs.

k. During the non-rainy season, identify the active and non-active DSAs. Depending on the Rainfall Area, DSAs may continue to require erosion and sediment control BMPs during the non- rainy season.

l. For individual BMPs, note if the BMP is properly installed. Also note if the BMP is in need of repair or maintenance.

Step 4. Report the Inspection Results

a. If the PE or RE did not attend the inspection, communicate the results to the Resident Engineer.

b. Ideally, observations should be discussed with the contractor during the inspection.

c. Missing BMPs and non-compliance issues must be communicated to the contractor. Refer to the contractor's SWPPP/IWPPP for required BMPs.

Step 5. Follow-up with Corrective Measures

The contractor must install missing BMPs and correct improperly installed or damaged BMPs immediately or by a date and time as approved in writing by the Project Engineer or Resident Engineer. In any event, corrections must be made prior to the next rain event.

Corrective actions will be implemented within 72 hours for deficiencies identified during inspections. SWPPP amendments will be prepared by a qualified SWPPP practitioner if warranted by the problem encountered and corrective action required.

At a minimum, erosion and sediment controls will be cleaned, repaired, or replaced under these conditions:

- In advance of the rainy season and prior to a storm event
- When sediment or other debris has accumulated to greater than one-third the height of the barrier
- When sediment accumulation reaches one-third of the trap capacity
- When more than one-third of the cross section of a conveyance structure, such as a drainage swale or ditch, is plugged or blocked

Table 7 provides a BMP implementation and maintenance schedule. The selection of BMPs can potentially change during Project construction, and Table 7 will be amended accordingly.

Table 7 - BMP Implementation and Maintenance Schedule

Best Management Practices	Implementation	Inspection Frequency	Maintenance
Silt fence	Prior to construction and in sequence with construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Replace torn sections; repair up-rooted sections; clean out collected sediment when greater than 1/3 height of fence
Fiber rolls; coir logs; compost socks; biofilter bags	Prior to construction and in sequence with construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Replace crushed sections; replace rotted sections; clean out collected sediment when greater than 1/3 height of roll
Sediment basin; Sediment trap	Prior to construction and in sequence with construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Repair damage and remove obstructions as needed; stabilize eroded areas; clean out collected sediment when 1/2 of designated storage volume of basin or 1/3 of trap capacity; dewater within 72 hours

Table 7 - BMP Implementation and Maintenance Schedule

Best Management Practices	Implementation	Inspection Frequency	Maintenance
Check dams; velocity dissipation devices	Prior to construction and in sequence with construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Replace degraded or missing rock, bags, etc.; clean out when collected soil greater than 1/3 of barrier height
Dikes and drainage swales; slope drains	Prior to construction and in sequence with construction activities	Inspect before and after storm events (and once each 24-hour period during	Repair as needed
Non-stormwater and materials management	Planned prior to construction	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Dispose of waste materials weekly; contract with outside vendors as needed; keep material storage areas clean and orderly; train all employees on correct use of materials and spill response
Erosion control blankets (geotextiles); non-vegetative stabilization; compost blankets	In sequence with construction activities; prior to forecasted rain event	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Repair eroded areas; replace and repair geotextiles and mats as needed
Sandbags	Prior to construction and in sequence with construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Repair, reshape, replace bags as necessary; replace bags exposed to sunlight every 2 to 3 months; clean out collected sediment when greater than 1/3 barrier height

Table 7 - BMP Implementation and Maintenance Schedule

Best Management Practices	Implementation	Inspection Frequency	Maintenance
Gravel bags	Prior to construction and in sequence with construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Repair, reshape, replace bags as necessary; replace bags exposed to sunlight every 2 to 3 months; clean out collected sediment when greater than 1/3 barrier height
Storm drain inlet protection	Prior to construction	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Clean and repair filters or fabric fence as needed; clean out collected sediment when greater than 1/3 barrier height
Hydraulic mulch	In sequence with construction activities; prior to forecasted rain event	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Repair eroded areas; reapply on bare areas as needed
Mulch (straw, wood, organic); soil binders	In sequence with construction activities; prior to forecasted rain event	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Repair eroded areas; reapply on bare areas as needed

Table 7 - BMP Implementation and Maintenance Schedule

Best Management Practices	Implementation	Inspection Frequency	Maintenance
Hydroseeding; seeding (if applicable)	As soon as possible after disturbance has permanently or temporarily ceased, but in no case more than 14 days after the construction activity in an area has ceased (except when construction activity will resume on that portion of the site within 21 days)	Inspect before and after storm events (and once each 24-hour period during extended storm events), weekly; monitored every May for the first 3 years following Project completion	Reseed areas that do not meet revegetation criteria
Streambank stabilization	In sequence with construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Repair eroded areas; replace BMP measure as needed
Straw bale barrier	In sequence with construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Replace rotted sections; clean out collected sediment when greater than 1/3 height of barrier
Active treatment system	In sequence with construction activities	Follow guidelines of the Construction General Permit	Follow guidelines of the Construction General Permit
Concrete washout	In sequence with construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Clean out, or construct new facility, once the washout is 75 percent full

Table 7 - BMP Implementation and Maintenance Schedule

Best Management Practices	Implementation	Inspection Frequency	Maintenance
Aggregate surfacing	Completion of grading activities	Weekly	Keep all temporary roadway ditches clear; periodically apply additional aggregate as needed
Stabilized construction entrance/exit	Prior to grading/earth disturbance	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Remove aggregate, separate and dispose of sediment when construction entrance/exit is clogged with sediment; keep all temporary roadway ditches clear; check for damage and repair as needed; replace gravel material when surface voids are visible
Stabilized construction roadway	Prior to start of associated construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Keep all temporary roadway ditches clear; periodically apply additional aggregate on gravel roads
Stockpile management	In sequence with construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Repair or replace perimeter controls and covers as needed

Table 7 - BMP Implementation and Maintenance Schedule

Best Management Practices	Implementation	Inspection Frequency	Maintenance
Street sweeping and vacuuming	Start of construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); when actively in use, inspect points of ingress and egress daily, otherwise weekly	Remove tracked or spilled sediment outside the construction limits at a minimum daily
Tire wash	Prior to start of associated construction activities	Inspect before and after storm events (and once each 24-hour period during extended storm events); weekly	Remove accumulated sediment in wash rack to maintain system performance; repair as needed

4.4 Rain Event Action Plans

The Rain Event Action Plans (REAP) is written document designed to be used as a planning tool by a qualified stormwater professional (QSP) to protect disturbed portions of the construction site and to ensure that adequate materials and staff are available to implement erosion and sediment control measures. It is the responsibility of the QSP to be aware of precipitation forecast and to obtain and print copies of forecasted precipitation from NOAA's National Weather Service Forecast Office (http://www.prh.noaa.gov/hnl/).

A REAP template for each applicable project phase can be found in Appendix F. The QSP shall customize these templates for each rain event and project phase when the project is under construction. The QSP shall maintain a paper copy of completed REAPs in compliance with the record retention requirements of the SWPPP/ IWPPP. Completed REAPs shall be maintained on the project site with the SWPPP/IWPPP throughout the duration of construction.

The QSP will develop the event-specific REAP 48 hours prior to precipitation event forecast to have a 50% or greater chance of producing precipitation in the project area. The REAP will be maintained onsite and be implemented 24 hours in advance of the predicted precipitation event.

At a minimum, the REAP will include the following site and phase-specific information:

- Site Address;
- Site Stormwater Manager Information including the name, company and 24-hour emergency telephone number;
- Erosion and Sediment Control Provider information including the name, company and 24-hour emergency telephone number;
- Stormwater Sampling/Inspector Agent information including the name, company, and 24-hour emergency telephone number;
- Activities associated with each construction phase;
- Trades active on the construction site during each construction phase;
- Trade Contractor information; and
- Recommended actions for each project phase.

4.4.1 Rain Event Triggered Observations and Inspections

Visual observations of the site and inspections of BMPs are required prior to a qualifying rain event, following a qualifying rain event, and every 24-hour period during a qualifying rain event. Pre-rain inspections will be conducted after consulting NOAA and determining that a precipitation event with a 50% or greater probability of precipitation has been predicted.

4.4.2 Visual Observations Prior to a Forecasted Qualifying Rain Event

The REAP must be available onsite at least 48-hours prior to a qualifying forecast storm event. A stormwater visual monitoring site inspection and observations shall be conducted at the following locations:

- Potential pollutant sources are properly stored (i.e. sorted in covered areas, elevated off ground surfaces, etc.);
- Stormwater drainage areas to identify any spills, leaks, or uncontrolled pollutant sources;
- BMPs to identify if they have been properly implemented or require maintenance;
- Any stormwater storage and containment areas to detect leaks and ensure maintenance of adequate freeboard.

4.4.3 BMP Inspections During an Extended Storm Event

During an extended rain event BMP inspections will be conducted every 24 hours during normal business hours to identify and record:

- Stormwater drainage areas to identify any spills, leaks, or uncontrolled pollutant sources;
- Evidence of any spills, leaks, or uncontrolled pollutant sources that may have migrated offsite;
- BMPs that are properly installed;
- BMPs that need maintenance to operate effectively;

- BMPs that have failed; or
- BMPs that could fail to operate as intended.

If the construction site is not accessible during the rain event, the visual inspections shall be performed at all relevant outfalls, discharge points, and downstream locations. The inspections should record any projected maintenance activities.

4.4.4 Visual Observations Following a Qualifying Rain Event

Within 48 hours following a qualifying rain event (½ inch of rain) a stormwater visual monitoring site inspection is required to observe:

- Evidence of any spills, leaks, or uncontrolled pollutant sources that may have migrated offsite;
- BMPs to identify if they have been properly designed, implemented, and effective;
- Need for additional BMPs or BMP maintenance;
- Any stormwater storage and containment areas to detect leaks and ensure maintenance of adequate freeboard; and
- Discharge of stored or contained rain water.

If the QSP or the Project Engineer (PE) identifies a deficiency in the implementation of the accepted SWPPP/IWPPP, the deficiency must be corrected immediately unless the PE authorizes an agreed date for correction. The correction must occur before the onset of precipitation.

If failure to correct the deficiency by the scheduled date or by the onset of precipitation occurs, the project may correct the deficiency and deduct the cost of correcting the deficiency from payment. Failure to comply with the corrective action may result in the suspension of work by the PE until the project complies with the requirements of the SWPPP/IWPPP.

CHAPTER 5:

5 CONSTRUCTION BMPS FOR WORKING IN, OVER OR ADJACENT TO WATERS OF THE U.S.:

5.1 WORKING ON OR OVER WATER; INCLUDING MATERIAL AND EQUIPMENT USE ON WATER:

5.1.1 DESCRIPTION AND PURPOSE

Procedures for the proper use, storage, and disposal of materials and equipment on barges, boats, temporary construction pads, or similar locations that minimize or eliminate the discharge of potential pollutants to a watercourse.

5.1.2 APPROPRIATE APPLICATIONS

Applies where materials and equipment are used on barges, boats, docks, and other platforms over or adjacent to a watercourse including waters of the United States. These procedures should be implemented for construction materials and wastes (solid and liquid), soil or dredging materials, or any other materials that may be detrimental if released.

5.1.3 LIMITATIONS

Dredge and fill activities are regulated by the USACE and DOH-CWB under Section 404/401 of the CWA and Section 10 of RHA. Ensure all appropriate permits are obtained prior to construction activities.

5.1.4 STANDARDS AND SPECIFICATIONS

- Refer to BMPs for Material Delivery and Storage and Spill Prevention and Control.
- Use drip pans and absorbent materials for equipment and vehicles and ensure that an adequate supply of spill clean-up materials is available.
- The exterior of vehicles and equipment that will encroach on a water body within the project should be maintained free of grease, oil, fuel, and residues and may require vegetable based hydraulic oil.
- Drip pans should be placed under all vehicles and equipment placed on docks, barges, or other structures over water bodies when the vehicle is expected to be idle for more than 1 hour.
- Maintain equipment in accordance with BMPs for Vehicle and Equipment Maintenance. If a leaking line cannot be repaired, remove equipment from over the water
- Provide watertight curbs or toe boards to contain spills and prevent materials, tools, and debris from leaving the barge, platform, dock, etc.
- Secure all material to prevent discharge to receiving waters via wind.

- Identify types of spill control measures to be employed, including the storage of such materials and equipment. Ensure that staff is trained regarding the use of the materials, deployment and access control measures, and reporting measures.
- In case of spills, contact the PE who will contact the USACE and DOH-CWB as soon as possible but within 48 hours.
- Refer to BMPs for Solid Waste Management (non-hazardous) and Hazardous Waste Management. Ensure the timely and proper removal of accumulated wastes.
- Comply with all necessary permits required for construction within or near the watercourse, such as DOH-CWB 401 WQC, USACE 404 permit
- Discharges to waterways should be reported to the USACE and DOH-CWB immediately upon discover. A written discharge notification must follow within 7 days. Follow the spill reporting procedures contained in the SWPPP.

5.1.5 Inspection and Maintenance

- Inspect and verify that activity–based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMP are under way, inspect weekly during the rainy season and of two-week intervals in the non-rainy season to verify continued BMP implementation.
- Inspect BMPs subject to non-stormwater discharge daily while non-stormwater discharges occur.
- Ensure that employees and subcontractors implement the appropriate measures for storage and use of materials and equipment.
- Inspect and maintain all associated BMPs and perimeter controls to ensure continuous protection of the water courses, including waters of the United States.

5.2 Demolition Over or Adjacent to Water

5.2.1 Description and Purpose

Procedures to protect water bodies from debris and wastes associated with structure demolition or removal over or adjacent to watercourses.

5.2.2 Appropriate Applications

Full bridge demolition and removal, partial bridge removal (barrier rail, edge of deck) associated with bridge widening projects, concrete channel removal, or any other structure removal that could potentially affect water quality.

5.2.3 Limitations

Specific permit requirements may be included in the contract documents.

5.2.4 Standards and Specifications

- Refer to Clear Water Diversion and Isolation Techniques, to direct water away from work areas.
- Use attachments on construction equipment such as backhoes to catch debris from small demolition operations.
- Use covers or platforms to collect debris.
- Platforms and covers are to be approved by the PE.
- Stockpile accumulated debris and waste generated during demolition away from watercourses and in accordance with Stockpile Management.
- Ensure safe passage of fish and wildlife.
- Discharges to waterways shall be reported to the DOH-CWB immediately upon discovery. A written discharge notification must follow within 7 days. Follow the spill reporting procedures in the SWPPP.
- For structures containing hazardous materials, i.e., lead paint or asbestos, refer to Hazardous Waste Management procedures. For demolition work involving soil excavation around lead-painted structures, refer to Contaminated Soil Management procedures.

5.2.5 Inspection and Maintenance

- Inspect and verify that activity–based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMP are under way, inspect weekly during the rainy season and of two-week intervals in the non-rainy season to verify continued BMP implementation.
- Inspect BMPs subject to non-stormwater discharge daily while non-stormwater discharges occur.
- Any debris-catching devices shall be emptied regularly. Collected debris shall be removed and stored away from the watercourse and protected from runon and runoff.

5.3 Temporary Stream/River Crossing

5.3.1 Description and Purpose

A temporary stream crossing is a temporary culvert, ford or bridge placed across a waterway to provide access for construction purposes for a period of less than one year. Temporary access crossings are not intended to maintain traffic for the public. The temporary access will eliminate erosion and downstream sedimentation caused by vehicles.

5.3.2 Appropriate Applications

Temporary stream crossings should be installed at all designated crossings of perennial and intermittent streams on the construction site, as well as for dry channels that may be significantly eroded by construction traffic.

Temporary streams crossings are installed at sites:

- Where appropriate permits have been secured for the temporary crossing (404 Permits, and 401 Certifications)
- Where construction equipment or vehicles need to frequently cross a waterway
- When alternate access routes impose significant constraints
- When crossing perennial streams or waterways causes significant erosion
- Where construction activities will not last longer than one year

5.3.3 Limitations

The following limitations may apply:

- Specific permit requirements or mitigation measures such as 401 Water Quality Certification, U.S. Army Corps of Engineers Section 404 or Section 10 permits, U.S. Coast Guard Section 9 or General Bridge Act Permits and approval by USFWS and NMFS supersede the guidance in this BMP. If numerical-based water quality standards are mentioned in any of these and other related permits, testing and sampling may be required.
- Installation and removal will usually disturb the waterway.
- Installation may require dewatering or temporary diversion of the stream. See , Dewatering Operations and Clear Water Diversion BMPs.
- Installation may cause a constriction in the waterway, which can obstruct flood flow and cause flow backups or washouts. If improperly designed, flow backups can increase the pollutant load through washouts and scouring.
- Use of natural or other gravel in the stream for construction of Cellular Confinement System (CCS) ford crossing will be contingent upon approval by fisheries agencies.
- Ford crossings may degrade water quality due to contact with vehicles and equipment.
- May be expensive for a temporary improvement.

- Requires other BMPs to minimize soil disturbance during installation and removal.
- Fords should only be used in dry weather.

5.3.4 STANDARDS AND SPECIFICATIONS

5.3.4.1 General

The purpose of this BMP is to provide a safe, erosion-free access across a stream for construction equipment. Minimum standards and specifications for the design, construction, maintenance, and removal of the structure should be established by an engineer registered in California. Temporary stream crossings may be necessary to prevent construction equipment from causing erosion of the stream and tracking sediment and other pollutants into the stream.

Temporary stream crossings are used as access points to construction sites when other detour routes may be too long or burdensome for the construction equipment. Often heavy construction equipment must cross streams or creeks, and detour routes may impose too many constraints such as being too narrow or poor soil strength for the equipment loadings. Additionally, the contractor may find a temporary stream crossing more economical for light– duty vehicles to use for frequent crossings, and may have less environmental impact than construction of a temporary access road.

Location of the temporary stream crossing should address:

- Site selection where erosion potential is low.
- Areas where the side slopes from site runoff will not spill into the side slopes of the crossing.

The following types of temporary stream crossings should be considered:

- **Culverts –** A temporary culvert is effective in controlling erosion but will cause erosion during installation and removal. A temporary culvert can be easily constructed and allows for heavy equipment loads.
- **Fords -** Appropriate during the dry season in arid areas. Used on dry washes and ephemeral streams, and low-flow perennial streams. A temporary ford provides little sediment and erosion control and is ineffective in controlling erosion in the stream channel. A temporary ford is the least expensive stream crossing and allows for maximum load limits. It also offers very low maintenance. Fords are more appropriate for ephemeral drainages in drier areas.
- **Bridges -** Appropriate for streams with high flow velocities, steep gradients and where temporary restrictions in the channel are not allowed.

5.3.4.2 Design

For short duration work in ephemeral drainages, a temporary ford may be sufficient. However, a ford is not appropriate if construction will continue through the rainy season, if summer thunderstorms are likely, or if the stream flows during most of the year. Temporary culverts and bridges should then be considered and, if used, should be sized to pass a design storm (i.e., at least a 2 to 5-year storm). The temporary stream

crossing should be protected against erosion, both to prevent excessive sedimentation in the stream and to prevent washout of the crossing.

Design and installation requires knowledge of stream flows and soil strength. Designs should be prepared under direction of, and approved by, a registered civil engineer and for bridges, a registered structural engineer. Both hydraulic and construction loading requirements should be considered with the following:

- Comply with any special requirements for culvert and bridge crossings, particularly if the temporary stream crossing will remain through the rainy season.
- Provide stability in the crossing and adjacent areas to withstand the design flow. The design flow and safety factor should be selected based on careful evaluation of the risks due to over topping, flow backups, or washout.
- Install sediment traps immediately downstream of crossings to capture sediments. See BMP Summary for Sediment Trap.
- Avoid oil or other potentially hazardous materials for surface treatment.
- Culverts are relatively easy to construct and able to support heavy equipment loads.
- Fords are the least expensive of the crossings, with maximum load limits.
- CCS crossing structures consist of clean, washed gravel and CCS blocks. These systems are appropriate for streams that would benefit from an influx of gravel; for example, streams or rivers below reservoirs, and urban, channelized streams. Many urban stream systems are gravel-deprived due to human influences, such as dams, gravel mines, and concrete channels.
- The CCS allows designers to use either angular or naturally occurring rounded gravel, because the cells provide the necessary structure and stability. In fact, natural gravel is optimal for this technique, because of the habitat improvement it will provide after removal of the CCS.
- A gravel depth of 6 to 12 in. for a CCS structure is sufficient to support most construction equipment.
- An advantage of a CCS crossing structure is that relatively little rock or gravel is needed, because the CCS provides the stability.
- Bridges are generally more expensive to design and construct, but provide the least disturbance of the streambed and constriction of the waterway flows.

5.3.4.3 Construction and Use

- Stabilize construction roadways, adjacent work area, and stream bottom against erosion.
- Construct during dry periods to minimize stream disturbance and reduce costs.
- Construct at or near the natural elevation of the streambed to prevent potential flooding upstream of the crossing.

- Install temporary erosion control BMPs in accordance with erosion control BMP fact sheets to minimize erosion of embankment into flow lines.
- Any temporary artificial obstruction placed within flowing water should only be built from material, such as clean gravel or sandbags, that will not introduce sediment or silt into the watercourse.
- Temporary water body crossings and encroachments should be constructed to minimize scour. Cobbles used for temporary water body crossings or encroachments should be clean, rounded river cobble.
- Vehicles and equipment should not be driven, operated, fueled, cleaned, maintained, or stored in the wet or dry portions of a water body where wetland vegetation, riparian vegetation, or aquatic organisms may be destroyed.
- The exterior of vehicles and equipment that will encroach on the water body within the project should be maintained free of grease, oil, fuel, and residues.
- Drip pans should be placed under all vehicles and equipment placed on docks, barges, or other structures over water bodies when the vehicle or equipment is planned to be idle for more than one hour.
- Disturbance or removal of vegetation should not exceed the minimum necessary to complete operations. Precautions should be taken to avoid damage to vegetation by people or equipment. Disturbed vegetation should be replaced with the appropriate soil stabilization measures.
- Riparian vegetation, when removed pursuant to the provisions of the work, should be cut off no lower than ground level to promote rapid re-growth. Access roads and work areas built over riparian vegetation should be covered by a sufficient layer of clean river run cobble to prevent damage to the underlying soil and root structure. The cobble must be removed upon completion of project activities.

5.3.5 Inspection and Maintenance

The following limitations may apply:

- Inspect and verify that activity-based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMP are under way, inspect weekly during the rainy season and at two week intervals in the non-rainy season to verify continued BMP implementation.
- Check for blockage in the channel, sediment buildup or trapped debris in culverts, blockage behind fords or under bridges
- Check for erosion of abutments, channel scour, riprap displacement, or piping in the soil
- Check for structural weakening of the temporary crossings, such as cracks, and undermining of foundations and abutments
- Remove sediment that collects behind fords, in culverts, and under bridges periodically

- Replace lost or displaced aggregate from inlets and outlets of culverts and cellular confinement systems
- Remove temporary crossing promptly when it is no longer needed

5.4 Streambank Stabilization

5.4.1 Description and Purpose

Stream channels, stream banks, and associated riparian areas are dynamic and sensitive ecosystems that respond to changes in land use activity. Streambank and channel disturbance resulting from construction activities can increase the stream's sediment load, which can cause channel erosion or sedimentation and have adverse effects on the biotic system. BMPs can reduce the discharge of sediment and other pollutants to minimize the impact of construction activities on watercourses. Proper planning and procedures for work in and around streams and channels can reduce the potential for discharge of sediment and other pollutants and minimize the impacts of construction activities on watercourses and habitat. Streams on the 303(d) list and listed for sediment may require numerous measures to prevent any increases in sediment load to the stream.

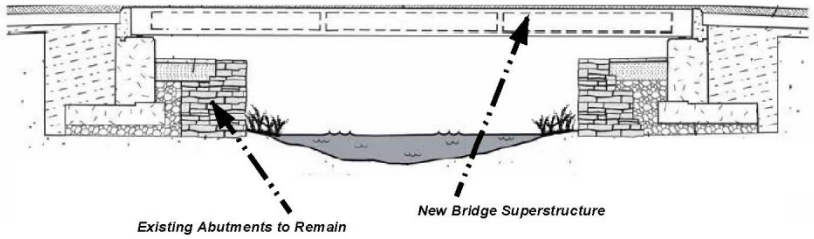
5.4.2 Suitable Applications

These procedures typically apply to all construction projects that disturb or occur within stream channels and their associated riparian areas. The site-specific stream bank practices used will be partially dependent upon the types of soils present, the slope of the bank, gradient of the river, flow, and uses of the watercourse.

5.4.3 Limitations

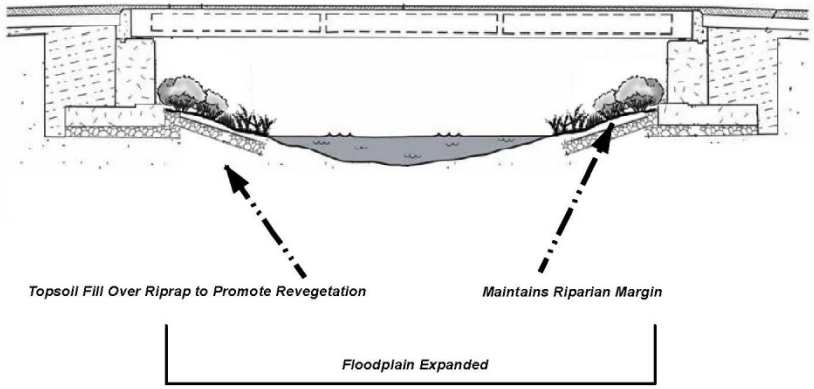
- The appropriate time to apply stream bank erosion controls is dependent upon the method used.
- Specific permit requirements or mitigation measures such as 401 Water Quality Certification, U.S. Army Corps of Engineers Section 404 or Section 10 permits, U.S. Coast Guard Section 9 or General Bridge Act Permits and approval by USFWS and NMFS supersede the guidance in this BMP. If numerical-based water quality standards are mentioned in any of these and other related permits, testing and sampling may be required.

Retain Existing Bridge Abutment Cross-Section:



Notes:
1) Minimizes new disturbance during the short term.
2) Previous active channel and floodplain widths are maintained.
3) Does not support a riparian margin.
4) Does not allow for any bioengineering features to be Integrated into Design

Remove Existing Bridge Abutment with Channel Improvement Cross-Section:



Notes:
1) Supports Riparian Functions
2) Provides Scour Protection Through Buried Riprap
3) Maintains a Riparian Margin Adjacent to Roadway.
4) Allows Bioengineering Features to be Integrated into Design

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Figure 9. Example of streambank stabilization options during bridge replacement.

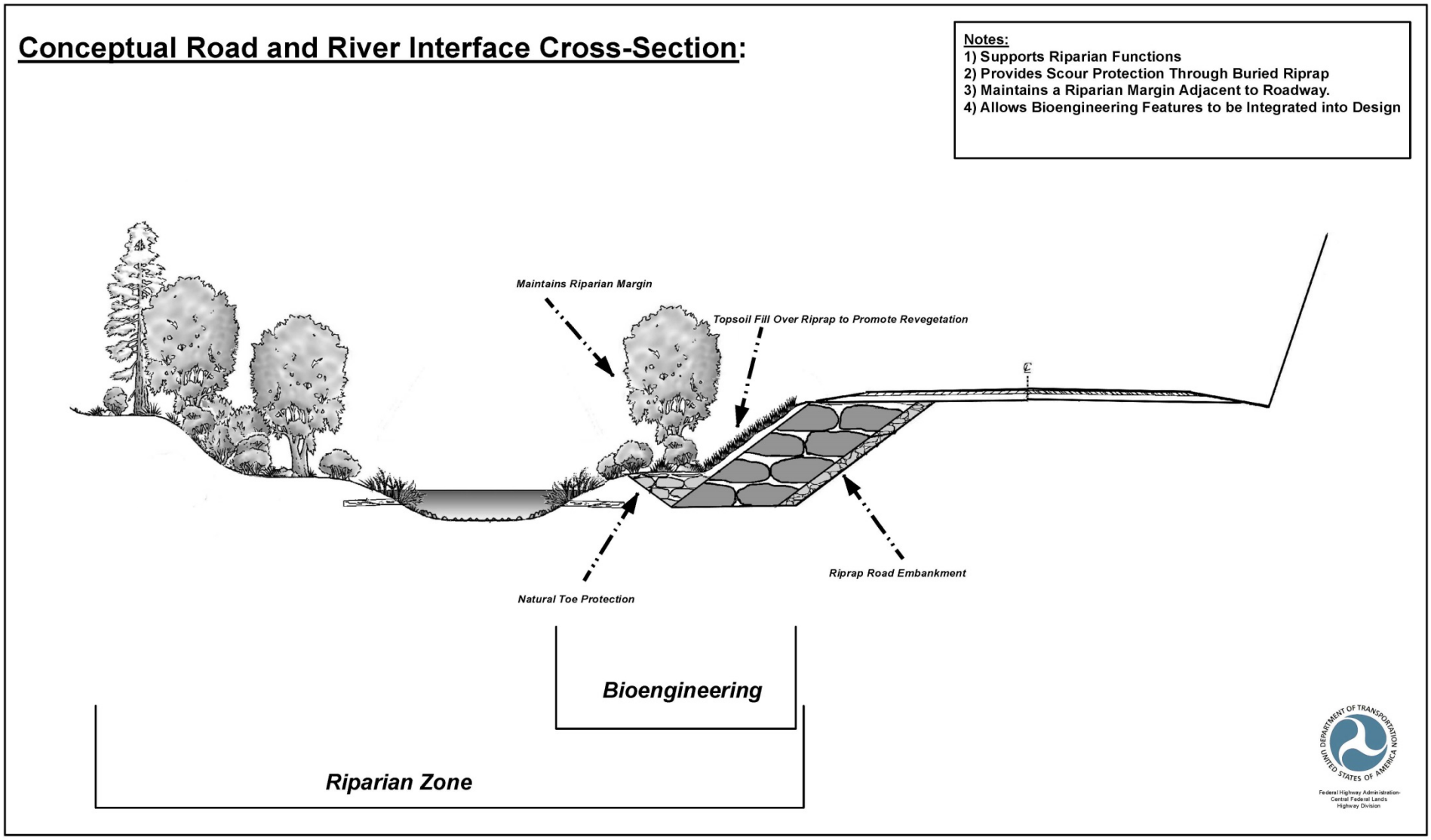


Figure 10. Example of roadway with riprap and bioengineering features.

5.4.4 IMPLEMENTATION

5.4.4.1 Planning

Proper planning, design, and construction techniques can minimize impacts normally associated with streambank construction activities. Poor planning can adversely affect soil, fish, wildlife resources, land uses, or land users. Planning should take into account: scheduling; avoidance/minimization of in-stream construction; minimizing disturbance area and construction time period; using pre-disturbed areas; selecting crossing location; and selecting equipment.

It is important to remember that streams are dynamic. Even without human influence streams may meander, and in the process, cause banks to erode. Therefore, not all eroding banks are "bad" and in need of repair. In fact, the wrong system of BMPs installed in the wrong place may cause more damage downstream (and therefore to the entire stream system) than leaving the stream in its natural state. For example, "hard structures" like large riprap or gabions, placed on one eroding bank, can displace the stream's energy downstream to a previously stable bank, causing the downstream bank to erode. If this downstream bank is also stabilized with a hard structure, the stream's energy may be moved further downstream to another previously stable bank, and so on.

So before stabilizing stream banks, consider the cause of the stream bank erosion. If the banks are eroding due to a natural meander, then it may be best to leave the bank alone. If the banks are eroding due to fluctuations in hydrology, the hydrologic fluctuations should be addressed before the banks are stabilized.

Once the cause of erosion is identified and addressed (If possible), determine the goal in stabilizing the stream banks. Some banks are stabilized to protect buildings, land and infrastructure. Others are stabilized to keep soil from entering the stream and to allow recreational or angler access to the stream. The purpose for stabilizing the banks and the users of the stream will help determine the type of structures needed.

Once the above concerns have been addressed, then it is important to work with agencies with expertise in stream bank erosion techniques to address stream bank erosion at the watershed level. Looking at the entire watershed will help prioritize bank stabilization efforts. This is especially important in Hawaii where restoration options must account for Hawaii's extreme hydrology (steep slopes and intense rainfall regime), extreme channel hydraulics (velocities, shear stress), flood control requirements, and limited space. Design considerations for streambank stabilization techniques should include:

- Channel Grade
- Discharge Frequency
- Discharge Velocities
- Freeboard
- Alignment
- Stream Type and Hydraulic Geometry
- Sediment Load and Bed Material
- Protection Against Failure
- Undermining
- Ends of Revetment
- Debris Removal
- Vegetative Systems

5.4.4.2 Scheduling

Construction activities should be scheduled according to the relative sensitivity of the environmental concerns and in accordance with the Scheduling BMP. Scheduling considerations will be different when working near perennial streams vs. ephemeral streams and are as follows.

When in-stream construction is conducted in a perennial stream, work should optimally be performed during the rainy season. This is because in the summer, any sediment-containing water that is discharged into the watercourse will cause a large change in both water clarity and water chemistry. During the rainy season, there is typically more and faster flowing water in the stream so discharges are diluted faster. However, should in-stream work be scheduled for summer, establishing an isolation area, or diverting the stream, will significantly decrease the amount of sediment stirred up by construction work. Construction work near perennial streams should optimally be performed during the dry season (see below).

When working in or near ephemeral streams, work should be performed during the dry season. By their very nature, ephemeral streams are usually dry in the summer, and therefore, in-stream construction activities will not cause significant water quality problems. However, when tying up the site at the end of the project, wash any fines (see Washing Fines) that accumulated in the channel back into the bed material, to decrease pollution from the first rainstorm of the season.

When working near ephemeral or perennial streams, erosion and sediment controls (see Chapter 4) should be implemented to keep sediment out of stream channel.

5.4.4.3 Minimize Disturbance

Minimize disturbance through: selection of the narrowest crossing location; limiting the number of equipment trips across a stream during construction; and, minimizing the number and size of work areas (equipment staging areas and spoil storage areas). Place non water dependent work areas at least 50 feet (ft) from stream channel to minimize impacts to stream. Field reconnaissance should be conducted during the planning stage to identify work areas.

5.4.4.4 Use of Pre-Disturbed Areas

Locate project sites and work areas in areas disturbed by prior construction or other activity when possible.

5.4.4.5 Selection of Project Site

Select project site that minimizes disturbance to aquatic species or habitat. Try to avoid steep and unstable banks, highly erodible or saturated soils, or highly fractured rock.

5.4.4.6 Equipment Selection

Select equipment that reduces the amount of pressure exerted on the ground surface, and therefore, reduces erosion potential and/ or use overhead or aerial access for transporting equipment across drainage channels. Use equipment that exerts ground pressures of less than 5 or 6 lb/in, where possible. Low ground pressure equipment includes: wide or high flotation tires (34 to 72 in. wide); dual tires; bogie axle systems; tracked machines; lightweight equipment; and, central tire inflation systems.

5.4.5 STREAMBANK STABILIZATION METHODS

Streambanks should be temporarily stabilized using approved soil stabilization and sediment control methods identified in Chapter 4 including but not limited to: preservation of existing vegetation, hydraulic mulch, hydroseeding, soilbinders, strawmulch, geotextiles or mats, silt fence, strawbale barriers, fiber rolls, velocity dissipation devices, slope drains and/or other appropriate erosion and sediment control methods.

There are numerous methods available to permanently stabilize stream banks. Rather than discuss all of them in detail, below is a discussion of the most common practices.

5.4.5.1 Bioengineering

Bioengineering is a method of using vegetation to stabilize a site with or without structural controls. Some refer to bioengineering as softening the traditional rock-the-bank approach because non-invasive vegetation is used to blend the site into its surrounding landscape. Bioengineering techniques may be as simple as installing erosion control blankets, then seeding exposed soil to help prevent soil movement, to full stream restoration plans. Common techniques utilized included:

Table 5: Streambank and Shoreline Stabilization Measures

	Type of Protection and Where Applicable										*Problems Addressed*						
Best Management Practices	Decrease Force	Increase Resistance	Immediate Protection	Protection Below or at Waterline	Streambank	Shoreline	Flat Banks (<2:1)	Steep Banks (>2:1)	Holes, Slumps	Natural Materials Present	Toe Erosioin, Undercutting	Wildlife Habitat	Aquatic Habitat	Water Quality/ Sediment Trap	Saturated Soil	Bare Bank	Overbank Erosion
Bioengineering																	
Fiber Rolls and Fiberschines, Coir Logs		X	X	X	X	X					X	X	X	X			
Brush Mattress		X	X		X	X				X		X		X	X	X	X
Brush Layering or Branch Packing	X	X	X		X	X	X		X	X		X	X	X	X	X	
Brush/Tree Revetment	X	X	X	X	X		X	X									
Brush Trench	X	X	X		X	X	X	X	X	X		X				X	
Stake Plantings		X			X	X	X		X			X		X	X	X	X
Vertical Bundles		X			X	X	X		X			X		X	X	X	X
Live Wattles or Fascines		X			X	X	X		X	X		X		X	X	X	X
Branchpacking	X	X	X		X	X	X		X	X							
Live Cribwall		X	X	X	X	X		X			X	X	X	X	X	X	X
Brushmattress		X	X		X	X				X		X		X	X	X	X
Structural																	
Rock Riffle	X	X	X	X	X		X	X			X		X	X			
Engineered Log Jams and Tree Revetments	X	X	X	X	X					X	X	X	X				

Log, Rootwad, Boulder Revetment	X	X	X	X	X					X		X	X	X			
Post/Pole Planting	X	X	X	X	X					X	X	X			X	X	X
Rock Riprap		X	X	X	X	X	X				X				X	X	X
Rock Gabions			X	X	X	X	X	X			X		X		X	X	
Vanes, Weirs, Barbs	X		X	X	X		X				X		X	X			
Notes: X = BMP may be applicable to activity																	

In a stream bank and shoreline environment, bioengineering and preservation of existing vegetation provides the following benefits:

5.4.5.1.1 Water Quality Protection:

Vegetated buffers on slopes trap sediment and promote groundwater recharge. The buffer width needed to maintain water quality ranges from 15 to 100 ft. On gradual slopes, most of the filtering occurs within the first 30ft. Steeper slopes require a greater width of vegetative buffer to provide water quality benefits.

5.4.5.1.2 Streambank Stabilization

The root system of riparian vegetation stabilizes stream banks by increasing tensile strength in the soil. The presence of vegetation modifies the moisture condition of slopes (infiltration, evapotranspiration, interception) and increases bank stability.

5.4.5.1.3 Riparian Habitat

Buffers of diverse riparian vegetation provide food and shelter for riparian and aquatic organisms. Minimizing impacts to fisheries habitat is a major concern when working near streams and rivers. Riparian vegetation provides shade, shelter, organic matter (leaf detritus and large woody debris), and other nutrients that are necessary for fish and other aquatic organisms. Buffer widths for habitat concerns are typically wider than those recommended for water quality concerns (100 to 1,500 ft).

When working near watercourses, it is important to understand the work site's placement in the watershed. Riparian vegetation in headwater streams has a greater impact on overall water quality than vegetation in downstream reaches. Preserving existing vegetation upstream is necessary to maintain water quality, minimize bank failure, and maximize riparian habitat, downstream of the work site.

5.4.5.1.4 Installation

As a general rule, the width of a buffer strip between a road and the stream is recommended to be 50 ft plus four times the percent slope of the land, measured between the road and the top of stream bank.

5.4.5.2 Riprap

Riprap is one of the more commonly used stream bank stabilization techniques. It is a permanent cover of rock used to stabilize stream banks, provide in-stream channel stability, and provide a stabilized outlet below concentrated flows. It is generally used on stream banks at the toe (bottom) of the slope, with other structures placed up-slope to prevent soil movement. It is often a component of many soil bioengineering techniques listed above.

Riprap stabilization designs should include appropriate bank slope and rock size to protect the bank from wave and current action and to prolong the life of the embankment. A final slope ratio of at least 1:2 (vertical to horizontal) is recommended, and a more stable 1:3 slope should be used where possible. However, steeper slopes may be appropriate.

A layer of gravel, small stone, or filter cloth placed under and/or behind the rock helps prevent failure. In many cases, only the toe of the slope may need rock reinforcement; the remainder can be planted with native vegetation.

5.5 Clear Water Diversion and Isolation Techniques

5.5.1 Description and Purpose

Clean water diversions are used to minimize water quality degradation by keeping clean water away from active construction sites. These diversions temporarily intercept and reroute water to 1) isolate surface waters from a construction area that is in or adjacent to water, or 2) divert upslope runoff around an active construction site or one that is newly constructed, unstable, unprotected, or recently seeded, and discharge downstream or down gradient to a protected outlet. They will divert surface waters until the construction is completed, BMPs are installed, and/or slopes are stabilized with vegetation and mulch.

Clear water diversion consists of a system of structures and measures that intercept clear surface water runoff upstream of a project, transport it around the work area, and discharge it downstream with minimal water quality degradation from either the project construction operations or the construction of the diversion. Clear water diversions are used in a waterway to isolate and confine construction area and reduce sediment pollution from construction work occurring in or adjacent to water. Structures commonly used as part of this system include diversion ditches, berms, dikes, slope drains, rock, gravel bags, wood, aqua barriers, cofferdams, filter fabric or turbidity curtains, drainage and interceptor swales, pipes, or flumes. This guidance will summarize these common practices as well as; identify suitable applications, limitations, standards and specifications, and inspection and maintenance of these practices.

5.5.2 Design Considerations

5.5.2.1 Construction Sites:

- Plan in advance for stable discharge of runoff collected in diversions. Discharge points must have outlet protection or energy dissipaters.
- Reduce diversion gradient to reduce water velocity.
- Size clean water diverters adequately for the catchment drainage size.
- Ensure that all diversion pipe connections are completely sealed and conduits are staked securely to the slope. Pipes are preferred to flumes for spill control.
- Ensure that any substance used to assemble or maintain diversion structures (e.g. form oil) or used to minimize seepage beneath these structures (e.g. grout) are non-toxic, non-hazardous, and neutral pH to minimize contamination of clean water.

5.5.2.2 Streams

- Schedule construction for periods of low flows, or when the stream is dry if possible. Consider seasonal releases of water from dams, fish migration and spawning seasons, and water demands due to vegetation irrigation.
- Always allow sufficient flow to pass to maintain aquatic life downstream. Never completely dam stream flow during isolation of a stream reach for construction.
- Never harm or remove riparian vegetation, unless approved by the permitting authority.

- Consider potential impacts to the stream channel or water body before installing diverters. Select less intrusive methods.
- Do not park equipment below the high water mark of a water body, unless approved by the permitting authority.
- Stabilize embankment slopes and diversion ditches with liners such as geotextiles, erosion control blanket systems, rock slope protection, or other slope stabilization materials in areas where erosion is anticipated.
- Avoid disturbing aquatic species during installation, dewatering, maintenance, or removal of clean water diverters. Maintain adequate flow downstream to support aquatic life.

5.5.3 Suitable Applications

A clear water diversion is typically implemented where appropriate permits (Section 10, Section 404, and Section 401 WQC) have been secured and work must be performed in a flowing stream or water body.

- Clear water diversions are appropriate for isolating construction activities occurring within or near a water body such as streambank stabilization, or culvert, bridge, pier or abutment installation. They may also be used in combination with other methods, such as clear water bypasses and/or pumps.
- Temporarily intercept and divert upslope runoff around construction areas and discharge to stable point downslope.
- Suitable for conveying runoff down steep slopes, particularly cut-and-fill slopes.
- Useful for diverting, removing, and treating sediment-laden water encountered during construction.
- Pumped diversions are suitable for intermittent and low flow streams.
- Excavation of a temporary bypass channel, or passing the flow through a heavy pipe (called a "flume") with a trench excavated under it, is appropriate for the diversion of streams less than 20 ft wide, with flow rates less than 100 cubic feet per second (cfs).

5.5.4 Limitations

- Diversion and encroachment activities will usually disturb the waterway during installation and removal of diversion structures.
- Specific permit requirements or mitigation measures such as 401 Water Quality Certification, U.S. Army Corps of Engineers Section 404 or Section 10 permits, U.S. Coast Guard Section 9 or General Bridge Act Permits and approval by USFWS and NMFS supersede the guidance in this BMP. If numerical-based water quality standards are mentioned in any of these and other related permits, testing and sampling may be required.
- Special permits or mitigation measures may be required.
- Diversion and encroachment activities may constrict the waterway, which can obstruct flood flows and cause flooding or washouts. Diversion structures

should not be installed without identifying potential impacts to the stream channel.

- Diversion or isolation activities are not appropriate in channels where there is insufficient stream flow to support aquatic species in the area dewatered as a result of the diversion.
- Diversion or isolation activities are inappropriate in deep water unless designed or reviewed by a hydraulic engineer.
- Diversion or isolation activities should not completely dam stream flow.
- Dewatering and removal may require additional sediment control or water treatment. See SM-17, Dewatering Operations.
- Not appropriate if installation, maintenance, and removal of the structures will disturb sensitive aquatic species of concern.

5.5.5 Standards and Specifications

There are two types of clean water diversions: (1) The diversion method involves intercepting clean runoff water from upslope, diverting it around a construction area, and conveying it by various means to a stable discharge point down slope. (2) The isolation method, on the other hand, uses various techniques to isolate and dewater a construction area that exists in a stream, lake, or other water environment.

5.5.6 General Considerations

- Implement the streambank stabilization guidelines to minimize impacts to streambanks.
- Divert clear water to clear water. This means that a diversion should be of sufficient length to completely bypass the area impacted by construction. If clear water is returned to a waterway too soon, it will exacerbate the sediment control problem rather than mitigating it by increasing the volume of sediment laden water on the job site.
- Where working areas encroach on flowing streams, barriers adequate to prevent the flow of muddy water into streams should be constructed and maintained between working areas and streams. During construction of the barriers, muddying of streams should be held to a minimum.
- Where possible, diversion/encroachment impacts should be avoided or minimized by scheduling construction during periods of low-flow or when the stream is dry (see also the project special provisions for scheduling requirements). Scheduling should also consider seasonal releases of water from dams, fish migration and spawning seasons, and water demands due to crop irrigation.
- Diversion structures must be adequately designed to accommodate fluctuations in water depth or flow volume due to tides, storms, flash floods, etc.
- Heavy equipment driven in wet portions of a water body to accomplish work should be completely clean of petroleum residue, and water levels should be below the fuel tanks, gearboxes, and axles of the equipment unless lubricants

and fuels are sealed such that inundation by water will not result in discharges of fuels, oils, greases, or hydraulic fluids.

- Excavation equipment buckets may reach out into the water for the purpose of removing or placing fill materials. Only the bucket of the crane/ excavator/backhoe may operate in a water body. The main body of the crane/excavator/backhoe should not enter the water body except as necessary to cross the stream to access the work site.
- Stationary equipment such as motors and pumps located within or adjacent to a water body should be positioned over drip pans.
- When any artificial obstruction is being constructed, maintained, or placed in operation, sufficient water should, at all times, be allowed to pass downstream to maintain aquatic life.
- The exterior of vehicles and equipment that will encroach on a water body within the project should be maintained free of grease, oil, fuel, and residues and may require vegetable based hydraulic oil.
- Equipment should not be parked below the high water mark unless allowed by a permit.
- Disturbance or removal of vegetation should not exceed the minimum necessary to complete operations, and as shown on the project plan sheets (i.e. construction limits). Precautions should be taken to avoid damage to vegetation by people or equipment. Disturbed vegetation should be replaced with the appropriate erosion control/soil stabilization measures.
- Riparian vegetation approved for trimming as part of the project should be cut off no lower than ground level to promote rapid re-growth. Access roads and work areas built over riparian vegetation should be covered by a sufficient layer of clean river run cobble to prevent damage to the underlying soil and root structure. The cobble should be removed upon completion of project activities.
- Drip pans should be placed under all vehicles and equipment placed on docks, barges, or other structures over water bodies when the vehicle or equipment is planned to be idle for more than 1 hour.
- Where possible, avoid or minimize diversion and encroachment impacts by scheduling construction during periods of low flow or when the stream is dry. Scheduling should also consider seasonal releases of water from dams, fish migration and spawning seasons, and water demands due to crop irrigation.
- Construct diversion structures with materials free of potential pollutants such as soil, silt, sand, clay, grease, oil or other petroleum products.
- • A “Diversion Plan” should be submitted to the Project Engineer for review prior to commencing any clear water diversion activities. This plan should include, at a minimum, the following:
    - Predicted diversion flow rates
    - Pump capacities (if required)

- Material to be used (i.e., piping, plastic sheeting)
- Appropriate permits and approvals (as required)
- Contingency plans
- Additional BMP(s) (as required)
- Removal and restoration plan

5.5.6.1 Stream Isolation Techniques (Temporary Dry Construction Areas)

Isolation techniques are methods that isolate near shore work from a waterbody. Techniques include sheet pile enclosures, water-filled geotextile (Aqua Dam), gravel berm with impermeable membrane, gravel bags, coffer dams, and K-rail.

The selection of which stream diversion or Isolation technique to use will depend upon the type of work involved, physical characteristics of the site, and the volume of water flowing through the project. Costs of clear water diversion vary considerably and can be very high. Manufactured diversion structures should be installed following manufacturer's specifications.

5.5.6.1.1 Filter Fabric

A relatively inexpensive isolation method is filter fabric isolation. This method involves placement of gravel bags or continuous berms to 'key-in' the fabric, and subsequently staking the fabric in place. This method should be used in relatively calm water, and can be used in smaller streams. Note that this is not a dewatering method, but rather a sediment isolation method.

5.5.6.1.2 Turbidity Curtain:

A turbidity curtain is a fabric barrier used to isolate the near shore work area. The barriers are intended to confine the suspended sediment. The curtain is a floating barrier, and thus does not prevent water from entering the isolated area; rather, it prevents suspended sediment from getting out. Turbidity curtains should be used where sediment discharge to a stream is unavoidable.

5.5.6.1.3 K-rail River Isolation:

K-rails are shaped concrete barriers that can be used to isolate an in-stream or near bank construction area or to form a sediment deposition area. The method can be used in streams with higher water velocities than allowable with many other isolation techniques, but it does not allow for full dewatering.

5.5.6.1.4 Sheet Pile Enclosures:

Sheet metal piles are installed in water to provide a waterproof area for full dewatering. This technique is useful in large streams and lakes. This technique is relatively expensive and staging and heavy equipment access areas are necessary.

5.5.6.1.5 Water-Filled Geotextile (Aqua Dam):

This technique allows for partial dewatering of in-stream/lake or near bank construction areas and can be used for small streams to large rivers. An aqua dam consists of a geotextile bag with two separate sections that is placed in water. Each section is then filled with water to reach above the high water level, preventing movement of the bag. Aqua dams are lightweight, easy to transport, reusable, and easy to install.

5.5.6.1.6 Gravel Berm with Impermeable Membrane:

This technique, designed for small streams, allows for partial dewatering of in-stream/lake or near bank construction areas. At the upstream end of the project area, clean washed gravel is placed into the stream to hold in place an impermeable membrane. The area can then be dewatered.

Gravel Bag Berms used in conjunction with an impermeable membrane are cost effective, and can be dewatered relatively easily. If spawning gravel is used, the impermeable membrane can be removed from the stream, and the gravel can be spread out and left as gravel in water habitat if approved in the permit. Only clean, washed gravel should be used for both the gravel bag and gravel berm techniques.

5.5.6.1.7 Gravel Bag:

Overlapping clean and washed gravel filled bags are placed into the water until they reach the height of the high water level. The work area downstream of the gravel bags can then be dewatered. Installation and removal of the gravel bags is labor intensive. Leaks between the gravel bags can also make dewatering an area difficult.

5.5.6.1.8 Coffer dams:

Coffer dams are watertight structures of steel, timber, earth, or other materials built in place to block off the construction area which is normally submerged. These dams are used in a variety of settings, including small to large streams, lakes, and coastal areas. Also, many options are now available and are relatively easy to install.

5.5.6.1.9 Isolation Technique Considerations

- When dewatering behind temporary structures to create a temporary dry construction area, such as cofferdams, pass pumped water through a sediment-settling device, such as a portable tank or settling basin, before returning water to the water body.
- Isolation structures must be in place for life of in-water work. Structures should be installed before work starts and removed after stabilization of in-water work area is complete to avoid impacts to aquatic environment.
- Any substance used to assemble or maintain diversion structures, such as form oil, should be inert, non-toxic and non-hazardous.
- Any material used to minimize seepage underneath diversion structures, such as grout, should be non-toxic, non-hazardous, and as close to a neutral pH as possible.

5.5.6.2 Stream Diversion Techniques

In conjunction with isolating and dewatering the work area in a stream reach, surface water upstream may be diverted around the work area and discharged downstream. There are three types of stream diversions. The stream diversion technique to use depends upon the type of work involved, physical characteristics of the site, and the volume of water flowing through the project. The three stream diversion techniques are:

5.5.6.2.1 Pumped diversions:

Effective for de-watering in relatively flat terrain. Pump capacity must be sufficient for design flow. Pumps require frequent monitoring.

5.5.6.2.2 Pipe/Flume diversions:

Requires moderate slope to generate adequate stream velocity to move water through the pipe/flume to the discharge area.

5.5.6.2.3 Dam-type or excavated diversions:

Water is diverted by temporary dams constructed above and below the work site. Dams must be constructed of erosion resistant materials such as steel plate, sheet pile, washed gravel bags, continuous berms, inflatable water bladders, and similar.

5.5.6.2.4 Diversion Technique Considerations

- When constructing a diversion channel, begin excavation of the channel at the downstream end and work upstream. Once the watercourse to be diverted is reached, and the excavated channel is stable, breach the upstream end, and allow water to flow down the new channel. Once flow has been established in the diversion channel, install the diversion weir in the main channel; this will force all water to be diverted from the main channel.
- All stream diversions will need to have a barrier installed to block the water and force it into the diversion (Refer to Stream Isolation Techniques above). Carefully evaluate site conditions to select type of diversion to use and installation specifications. Size diversions to convey design flood flows. Provide adequate energy dissipation at the outlet to minimize erosion.
- In high flow velocity areas, stabilize slopes of embankments and diversion ditches using an appropriate liner, in accordance with standard specifications for Geotextiles and Mats, or use rock slope protection.
- Where appropriate, use natural streambed materials such as large cobbles and boulders for temporary embankment and slope protection, or other temporary soil stabilization methods.
- Provide for velocity dissipation at transitions in the diversion, such as the point where the stream is diverted to the channel and the point where the diverted stream is returned to its natural channel. See standard specifications for Velocity Dissipation Devices.

5.6 Filter Fabric Isolation Technique

5.6.1 Definition and Purpose

A filter fabric isolation structure is a temporary structure built into a waterway to enclose a construction area and reduce sediment pollution from construction work in or adjacent to water. This structure is composed of filter fabric, gravel bags, and steel t-posts.

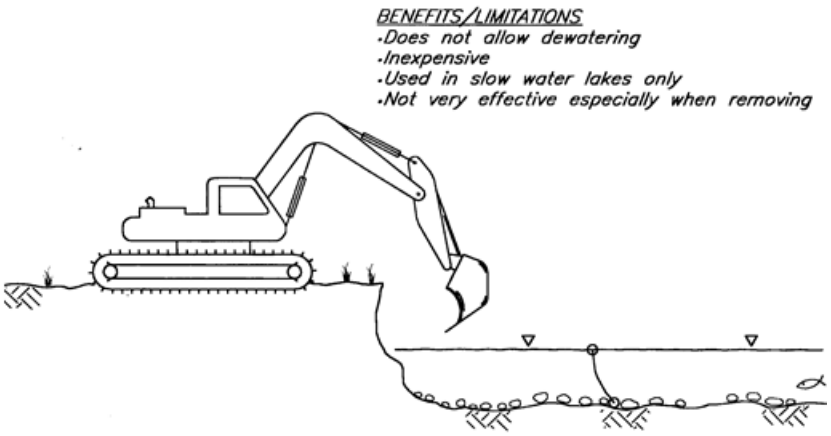


Figure 11: Geotextiles, Silt Barriers, Curtain Enclosure Method.

5.6.2 Appropriate Applications

- Filter fabric may be used for construction activities such as streambank stabilization, or culvert, bridge, pier or abutment installation. It may also be used in combination with other methods, such as clean water bypasses and/or pumps.
- Filter fabric isolation is relatively inexpensive. This method involves placement of gravel bags or continuous berms to 'key-in' the fabric, and subsequently staking the fabric in place.
- If spawning gravel is used, all other components of the isolation can be removed from the stream, and the gravel may be spread out and left as gravel stream habitat if approved in the permit. Whether spawning gravel or other types of gravel are used, only clean washed gravel should be used as infill for the gravel bags or continuous berm.
- This method should be used in relatively calm water, and can be used in smaller streams.
- This is not a dewatering method, but rather a sediment isolation method.
- Water levels inside and outside the fabric curtain must be about the same, as differential heads will cause the curtain to collapse.

5.6.3 Limitations

- Do not use if the installation, maintenance and removal of the structures will disturb sensitive aquatic species of concern.
- Filter fabrics are not appropriate for projects where dewatering is necessary.

- Filter fabrics are not appropriate to completely dam stream flow.

5.6.4 Standards and Specifications

- For the filter fabric isolation method, a non-woven or heavy-duty fabric (refer to Standard Specification FP-14, Section 713) is required over standard silt fence. Using rolled geotextiles allows non-standard widths to be used.
- Anchor filter fabric with gravel bags filled with clean, washed gravel. Do not use sand. If a bag should split open, the gravel can be left in the stream, where it can provide aquatic habitat benefits. If a sandbag splits open in a watercourse, the sand could cause a decrease in water quality, and could bury sensitive aquatic habitat. Exceptions may apply if streambed is composed of sand and similar sand material is used to fill bags.
- Another anchor alternative is a continuous berm, made with the Continuous Berm Machine. This is a gravel-filled bag that can be made in very long segments. The length of the berms is usually limited to 20 ft for ease of handling (otherwise, it gets too heavy to move).

5.6.5 Installation

- Place the fabric on the bottom of the stream, and place either a bag of clean, washed gravel or a continuous berm over the bottom of the silt fence fabric, such that a bag-width of fabric lies on the stream bottom. The bag should be placed on what will be the outside of the isolation area.
- Pull the fabric up, and place a metal t-post immediately behind the fabric, on the inside of the isolation area; attach the silt fence to the post with three diagonal nylon ties.
- Continue placing fabric as described above until the entire work area has been isolated, staking the fabric at least every 6 ft.

5.6.6 Inspection and Maintenance

- Conduct inspections as required by the NPDES, 404 permit, 401 WQC or contract specifications. At a minimum, during construction inspect daily during the workweek.
- Schedule additional inspections during and after storm events.
- Immediately repair any gaps, holes or scour.
- Remove and properly dispose of sediment buildup.
- Remove BMP upon completion of construction activity. Recycle or reuse if applicable.
- Revegetate areas disturbed by BMP removal if needed.

5.7 Turbidity Curtain Isolation Technique

5.7.1 Definition and Purpose

A turbidity curtain is a fabric barrier used to isolate the near shore work area. The barriers are intended to confine the suspended sediment. The curtain is a floating barrier, and thus does not prevent water from entering the isolated area; rather, it prevents suspended sediment from getting out.

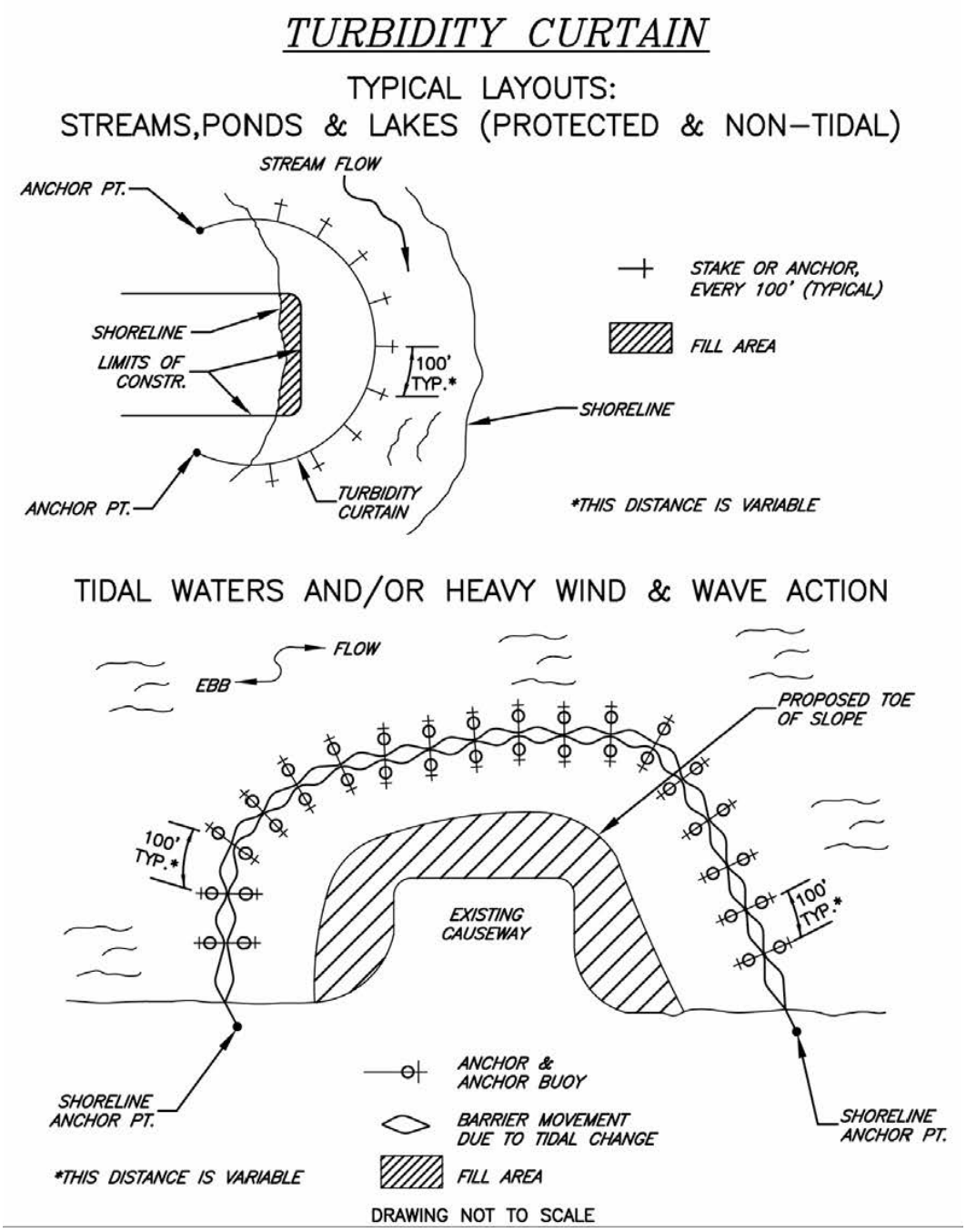


Figure 12: Turbidity Curtain Enclosure Method.

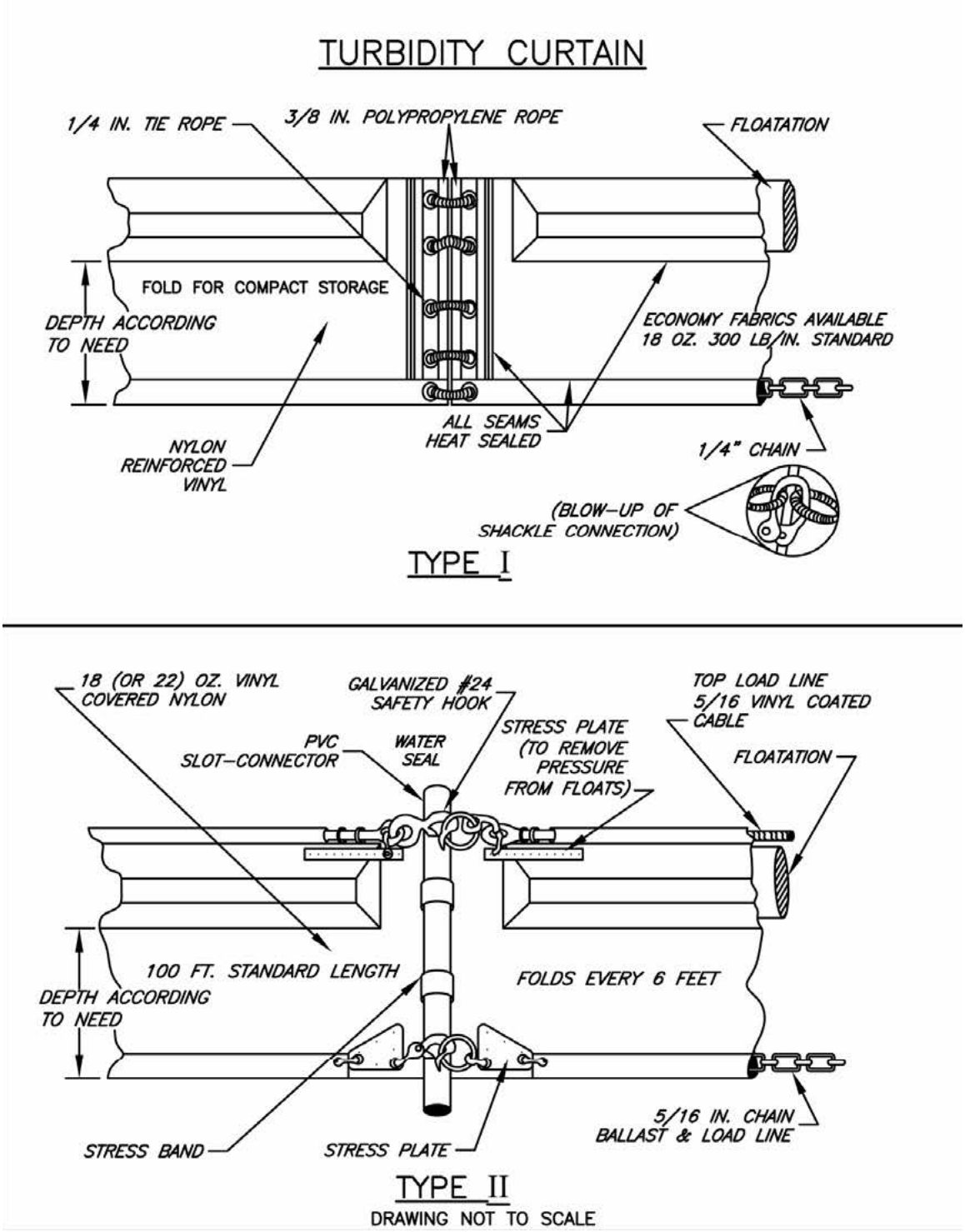


Figure 13: Turbidity Curtain Enclosure Method.

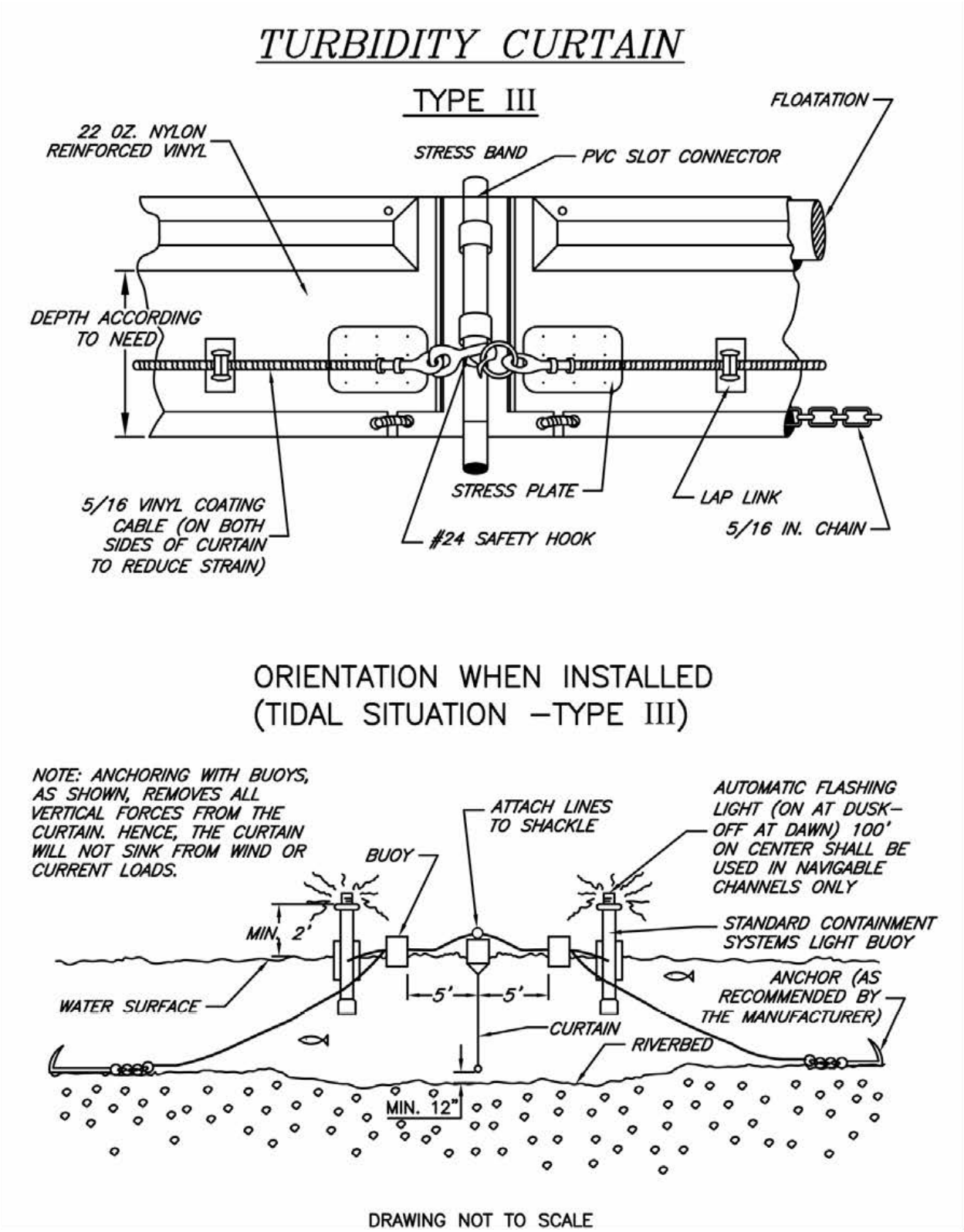


Figure 14: Turbidity Curtain Enclosure Method.

5.7.2 Appropriate Applications

- Turbidity curtains should be used where sediment discharge to a stream is unavoidable. They are used when construction activities adjoin quiescent waters, such as lakes, ponds, and slow flowing rivers. The curtains are designed to deflect and contain sediment within a limited area and provide sufficient retention time so that the sediment particles will fall out of suspension.
- These BMPs are designed and selected for specific flow conditions. For sites with flow velocities or currents greater than 5 feet per second, a qualified engineer and product manufacturer shall approve of the use.

5.7.3 Limitations

- May be insufficient as a primary isolation technique and may be better suited for use in conjunction with other isolation or confinement techniques
- Turbidity curtains should not be used in flowing water; they are best suited for use in ponds, lakes, and very slow-moving rivers.
- Turbidity curtains should not be placed across the width of a channel unless they are specifically engineered to withstand expected flows and approved by project engineer.
- Removing sediment that has been deflected and settled out by the curtain may create a discharge problem through the re-suspension of particles and by accidental dumping by the removal equipment.

5.7.4 Standards and Specifications

- Turbidity curtains shall be installed parallel to the flow of the watercourse, allowing for 10 to 20 percent variance in the straight-line measurements. Allow for at least 50 feet between joints in the curtain and no more than 100 feet between anchor or stake locations.
- The curtain should extend the entire depth of the watercourse in calm-water situations.
- In wave conditions, the curtain should extend to within 1 ft of the bottom of the watercourse, such that the curtain does not stir up sediment by hitting the bottom repeatedly. If it is desirable for the curtain to reach the bottom in an active-water situation, a pervious filter fabric may be used for the bottom 1 ft.
- Multiple concentric curtains, in some cases both top-down and bottom-up, may be necessary to fully contain sediment during in-water work.
- Turbidity monitoring shall be conducted to evaluate curtain effectiveness, and contingency measures shall be implemented immediately if suspended sediment escapes in excess of allowable limits.
- Turbidity curtains shall extend the entire depth of the watercourse. In significant wind, wave, or tidal action areas, a 10- to 12-foot depth is the most practical because of fabric and mooring anchor strain from the heavy water and sediment loads.

- For tidal situations or in areas heavily impacted by wind-generated wave action, turbidity curtains shall have slack to follow the rise and fall of the water level without submerging. Curtains shall also maintain adequate flow-through, usually by using heavier woven fabric for the bottom sections of the curtain.
- Materials shall be of strong, heavyweight materials that have UV inhibitors. The tensile strength shall be sufficient to withstand predicted flows. All material seams and line attachments shall be sewn or vulcanized welded into place. Materials shall be of bright colors, when applicable, to attract attention of boaters or swimmers using areas near the worksite. Flotation devices for turbidity curtains shall be flexible, buoyant units contained in an individual flotation sleeve or collar attached to the curtain. Flotation devices shall be secured to prevent shifting and ensure proper flotation along the entire length of the curtain.
- Turbidity curtains shall be anchored by vinyl-sheathed steel cable at the top, with a breaking strength as per engineer specifications, but 10,000 pounds at the minimum. At the bottom, a load line with chain incorporated into the bottom hem of the curtain shall be used for ballast to hold the curtain vertical.
- Shoreline turbidity curtain anchors and instream sediment mats shall be anchored by chains, 2x4-foot wood, or 1.33 pounds/linear foot metal stakes. Bottom anchors for turbidity curtains shall hold the curtain in position and may be any of the following anchor types: plow, fluke, mushroom, or grappling hook. All instream anchors shall have a floating anchor buoy or other identifying mark.
- Best installation is achieved by setting the upstream anchor points first, then unfurling the fabric, letting the flow carry the fabric downstream or to a vertical position for turbidity curtains.
- The anchors should first be placed, and then the fabric should be towed out in a furled condition and connected to the anchors. The anchors should be connected to the flotation devices, not to the bottom of the curtain. Once in place, the furling lines should be cut, and the bottom of the curtain should be allowed to sink.
- Sediment shall be allowed to settle for a minimum of 6 to 12 hours before BMP removal or cleaning. All cleaning operations shall also use good sediment control practices. However, consideration must be given to the potential for re-suspension of the particles or by accidental dumping of material during removal. It is recommended that the soil particles trapped by the turbidity curtain be removed only if there has been a significant change in the original contours of the affected area in the watercourse.
- Consider sizing materials adequately to allow maintenance to occur only before removal and not throughout the project.

5.7.4.1 Removal Specifications

- Particles should always be allowed to settle for a minimum of 6 to 12 hours prior to their removal or prior to removal of the turbidity curtain.

- All materials shall be removed at low flows and in a way that scoops and traps sediments within the fabric. The removal area shall be clear of any obstructions that could tear the fabric.
- For curtains, consider pulling the bottom line and top lines in together like a parachute to pull soils ashore.
- Spoils shall be reused and controlled for erosion on a nearby bank or upland area needing stabilization.

5.7.5 Inspection and Maintenance

- Inspect turbidity curtains as least daily during in-water work. Immediately repair floats, fabric, or seams to maintain a fully intact barrier. Conduct inspections as required by the NPDES, 404 permit, 401 WQC or contract specifications.
- The curtain should be inspected for holes or other problems, and any repairs needed should be made promptly. Follow the manufacturer's instructions for fabric and material repair.
- Allow sediment to settle for 6 to 12 hours prior to removal of sediment or curtain. This means that after removing sediment, wait an additional 6 to 12 hours before removing the curtain.
- To remove, install furling lines along the curtain, detach from anchors, and tow out of the water.

5.7.5.1 Signs of Failure

Symptoms	Cause	Solution
Turbid water releasing from curtain.	• Bottom anchor is loose or gone. • Joints/overlaps are loose. • Floatation is gone/ diminished. • Curtain material is torn.	• Repair/replace parts as needed. • Reevaluate curtain strength versus strength of water flows.

5.8 K-RAIL (JERSEY BARRIER) RIVER ISOLATION TECHNIQUE

5.8.1 DEFINITION AND PURPOSE

This temporary sediment control or stream isolation method uses K-rails to form the sediment deposition area, or to isolate the in-stream or near-bank construction area.

Barriers are placed end-to-end in a pre-designed configuration and gravel-filled bags are used at the toe of the barrier and at their abutting ends to seal and prevent movement of sediment beneath or through the barrier walls.

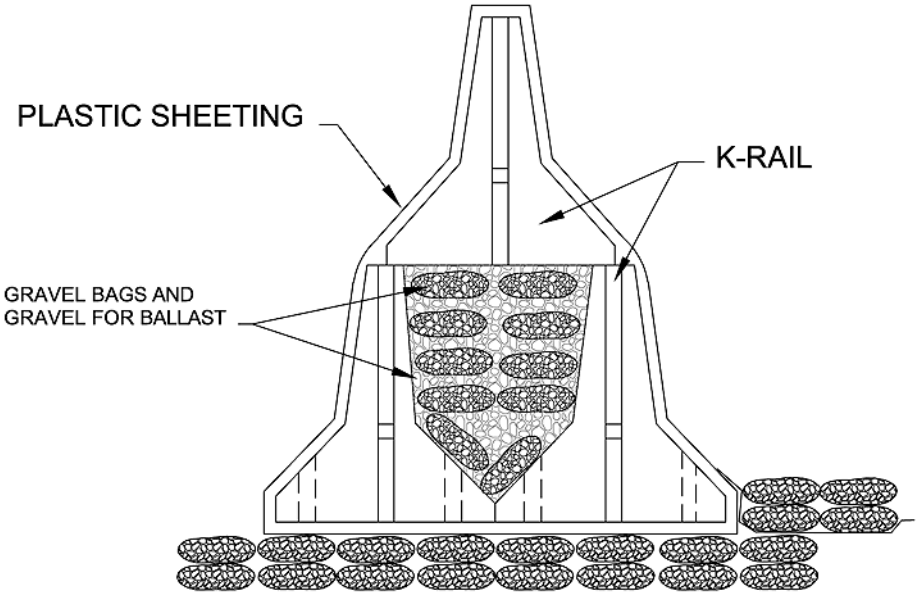


Figure 15: K-Rail Isolation Method.

5.8.2 APPROPRIATE APPLICATIONS

- The K-rail isolation can be used in streams with higher water velocities than many other isolation techniques.
- This technique is also useful at the toe of embankments, and cut or fill slopes.

5.8.3 LIMITATIONS

- The K-rail method should not be used to dewater a project site, as the barrier is not watertight. Refer to standard specifications for construction dewatering techniques.

5.8.4 Standards and Specifications

- To create a floor for the K-rail, move large rocks and obstructions. Place washed gravel and gravel-filled bags to create a level surface for K-rails to sit. Washed gravel should always be used.
- Place the bottom two K-rails adjacent to each other, and parallel to the direction of flow; fill the center portion with gravel bags. Then place the third K-rail on top of the bottom two (See Figure 15). There should be sufficient gravel bags between the bottom K-rails such that the top rail is supported by the gravel. Place plastic sheeting around the K-rails, and secure at the bottom with gravel bags.
- Further support can be added by pinning and cabling the K-rails together. Also, large riprap and boulders can be used to support either side of the K-rail, especially where there is strong current.

5.8.5 Inspection and Maintenance

- Conduct inspections as required by the NPDES, 404 permit, 401 WQC or contract specifications.
- The barrier should be inspected and any leaks, holes, or other problems should be addressed immediately.
- Sediment should be allowed to settle for at least 6 to 12 hours prior to removal of sediment, and for 6 to 12 hours prior to removal of the barrier.

5.9 COFFERDAM AND/OR SHEET PILE ISOLATION TECHNIQUE

5.9.1 DEFINITION AND PURPOSE

Coffer dams and Sheetpile walls are temporary structures built into a waterway to contain or divert movement of water and to provide a reasonably dry construction area. Coffer dams are commonly made of steel sheet pile, rock, gabions, concrete jersey barriers, vinyl tubes filled with water, or wood and may be lined with geotextile, plastic sheeting, or other materials to prevent water from entering the construction area.

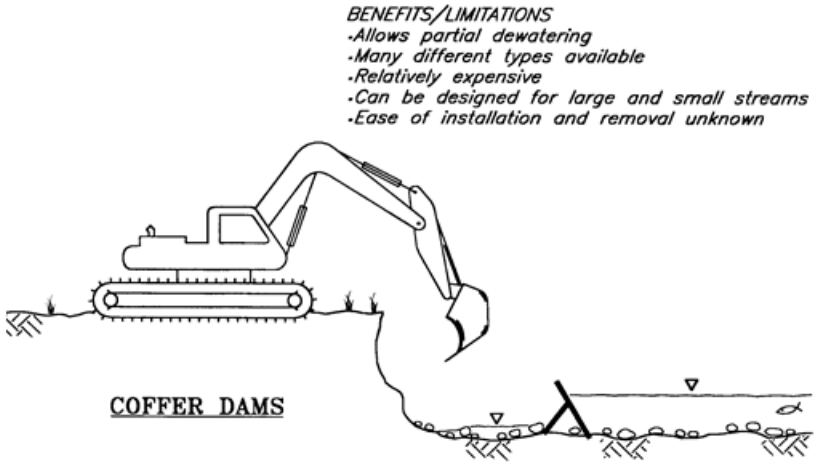


Figure 16: Coffer Dam Isolation Method.

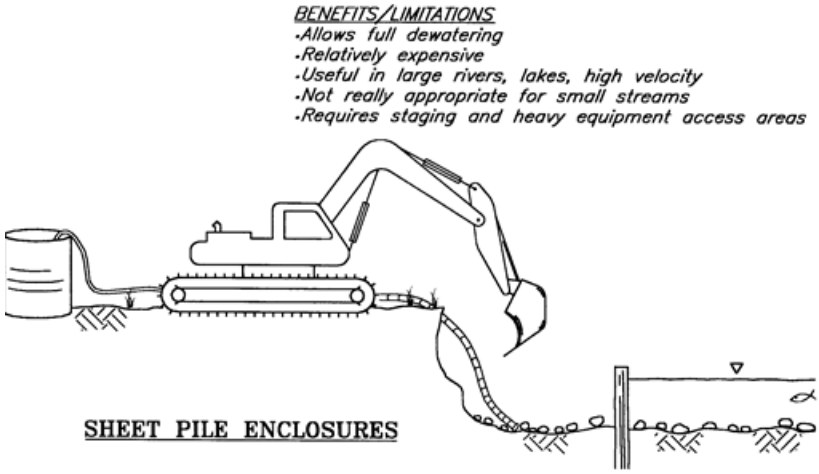


Figure 17: Sheet Pile Isolation Method.

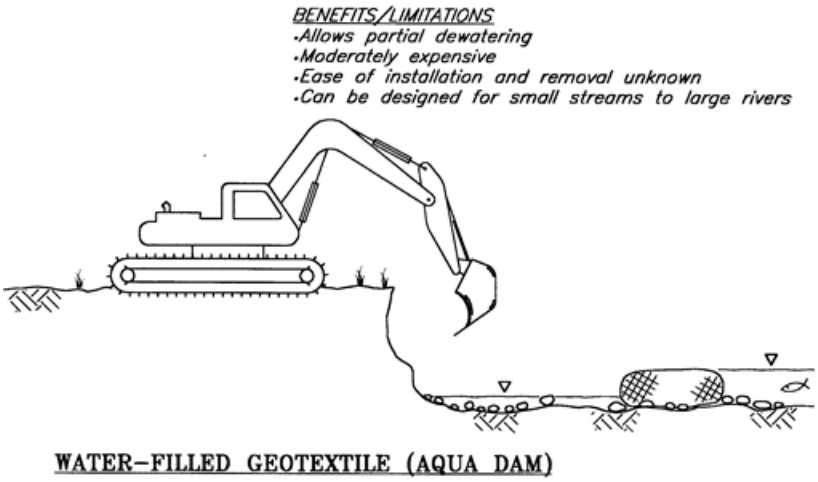


Figure 18: Water-Filled Geotextile (Bladder Dam).

5.9.2 Appropriate Applications

- Where dewatering is necessary.
- Work areas that require isolation from flows.
- Often used in conjunction with stream diversion techniques.

5.9.3 Limitations

- Under some conditions, the design must be developed or approved by a qualified licensed engineer.
- The coffer dam should be sturdy enough to withstand anticipated water pressure, shear stresses and scouring.

5.9.4 Standards and Specifications

- Site specific design is required for a coffer dam.
- Coffer dams should be designed to withstand currents and scour conditions expected under normal stream flow and annual high water. The functional life expectancy is generally 6 months or less.
- Construction materials commonly include steel sheet piles, rock, vinyl tubes, or wood. Piling could consist of standard steel sheet interlocked and driven into the soil or anchored to bedrock. Wooden structures may consist of planks or wood timbers. Concrete jersey barriers may be used, depending on the anticipated water flow, depth and appropriate fit and contact with the stream bed.
- The water side of the coffer dam may be lined with plastic sheeting or some other suitable material that would prevent water passage into the construction area.
- The coffer dam should be built as shown on the plans. Field adjustments should be made as necessary. Water-filled Geotextile (bladder dams) should be installed

following manufacturer's recommendations and guidelines. Rocks or sharp objects should be removed prior to installation.

- If dewatering is required while utilizing a coffer dam, meet dewatering requirements of the NPDES permit and/or 404 permits.

5.9.5 Inspection and Maintenance

- Conduct inspections as required by the NPDES, 404 permit, 401 WQC or contract specifications.
- Remove accumulated sediment and debris regularly and just prior to removing the coffer dam.
- Conduct required dewatering operations such that all permitting requirements are met.
- Upon removal of the coffer dam, stabilize the area and streambed and restore to as near-natural condition as possible. This may require some form of rock riprap and permanent revegetation if the stream bank has been disturbed.

5.10 GRAVEL/ROCK BERM WITH IMPERMEABLE MEMBRANE ISOLATION TECHNIQUE

5.10.1 DEFINITION AND PURPOSE

This temporary sediment control or stream isolation method uses a gravel or rock berm with an impermeable membrane to isolate the in-stream or near-bank construction area.

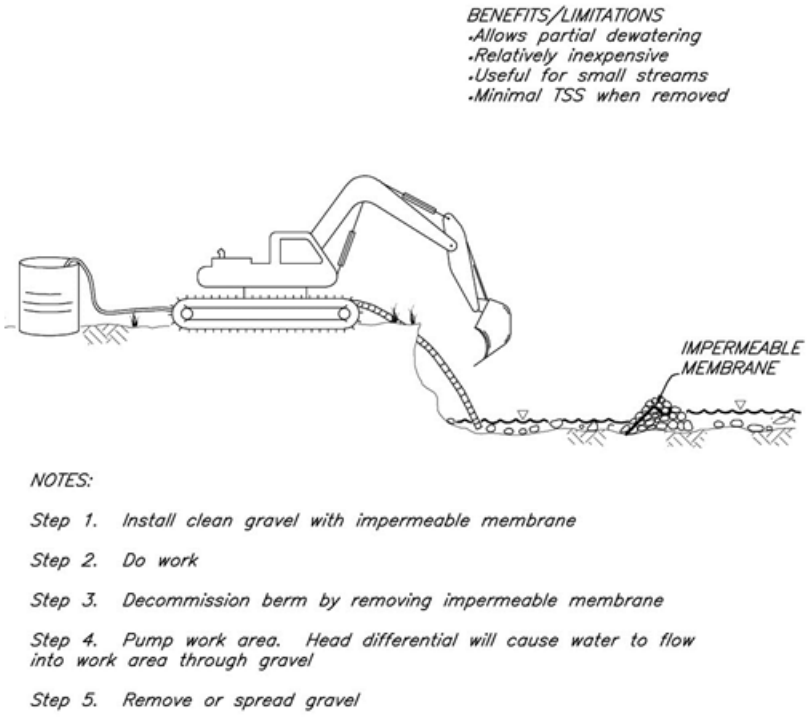


Figure 19: Gravel/Rock Berm with Impermeable Membrane.

5.10.2 APPROPRIATE APPLICATIONS

- Where dewatering is necessary.
- Work areas that require isolation from flows.

5.10.3 LIMITATIONS

- Under some conditions, the design must be developed or approved by a qualified licensed engineer.
- The gravel/rock size should be sturdy enough to withstand anticipated water pressure, shear stresses and scouring.

5.10.4 STANDARDS AND SPECIFICATIONS

- Installation guidelines will vary based on existing site conditions and type of diversion used.

- Gravel berm should be designed to withstand currents and scour conditions expected under normal stream flow and annual high water.
- The impermeable barrier imbedded within the berm should be made of plastic sheeting or some other suitable material that would prevent water passage into the construction area.

5.10.5 INSPECTION AND MAINTENANCE

- Conduct inspections as required by the NPDES, 404 permit, 401 WQC or contract specifications.
- Conduct required dewatering operations such that all permitting requirements are met.
- Check for any erosion and/or undercutting around the inlet and outlet structures, repair as needed.
- Remove accumulated sediment and debris regularly and just prior to removing the coffer dam.
- Upon decommissioning of the gravel/rock berm, stabilize the area and streambed and restore to as near-natural condition as possible. This may require some form of rock riprap and permanent revegetation if the stream bank has been disturbed.
- Inspect berm before and after large storms, and inspect daily during construction. Visually inspect for clogging, damage to linings, accumulation of debris, and adequacy of slope protection. Remove debris and repair linings and slope protection as required. Repair holes, gaps, or scour.
- Upon completion of work, remove the diversion or isolation structure and redirect flow back into the original stream channel.

5.11 GRAVEL BAG OR SANDBAG ISOLATION TECHNIQUE

5.11.1 DEFINITION AND PURPOSE

A sandbag barrier is a temporary linear sediment barrier consisting of stacked gravel bag/sandbags, designed to intercept and slow the flow of sediment-laden sheet flow runoff. Gravel bag / Sandbag barriers allow sediments to settle from runoff before water leaves the construction site. Large gravel bag / sandbag barriers can also be used for in-water work and/or water diversions if site conditions allow.

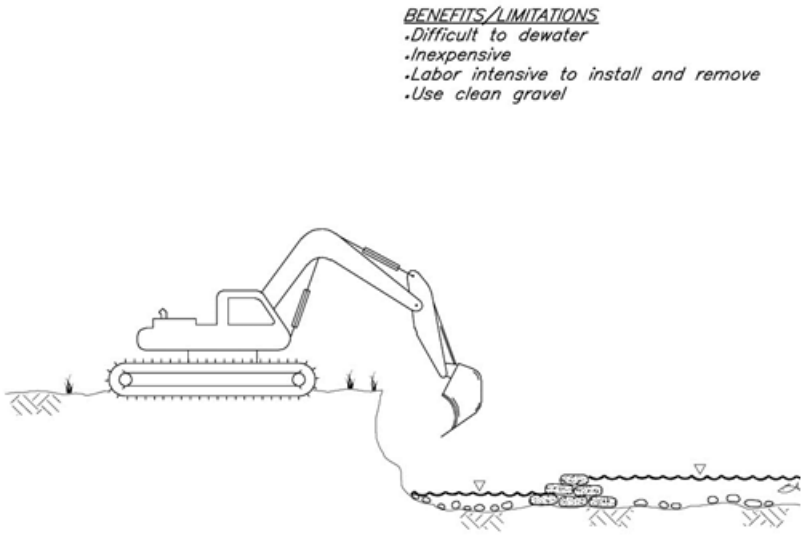


Figure 20: Gravel Bag / Sand Bag Method

5.11.2 APPROPRIATE APPLICATIONS

- To divert or direct flow or create a temporary sediment/de-silting basin.
- During construction activities in stream beds when the contributing drainage area is typically less than 5 acres.
- To capture and detain non-stormwater flows until proper cleaning operations occur.
- When site conditions or construction sequencing require adjustments or relocation of the barrier to meet changing field conditions and needs during construction.
- To temporarily close or continue broken, damaged, or incomplete curbs.

5.11.3 LIMITATIONS

- The drainage area upstream of the barrier should be limited to 5 acres.
- Degraded sandbags may rupture when removed, spilling sand.
- Installation can be labor-intensive.
- Limited durability of bag material.
- When used to detain concentrated flows, maintenance may increase.

5.11.4 STANDARDS AND SPECIFICATIONS

- Installation guidelines will vary based on existing site conditions and type of diversion used.
- **Bag Material:** Bags should be woven canvas, geotextile, or burlap material that is UV-resistant and impermeable. Minimum unit weight 4 ounces per square yard; Mullen burst strength exceeding 300 psi in conformance with the requirements in ASTM designation D3786; minimum water flow rating of 145 gallons per minute per foot in conformance with the requirements in ASTM D4491; and ultraviolet stability exceeding 70 percent in conformance with the requirements in ASTM designation D4355.
- **Fill Material:** Use clean gravel or sand (if more suitable based on site conditions) to fill bags Fill material should be inert and easily recoverable if spilled (minimum 3" aggregate for gravel). Fill should be inert clean and free from clay balls, organic matter, and other deleterious materials that could leach from the bag. Fill material is subject to approval by the Engineer.
- Place bags in a manner that causes the least amount of disturbance to the stream bed. Applicable in waters with smooth bed surfaces where bag can create seal along bottom.

5.11.5 INSPECTION AND MAINTENANCE

- The barrier should be inspected and any leaks, holes, or other problems should be addressed immediately.
- Conduct inspections as required by any applicable permit or contract specifications.
- Reshape or replace sandbags as needed, or as directed by the Engineer.
- Repair washouts or other damages as needed, or as directed by the Engineer.
- Removed sediment should be incorporated in the project at locations designated by and approved by the Engineer or if deemed contaminated (i.e. hazardous waste) should be disposed of in accordance with federal and state laws.
- Remove sandbags when no longer needed. Remove sediment accumulation, and clean, re-grade, and stabilize the area.

5.12 Pipe Piles and Caisson Isolation Technique

5.12.1 Definition and Purpose

Piles and Caissons come in many different forms and are commonly used during construction of transportation structures, including bridges. Driven piles are typically constructed of precast concrete, steel, or timber. Driven sheet piles are also used for shoring and cofferdam construction.

5.12.1.1 Piles

Piled foundations are usually the first alternative considered when it is impractical, uneconomical or unsafe to found conventional structure footings at shallow or intermediate depths below ground. There is a sufficiently wide range of piling systems available from which to select appropriate foundation solutions in most types of ground conditions for road bridges which often require deep founding.

Piles are commonly used to construct bridge or other structural foundations. In this use they are able to transmit the applicable combinations of permanent and transient loads which are applied at the top of the piles, through weak compressible soil or fill materials onto stiff or dense soil strata or rock at lower levels, in such a manner as to prevent excessive settlement, horizontal displacement or rotation of the supported structure.

Driven piles are usually slender, 'column like' structural members (usually acting in groups) which are installed vertically or at a slope in the ground by various techniques, to sufficient depth to achieve the necessary load bearing capacity through frictional resistance along their sides, end bearing resistance at their bases, or combinations of both.

5.12.1.2 Caissons

Caissons provide an alternative means to achieve adequate founding at intermediate to significant depths in both land and water environments. This system has been frequently as a practical means to found major bridges in deep water conditions.

Caissons provide a watertight space for underwater construction. The function of caissons is essentially the same as for piles, they transmit the applicable combination of permanent and transient loads applied at the top of the caisson through weak compressive soil or fill materials onto stiff or dense soil strata or rock at lower levels, in such a manner as to prevent excessive settlement, horizontal displacement or rotation of the supported structure at the caisson cap level.

Caissons for bridge foundations are usually cellular reinforced concrete structures, with circular, rectangular or more streamlined plan cross sections comprising one or more excavation compartments, and which are wholly or partly constructed at higher level and sunk in stages to the desired founding level. Sinking of Caisson usually occurs by internal excavation (bucket or crane excavation) sometimes assisted by the application of weights.

Small diameter concrete shafts comprising single open cells and constructed in the same manner as caissons are usually called cylinders. The distinction between cylinders and caissons is merely one of size. Because of their smaller size (usually up to about 8 foot diameter), cylinders lend themselves readily to precast concrete ring elements in their

construction. This form of caisson construction can be very economical down to intermediate depths but are not well suited to sinking through ground containing large boulders or with high water tables. Cylinders constructed with precast concrete rings are usually filled with reinforced concrete.

5.12.2 APPROPRIATE APPLICATIONS

All construction sites near or adjacent to a watercourse or groundwater where permanent and temporary pile driving (impact and vibratory) takes place.

5.12.3 LIMITATIONS

Proper control and use of equipment, materials, and waste products from pile driving operations will reduce or eliminate the discharge of potential pollutants to the storm drain system, watercourses, and waters of the United States.

- Piles and Caissons are required to be founded at sufficient depth to prevent instability due to scour arising from major floods, when located in riverine environments.
- Specific permit requirements or mitigation measures such as 401 Water Quality Certification, U.S. Army Corps of Engineers Section 404 or Section 10 permits, U.S. Coast Guard Section 9 or General Bridge Act Permits and approval by USFWS and NMFS supersede the guidance in this BMP. If numerical-based water quality standards are mentioned in any of these and other related permits, testing and sampling may be required.

5.12.4 STANDARDS AND SPECIFICATIONS

- Use drip pans or absorbent pads during vehicle and equipment operation, maintenance, cleaning, fueling, and storage. Refer BMPs for Vehicle and Equipment Cleaning, Vehicle and Equipment Fueling, and Vehicle and Equipment Maintenance.
- Have spill kits and cleanup materials available at all locations of pile driving. Refer to BMP for Spill Prevention and Control.
- Equipment that is stored or in use in streambeds, or on docks, barges, or other structures over water bodies should be kept leak free.
- Park equipment over plastic sheeting or equivalent where possible. Plastic is not a substitute for drip pans or absorbent pads. The storage or use of equipment in streambeds or other bodies of water must comply with all applicable permits.
- Implement other BMPs as applicable, such as Dewatering Operations, Solid Waste Management, Hazardous Waste Management, and Liquid Waste Management.
- When not in use, store pile-driving equipment away from concentrated flows of stormwater, drainage courses, and inlets. Protect hammers and other hydraulic attachments from run-on and runoff by placing them on plywood and covering them with plastic when rain is forecast.
- Use less hazardous products, e.g., vegetable oil, when practicable.

5.12.5 INSPECTION AND MAINTENANCE

- Inspect and verify that activity-based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMP are under way, inspect weekly during the rainy season and at two-week intervals in the non-rainy season to verify continued BMP implementation.
- Inspect BMPs subject to non-stormwater discharges daily while non-stormwater discharges occur.
- Inspect equipment every day at startup and repair equipment as needed (i.e., worn or damaged hoses, fittings, and gaskets). Recheck equipment at shift changes or at the end of the day and scheduled repairs as needed.
- Inspect entire pile driving areas and equipment for leaks and spills on a daily basis. Inspect equipment routinely for damage and repair equipment as needed.

5.13 Stream Diversion Techniques: Pumped, Pipe/Flume, and Excavated

5.13.1 Definition and Purpose

Stream diversions consists of a system of structures and measures that intercept an existing stream upstream of the project, transports it around the work area, and discharges it downstream. The selection of which stream diversion technique to use depends upon the type of work involved, physical characteristics of the site, and the volume of water flowing through the project.

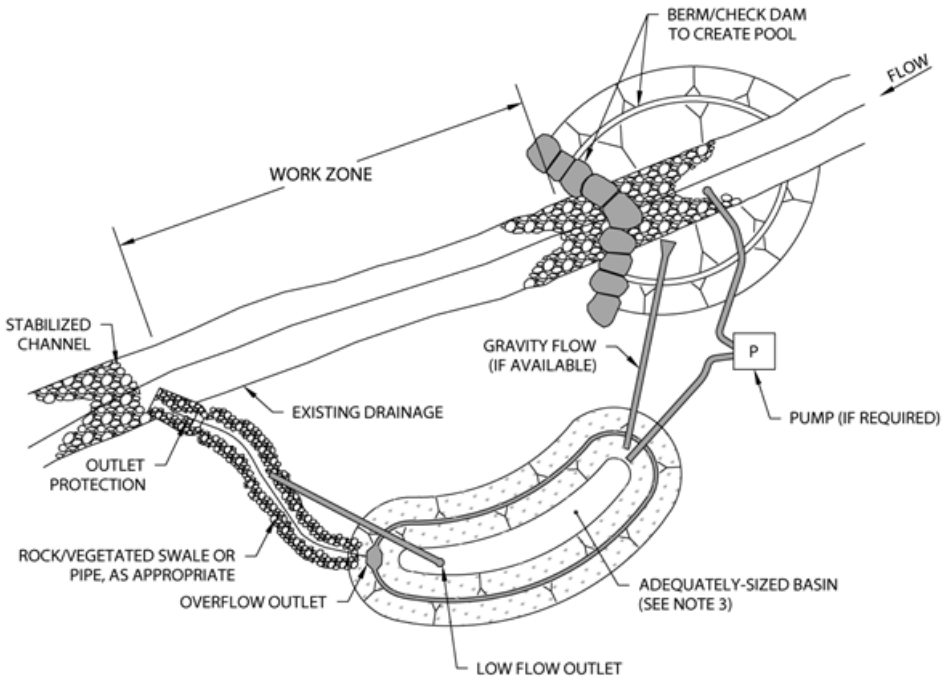


Figure 21: Diversion Method

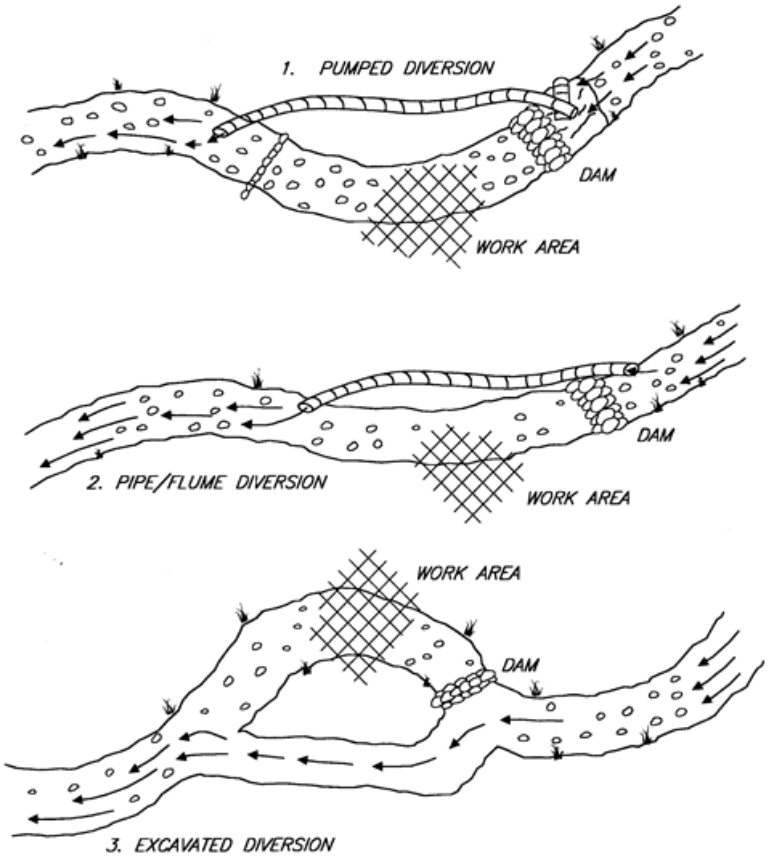


Figure 22: Diversion Methods.

5.13.2 APPROPRIATE APPLICATIONS

- Where Dewatering of the work area is necessary.
- Work areas that require isolation from flows.

5.13.3 ADVANTAGES

- Downstream sediment transport can be nearly eliminated.
- Pipes can be moved around to allow construction operation sequencing.
- The dams can also serve as temporary access to the site.
- Increased flows can be managed by adding more pumping capacity.
- Excavated channels isolate work from water flow and allow dewatering.
- Excavated channels can handle larger flows than pumps.

5.13.4 LIMITATIONS

- Flow volume is limited by pump capacity.
- A pumped diversion requires frequent monitoring of pumps.

- Large flows during storm events can overtop dams.
- Erosion at the outlet can occur.
- Flow diversion and re-direction with small dams involves in-stream disturbance and mobilization of sediment during installation and removal.
- Bypass channel or flume must be sized to handle flows, including possible floods.
- Channels must be protected from erosion.
- Flow diversion and re-direction with small dams involves in-stream disturbance and mobilization of sediment.
- Flow volume is limited by temporary channel/flume capacity.
- Sudden rain could overtop excavated channels/flumes.
- Minor in-stream disturbance is required to install and remove dams to detour water into temporary channels/flumes.

5.13.5 STANDARDS AND SPECIFICATIONS

- Any type of water diversion requires special permitting.
- Water diversions are custom designed for unique site specific conditions. Contact system suppliers or design engineers for assistance.
- Installation guidelines will vary based on existing site conditions and type of diversion used.
- Diversions should be sized to convey design flood flows.
- Pump capacity must be sufficient for design flow; the upper limit is approximately 0.3 m^3/sec (10 cfs) (the capacity of two 200 mm [8 inch] pumps).
- Adequate energy dissipation must be provided at the outlet to minimize erosion.
- Materials used to create dams upstream and downstream of the diversion should be erosion-resistant. Materials such as steel plates, sheet piles, sandbags, continuous berms, inflatable water bladders, etc., would be acceptable.
- Construction of a diversion channel should begin with excavation of the channel at the proposed downstream end, with work proceeding upstream. Once the watercourse to be diverted is reached, and the excavated channel is stable, the upstream end should be breached, and water should be allowed to flow down the new channel. Once flow has been established in the diversion channel, the diversion weir should be installed in the main channel; this will force all water to be diverted from the main channel.
- Installation guidelines will vary based on existing site conditions and type of diversion used.
- Pump capacity must be sufficient for design flow.
- A standby pump is required in case a primary pump fails.

- Dam materials used to create dams upstream and downstream of diversion should be erosion resistant; materials such as steel plate, sheet pile, sandbags, continuous berms, inflatable water bladders, etc., would be acceptable.
- When constructing a diversion channel, begin excavation of the channel at the proposed downstream end, and work upstream. Once the watercourse to be diverted is reached and the excavated channel is stable, breach the upstream end and allow water to flow down the new channel. Once flow has been established in the diversion channel, install the diversion weir in the main channel; this will force all water to be diverted from the main channel.

5.13.6 INSPECTION AND MAINTENANCE

- Conduct inspections as required by the NPDES permit or contract specifications.
- Pumped diversions require frequent monitoring of pumps.
- Monitor pumps, which may be required frequently for pumped diversions.
- Remove debris and repair linings and slope protection as required.
- The barrier should be inspected and any leaks, holes, gaps, scour or other problems should be addressed immediately.
- Upon completion of work, remove the diversion or isolation structure and redirect flow through the new culvert or back into the original stream channel. Recycle or re-use if applicable.
- Re-vegetate areas disturbed by BMP removal, if needed.
- Inspect embankments and diversion channels for damage to the linings, accumulating debris, sediment buildup, and adequacy of the slope protection. Remove debris and repair linings and slope protection as required. Remove holes, gaps, or scour.

5.14 In-stream Construction Sediment Control

5.14.1 Definition and Purpose

Instream sediment control BMPs are designed to provide sediment trapping for projects that must take place within the waterway. Projects that cross or otherwise work within the waterway shall strive to limit the amount of work that occurs within the water flow line. Measures that can reduce the amount of instream work include working from bank areas, diverting the stream around work areas, or scheduling for seasons of no or limited flows.

Instream sediment trapping devices include both floating materials (turbidity curtains described above) anchored to the watercourse bottom, instream sediment collection mats that run along the watercourse bottom and constructed sediment traps within a water coarse. These materials are specifically designed to limit sediment transport impacts within a body of water.

Coarse sediment traps are excavations in the bed or structures across a watercourse designed to limit the downstream movement of sand and gravel from upstream sediment sources. Depending on trap design and stream characteristics, lesser amounts of fine sediments (the fine sand, silts and clays that move in the flow rather than along the bed) can be trapped.

Sediment traps confine sediment deposition to a small reach of channel and reduce excavation costs: Sediment traps are relatively wide, short and deep excavations in the bed. Trapped sediment does not progress downstream where deposition would reduce channel capacity. The trap itself has to be episodically excavated (after major storms) rather than a much greater length of the stream.

5.14.2 Appropriate Applications

These devices provide sedimentation protection for instream, bank, or upslope ground disturbance, dredging, or filling within a waterway. There are three different options currently available for reducing turbidity while working in a stream or river. The stream can be; (1) isolated from the area in which work is occurring by means of a water barrier, (2) the stream can be diverted around the work site through a pipe or temporary channel, or (3) one can employ construction practices that minimize sediment suspension.

5.14.3 Limitations

Instream sediment traps are used in conjunction with other sediment control measures to reduce excessive sediment in watercourses: For upland sediment sources, the most desirable strategy is to implement land management practices that reduce erosion and transport of sediment and associated contaminants. The second strategy is to retain sediments on the land before they get to aquatic resources (e.g. filter strips, sediment retention ponds). For channel sources, streamflow should be retarded to protect the channel (e.g. vegetated banks); eroding banks should be repaired (e.g. contour and vegetate); and livestock that cause erosion should be removed from the channel and banks. If these measures are not undertaken, then continuous in-channel sediment

problems will occur. In some cases, an in channel sediment trap can be the first line of defense (e.g. multiple, uncontrollable sediment sources).

5.14.4 STANDARDS AND SPECIFICATIONS

The highest hazard for sedimentation from in-stream construction generally occurs when the sediment control structure is being installed and when it is being removed. Generally the best time to install the stream isolation or diversion structure is when the stream is low. Conversely, the optimum time to remove in-stream diversion or isolation structures may be during the rising limb of a storm hydrograph aka the rapid increase in flow resulting from rainfall causing increased surface runoff and stream flow. A probable "worst time" to release high TSS into a stream system with diminishing aquatic habitat might be when the stream is very low; summer low flow, for example. During these times, the flow may be low while the biological activity in the stream is very high. On the other hand, the addition of short-term spike in TSS or sediment during a big storm discharge might have a relatively low impact on the aquatic habitat or turbidity because the stream is already turbid, and the stream energy is capable of transporting both suspended solids, and large quantities of bedload through the system.

- All embankments and structures must be constructed in accordance with accepted engineering practice, and with appropriate materials.
- Determine the design flow for the channel where the sediment trap is to be located and establish the viability of creating a trap (see location).
- Determine the target size of material to be trapped, and the trapping efficiency required. Fine sand (i.e. sediment ≥0.125 mm) and 90% trapping are often used.
- Determine the surface area of the sediment trap.
- Check the depth required to prevent re-suspension of the trapped sediment.
- These BMPs are designed and selected for specific flow conditions. For sites with flow velocities or currents greater than 5 feet per second, a qualified engineer and product manufacturer shall approve of the use.
- Instream sediment mats can be aligned either direction along the watercourse bottom, as long as the upstream mat overlaps the downstream mat (like a drainage ditch erosion control blanket installation). Ensure that the upstream edge is firmly trenched in to prevent flows from going under the mat. Mats shall cross the entire stream and be staked or use stones to keep them in place. Follow the manufacturer's specifications for the length of mat needed for the site's flow rate.

5.14.4.1 Techniques to minimize Total Suspended Solids

- **Padding -** Padding laid in the stream below the work site may trap some solids that are deposited in the stream during construction. After work is done, the padding is removed from the stream, and placed on the bank to assist in revegetation.
- **Clean, washed gravel -** Using clean, washed gravel as fill decreases solid suspension, as there are fewer small particles deposited in the stream.

- **Excavation using a large bucket -**Each time a bucket of soil is placed in the stream, a portion is suspended. Approximately the same amount is suspended whether a small amount of soil is placed in the stream, or a large amount. Therefore, using a large excavator bucket instead of a small one will reduce the total amount of soil that washes downstream.
- **Use of dozer for backfilling -** Using a dozer for backfilling instead of a backhoe follows the same principles – the fewer times soil is deposited in the stream, the less soil will be suspended.
- **Partial dewatering with a pump -** Partially dewatering a stream with a pump reduces the amount of water, and thus the amount of water that can suspend sediment

5.14.5 INSPECTION AND MAINTENANCE

- The design depth of the sediment trap should be marked in the sediment trap (e.g. a stage gauge board). Once the effective capacity of the sediment trap is reached, the trap effectiveness declines, and the sediment trap should be re-excavated.

5.15 Washing Fines (Streambed Restoration Technique)

5.15.1 Definition and Purpose

Washing fines is an "in-channel" sediment control method, which uses water, either from a water truck or hydrant, to wash any stream fines that were brought to the surface of the channel bed during restoration, back into the interstitial spaces of the gravel and cobbles. This technique is useful in both intermittent or ephemeral stream channels with gravelly to cobbely substrate and may be useful in perennial streams just prior to removing isolation structures.

The purpose of this technique is to reduce or eliminate the discharge of sediment from the channel bottom during the first seasonal flows, or "first flush." Sediment should not be allowed into stream channels; however, occasionally in-channel restoration work will involve moving or otherwise disturbing fines (sand and silt-sized particles) that are already in the stream, usually below bankfull discharge elevation. Subsequent re-watering (resumption of flows) of the channel can result in a plume of turbidity and sedimentation.

This technique washes the fines back into the channel bed. Bedload materials, including gravel cobbles, boulders and those fines, are naturally mobilized during higher storm flows. This technique is intended to delay the discharge until the fines would naturally be mobilized.

5.15.2 Appropriate Applications

- This technique should be used when construction work is required in channels. It is especially useful in intermittent or ephemeral streams in which work is performed "in the dry", and which subsequently become re-watered.

5.15.3 Limitations

- The stream must have sufficient gravel and cobble substrate composition.
- The use of this technique requires consideration of time of year and timing of expected stream flows.
- The optimum time for the use of this technique is in the fall, prior to winter flows.
- Consultation with, and approval from the Department of Fish and Game and the Regional Water Quality Control Board may be required.

5.15.4 Standards and Specifications

- Apply sufficient water to wash fines, but not cause further erosion or runoff.
- Apply water slowly and evenly to prevent runoff and erosion.
- Consult with appropriate Federal and State agencies (i.e. USACE, CWB-DOH, USFWS, NMFS and Department of Land and Natural Resources (DLNR)) for specific water quality requirements of applied water (e.g. chlorine)

CHAPTER 6:

6 GLOSSARY

Acute. Acute effects refer to physiological effects observed following limited duration exposure to contaminants.

Adsorption. Adsorption is the process by which dissolved pollutants adhere to suspended particulates, bottom sediments, vegetation surfaces, or other media (such as activated carbon). Some filtration media help remove charged pollutant particles, such as metal cations, by adsorption.

Aquatic or Riparian Problems: means construction or development sites where control practices are needed to protect aquatic or riparian environments or conditions (e.g., bank habitat, associated vegetative cover, preservation of habitat, life cycle impacts to plants and animals, water quality limitations that affect fish and wildlife).

Avulsion (avulsing). The rapid migration of the primary stream channel from its previous course, usually during flood events.

Backwater. The accumulation of water and slowing of flow behind (upstream of) an obstruction or constriction in a stream or floodplain.

Bank erosion. The carrying away or displacement of solids (sediment, soil, rock, and other particles) along a stream bank usually by the agents of streamflow or by downward or down-slope movement in response to gravity or by living organisms. Bank erosion is distinguished from weathering, which is the process of chemical or physical breakdown of the minerals in the rocks, although the two processes may be concurrent.

Bed load. The portion of the total sediment load of a river or stream that is in intermittent contact with the streambed.

Bedrock. The native, contiguous, consolidated rock underlying the surface of the Earth. Above bedrock is usually an area of broken and weathered unconsolidated rock, usually called sediment. Occasionally bedrock is exposed on the surface indicating that sediment has been removed by streamflow or some other sediment transport process (e.g., landsliding).

Best Management Practices (BMPs): means structural and non-structural methods, measures or practices implemented to prevent, reduce or mitigate adverse water quality impacts resulting from construction and operation of a project.

Better site design: includes a series of techniques that reduce impervious cover, conserve natural areas, and use pervious areas to more effectively treat stormwater runoff and promote the treatment train approach to runoff management.

Bioavailable. Able to interact with an organism in a physiologically meaningful (e.g., tissue uptake, bioaccumulation in tissue, metabolism) way.

Biochemical oxygen demand. A measure of the amount of oxygen needed by aquatic organisms to break down solids and other readily degradable organic matter present in water. Also called biological oxygen demand.

Biofiltration. The process of reducing pollutant concentrations in water by filtering the polluted water through biological materials, such as vegetation.

Bioinfiltration. The process of reducing pollutant concentrations in water by infiltrating the polluted water through grassy vegetation and soils into the ground. Biological oxygen demand. A measure of the quantity of oxygen used by microorganisms (e.g., aerobic bacteria) in the oxidation of organic matter. Frequently used as an indicator of water quality.

Bypass. An alternate flow path, such as an emergency overflow spillway, provided as part of a BMP. Designed to prevent facility failure when the primary mode of discharge is blocked.

Catch basin. A structure, typically concrete, that collects surface runoff through a metal grate. Catch basins typically include a sump where sediment can settle out.

Channel aggradation. The accumulation of sediment in a channel. It occurs when sediment supply exceeds the ability of a river to transport the sediment.

Channel incision. The deepening of the channel of a stream by erosion.

Channel migration. The movement of the horizontal position of a channel over time. Channel migration is often associated with the movement of a meander.

Chemical oxygen demand (COD). COD is a measure the amount of organic compounds in water. In natural surface waters, such as lakes and rivers, it indicates the presence of organic pollutants and is therefore a useful indicator of water quality. It is expressed in milligrams [of oxygen] per liter [of water, or other solution].

Chronic. Chronic effects refer to physiological effects observed following prolonged duration exposure to contaminants.

Colloidal. Remaining suspended without forming an ionic or dissolved solution.

Complexing. Bonding between a dissolved metal and another chemical (ligand) that keeps a dissolved metal in solution.

Composite sample. Composite samples involve a collection and mixing of multiple subsamples throughout a sampling period (usually an individual storm event) to provide water quality data that is more representative of the overall sampling period.

Contributing impervious area (CIA). All impervious surface within the project limits, plus impervious surface owned or operated by ODOT outside the project limits, that drains to the project via direct flow or discrete conveyance.

Cut bank. An erosional feature of streams. Cut banks are found in abundance along mature or meandering streams, they are located on the outside of a stream bend, known as a meander. They are shaped much like a small cliff, and are formed by the erosion of soil as the stream collides with the river bank. As opposed to a point bar, it is an area of erosion rather than deposition.

Detention. The temporary storage of stormwater runoff in a facility (typically a pond, vault, or large pipe) which is used to control the peak discharge rates. The entire stormwater volume is ultimately released, but at a lower discharge rate.

Dispersion. Release of surface water and stormwater runoff in such a way that the flow spreads over a wide area and is located so as not to allow flow to concentrate. Dispersion areas should be gently sloped, vegetated, and with underlying soils suitable for infiltration.

Dissolution. Dissolving a solid substance into a solvent to yield a solution.

Dissolved Metals. Metals bound to another chemical (ligand) through complexing that are in solution.

Dissolved Oxygen. The amount of oxygen dissolved in water. This term also refers to a measure of the amount of oxygen available for biochemical activity in a waterbody, an indicator of water quality.

Disturbed Soil Area: Disturbed soil areas (DSAs) are areas of exposed, erodible soil that are within the construction limits and that result from construction activities. The following are not considered DSAs:

> Areas where soil stabilization, erosion control, highway planting, or slope protection are applied and associated drainage facilities are in place and functional.
>
> Roadways, construction roads, access roads or contractor's yards that have been stabilized by the placement of compacted subbase or base material or paved surfacing.
>
> Areas where construction has been completed in conformance with the contract plans and permanent erosion control is in place and functional.

Durations. The cumulative amount of time that a receiving water experiences higher flows during and after storm events.

Effluent: The U.S. EPA defines effluent as wastewater, treated or untreated, that flows out of a treatment plant, sewer, or industrial outfall.

Emergency Overflow Spillway. An armored surface outlet from detention pond or other surface BMP to allow stormwater to discharge even in the event of outlet plugging or higher than design flows.

Ephemeral stream: An ephemeral stream has flowing water only during, and for a short duration after, precipitation events in a typical year. Ephemeral stream beds are located above the water table year-round. Groundwater is not a source of water for the stream. Runoff from rainfall is the primary source of water for stream flow.

Erosion and sediment control (ESC) measures. Erosion control is the process of minimizing the amount of soil that runs off of a site (such as during construction). Sediment control is the process of retaining eroded soil on site, preventing damage to watercourses and infrastructure.

Eutrophication. A process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth. Under

eutrophic conditions, dissolved oxygen levels may be depleted by the respiring algae and by microorganisms that feed on dead algae, threatening salmon and other marine animals.

Evapotranspiration. The sum of evaporation (movement of water to the air through tree canopy interception, soil, and water bodies) and transpiration (water loss as vapor through plant activity).

Event Mean Concentration (EMC). Mean concentration of pollutants in runoff from a storm event.

Federal nexus. A project receiving federal funding (e.g., a highway construction project) is subject to federal laws and regulations. For example, ESA issues must be addressed either in a no-effect memorandum or in a BA.

Filter strip. A grassy area with gentle slopes that treats stormwater runoff from adjacent paved areas before it can concentrate into a discrete channel.

Filtration: Physical trapping of suspended pollutants. Filtration can encompass a wide range of physical and chemical mechanisms, depending on the filtering media, typically some sand media, natural soil, grassy vegetation, or mixes of chemically active ingredients such as perlite, zeolite, and granular activated carbon. Filtration removes particulate matter either on the surface of the filter or within the pore space of the filter. Filtration such as a sand filter can provide the added benefit of removing stormwater constituents that may be attached to solids such as metals and bacteria. Filtration can also provide opportunities for sorption processes to occur, reducing dissolved and fine suspended constituents. Filtration can often be an effective preliminary treatment for stormwater, by increasing the longevity of downstream BMPs and reducing maintenance frequency.

Floodplain. A floodplain is an area adjacent to a river or stream channel that is usually fairly flat and experiences occasional or periodic inundation during floods. The floodplain includes the floodway and other areas sometimes referred to as the flood fringe, which are inundated during floods but do not contribute significantly to flood flow conveyance and do not experience significant flow velocities.

Floodway. A floodway is an area that includes that channel of a river, stream, or other watercourse and adjacent lands that conveys floodwaters. The floodway is composed of the active river channel and those parts of the floodplain which experience flows of significant velocity and convey flow during flood events. The floodway concept has regulatory significance, imposing boundaries on developable area.

Flow concentration. The result of large flows in association with developed (impervious surface) areas, where infiltration is prevented. In these areas, flow becomes concentrated and channelized much more quickly than in undeveloped settings.

Flow regime. Generally referring to type of flow present in a stream. This has impacts on the position of hydraulic control in a stream. Fast moving, or supercritical flows, are controlled from upstream conditions; while slow moving, or subcritical flows, are controlled from downstream conditions.

Flow-through. Facilities such as grass swales that convey stormwater, or store it temporarily, prior to release through surface runoff or enclosed (piped) drainage systems. Flow-through facilities are in contrast to infiltration facilities.

Grab sample. A single sample of stormwater collected for analysis. Grab samples provide a snapshot of water quality conditions, and may be useful if collected during the rising limb or at the peak of a storm hydrograph when higher concentrations might be expected.

Gutter. A depressed concrete channel that conveys stormwater along the edge of a street.

Hardness. Water hardness measures the presence of multivalent cations dissolved in water; particularly calcium and magnesium divalent cations (ions with a charge of +2).

Headcut. An active eroding bank or channel that moves further upstream as it continues to erode material.

Hydraulic gradient. Difference in hydraulic head between two or more hydraulic head measurements divided by the length of the flow path.

Hydraulic head. Measure of water pressure above a datum. Typically expressed as an elevation, in feet.

Hydrologic attenuation: Hydrologic attenuation achieves pollutant reduction through runoff volume reduction. Infiltration is the primary means of hydrologic attenuation for the purposes of the types of BMPs used in stormwater management. Attenuation reduces the pollutant load discharged to surface waters, but does not necessarily reduce pollutant concentrations. Infiltration includes several different treatment mechanisms. Processes such as sorption, filtration, and microbial degradation occur as runoff infiltrates through the soil matrix.

Hydrologic soil groups. A soil characteristic classification system defined by the Natural Resources Conservation Service in which a soil may be categorized into one of four soil groups (A, B, C, or D) based on infiltration rate and other properties.

Impervious surface. A hard surface area that either prevents or slows the entry of water into the ground as compared with natural conditions (prior to development), and from which water runs off at an increased rate of flow or in increased volumes. Common impervious surfaces include but are not limited to rooftops, walkways, roads, and other concrete or asphalt surfaces.

Incised, incision. See channel incision.

Inert. Not chemically active. Inert filtration media would rely only on physical properties, rather than chemical treatment mechanisms such as sorption, for pollutant removal.

Infiltration rate. The rate, usually expressed in inches per hour, at which water moves downward (percolates) through the soil profile.

Infiltration. The downward movement of rainwater or surface water through the soil.

Inlet. A structure, typically concrete, that collects surface runoff through a metal grate. Inlets may include a sump where sediment can settle out.

Inundate. To cover with water, usually associated with flooding.

Jurisdictional wetland. A wetland that is connected to a Water of the United States (WOUS) using the Corps definition of WOUS (Section 404 Clean Water Act).

Large woody debris (LWD). The accumulation of trees and large branches that have fallen into a stream. LWD serves many purposes in a stream that are vital to life history of many native species of fish, plants and animals.

Levee. A natural or artificial slope or wall, usually earthen and often parallel to the course of a stream, to protect adjacent areas (usually development) from flooding.

Log jams. These features are large accumulations of large woody debris (LWD) in particular places along a stream bank or in the middle of a stream. Log jams have traditionally been removed from streams. However, increased awareness of these features has shown to provide key hydraulic and geomorphic function necessary for a healthy stream ecosystem.

Low Impact Development (LID): A comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds. LID is a stormwater management design approach that attempts to mimic a site's predevelopment hydrology by using design practices and techniques that reduce impervious areas, and preserve native vegetation and soils. LID stormwater management techniques capture, filter, store, evaporate and infiltrate runoff near its source.

Meander(ing). A bend in a stream, also known as an oxbow loop, or simply an oxbow. A stream of any volume may assume a meandering course, alternatively eroding sediments from the outside of a bend and depositing them on the inside. The result is a "snaking" pattern as the stream meanders back and forth across its down-valley axis.

Microbially mediated transformation: Microbial activity promotes or catalyzes redox reactions and transformations including degradation of organic and inorganic pollutants and immobilization of metals. Bacteria, algae, and fungi present in the soil or water column are primarily responsible for the transformations. Stormwater treatment that incorporates vegetation or permanent water pools usually has a diverse microbial population. These transformations can remove dissolved nitrogen species, metals, and simple and complex organic compounds. Soils may be inoculated with desirable microbes to promote specific reactions.

Municipal Separate Storm Sewer Systems: is defined as any conveyance or system of conveyances (roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, human-made channels, and storm drains) owned or operated by a state, city, town, county, or other public body having jurisdiction over storm water, that is designed or used for collecting or conveying storm water.

Non-Point Source:

Nonstructural BMPs: include pollution prevention practices and source control activities, designed to minimize or eliminate a problem before it occurs. Source control BMPs are sometimes referred to as "good housekeeping" measures because a clean site

will produce less pollutants than will a dirty one. Site planning and design of BMPs may, in and of itself, be considered a nonstructural BMP.

Outfall. Any location where concentrated stormwater runoff leaves the right if way as concentrated runoff. Outfalls may discharge to surface waters or groundwater.

Outlet protection. A protective barrier of rock, erosion control blankets, vegetation, or sod constructed at a conveyance outlet.

Overflow Spillway. See Emergency Overflow Spillway.

Particulates. A minute separate particle, such as a granular substance or powder.

Peak flow. Maximum discharge of stormwater associated with a particular design storm, e.g. 2-year, 24-hour design storm.

Perennial stream: A perennial stream has flowing water year-round during a typical year. The water table is located above the stream bed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from rainfall is a supplemental source of water for stream flow.

Pipe cover. Vertical separation between pavement subgrade and the top of a pipe.

Planimeter. An instrument that measures the area of a plane figure as a mechanically coupled pointer traverses the perimeter of the figure.

Plug flow. A laminar flow regime where water flows as if in a full pipe, the unit that enters first, exits first and there is no mixing between different units of water, designing for this type of flow prevents "short circuiting".

Point bar. A depositional feature of streams. Point bars are found in abundance in mature or meandering streams. They are crescent-shaped and located on the inside of a stream bend.

Pollutant load. Mass of a pollutant that a waterbody receives.

Polycyclic aromatic hydrocarbons (PAHs). PAHs are hydrocarbon compounds with multiple benzene rings. PAHs are typical components of asphalts, fuels, oils, and greases.

Pour point. The point at which smaller stream or river basins meet larger stream or river basins.

Pretreatment. The removal of material such as solids, grit, and grease from flows to improve treatability prior to biological or physical treatment processes; may include screening, settling, oil/water separation, or application of a basic treatment BMP prior to infiltration.

Primary Treatment Mechanisms:

Project Types: means general categories and types of construction or development projects (e.g., bridges, crossing structures, channel work, utility construction, site development, roads and highways, instream mining, dams and reservoirs, specialty activities such as go f courses and driveways) in Hawaii that are likely to require federal or state permits (e.g. 404 permit, 401 certification).

Point Source: A point source is any discrete conveyance such as a pipe or a man-made ditch.

Pollutant load: refer to the mass of pollutants, or the total amount delivered to the storm system or receiving waters independent of the volume of stormwater.

Rain Event: A qualifying rain event is any storm event that produces precipitation of ½ inch or more at the time of discharge. In conformance with the USEPA definition, a minimum of 72 hours of dry weather will be used to distinguish between separate qualifying rain events.

Reference Types: means categories that refer to structural or source controls, permanent best management practices, and specialty practices used by Federal, State or local agencies (e.g. National Park Service). Reference types are applicable to construction or development sites.

Release rate. The design peak discharge rate, typically expressed in cubic feet per second (cfs) from a detention facility. When detention is required, design standards often stipulate that post development release rates must match pre-pre-development peak discharge rates.

Riparian Area: Vegetated ecosystems along a waterbody through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent waterbody. These systems encompass wetlands, uplands, or some combination of these two land forms. They will not in all cases have all of the characteristics necessary for them to be classified as wetlands.

Runoff: Rainwater or snowmelt that directly leaves an area as surface drainage.

Salinity: The dissolved salts content of a body of water.

Sand filter: A manmade depression or basin with a layer of sand that treats stormwater as it percolates through the sand and is discharged via a central collector pipe.

Saturated hydraulic conductivity: The rate of movement of water through a saturated porous medium.

Sediment Problems: means construction or development sites where sediment and erosion controls are necessary to prevent sediment pollution (e.g., sediment deposits and loading, steep slopes, stream bank instability, runoff or velocity controls, wind erosion).

Sedimentation/density separation: Density separation refers to the unit processes of sedimentation and flotation that are dependent on the density differences between the pollutant and the water to effect removal. Sedimentation is the gravitational settling of particles having a density greater than water. Flotation is similar to gravitational sedimentation except in the opposite direction. Typically, floatable materials such as trash, debris, and hydrocarbons are removed through treatment processes that utilize the location of these pollutants on the water surface for removal. Stormwater treatment that incorporates vegetation and or permanent water bodies usually has a diverse microbial population, and it is not possible to optimize conditions for all beneficial species.

Sediment supply: The amount of sediment made available to a stream from the surrounding landscape and its runoff.

Sediment transport: The movement of solid particles ("sediments") due to the movement of the fluid in which they are immersed. In streams, the particles are rocks (sand, gravel, boulders, etc.) or clay, and the fluid is water.

Sheet flow: Runoff that flows over the ground surface as a thin, even layer, not concentrated in a channel.

Short Circuiting: the passage of runoff through a BMP in less than the design treatment time

Sorption: Sorption refers to the individual unit processes of both absorption and adsorption. Absorption is a physical process whereby a substance of one state is incorporated into another substance of a different state (e.g., liquids being absorbed by a solid or gases being absorbed by water). Adsorption is the physiochemical adherence or bonding of ions and molecules (ion exchange) onto the surface of another molecule. In stormwater treatment application, particularly for highway runoff, the primary pollutant types targeted with absorption unit processes are petroleum hydrocarbons, while adsorption processes typically target dissolved metals, nutrients, and organic toxicants such as pesticides and polycyclic aromatic hydrocarbons (PAHs). Different types of filter media may provide either or both of these unit processes.

Source Control BMP: Appropriate operational or structural measures that prevent or reduce pollutants from entering storm water. Examples of operational source control BMPs include good housekeeping practices, spill prevention, and employee training. Structural source control BMPs consist of enclosures or roofs for working areas where pollutants are present or installing devices that direct contaminated storm water to appropriate treatment BMPs.

Soil amendments. Materials that improve soil fertility for establishing vegetation or permeability for infiltrating runoff.

Soil texture. The proportion of sand, silt and clay in a soil. Many properties of soil are heavily dependent on texture including infiltration rate, resistance to erosion, and water-holding capacity.

Sorptive. A substance capable of taking up water or dissolved compounds.

Stormwater Management Plan. A document that describes the condition of receiving waters including water quality issues, channel conditions, watershed size and characteristics, and climate. It also describes the proposed drainage and stormwater management systems and estimates project impacts.

Stormwater treatment BMP. A BMP specifically designed for pollutant removal.

Swale. A wide natural channel with relatively gentle side slopes, generally with flow depths less than 1 foot, used to filter runoff.

Structural BMPs: are facilities constructed to passively treat runoff before it enters the receiving waters. Such BMPs (sometimes called "dirt moving" practices) used on a construction or development site can be either temporary or permanent, depending on the duration of their application, and are designed to reduce sediment pollution and

other pollutants in runoff. Additionally, they can provide for the protection of aquatic or riparian areas. A limited number of special use practices requiring additional demonstration under the semi-arid or mountainous conditions in Hawaii are also listed in the matrix and can be used on a case-by-case basis. Special use practices have been developed for golf course projects, driveways and high-altitude construction. Some construction BMPs result in permanent sediment and erosion control structures, which are designed to work beyond the construction period.

Total Dissolved Solids: The dissolved matter found in water comprised of minerals salts and small amount of other inorganic and organic substances.

Total Kjeldahl Nitrogen: The sum of organic nitrogen and ammonia in a water body, measured in milligrams per liter (mg/L). High measurements typically result from sewage and manure discharges to water bodies.

Total Maximum Daily Load (TMDL): the maximum amount of a pollutant that can be discharged into a water body from all sources (point and non-point) and still maintain water quality standards. Under Clean Water Act section 303(d), TMDLs must be developed for all water bodies that do not meet water quality standards after application of technology-based controls.

Total Nitrogen: A measure of all forms of nitrogen (e.g., nitrate, nitrite, ammonia-N, and organic forms) that are found in a water sample.

Total Phosphorus: the total concentration of phosphorus found in the water. Phosphorus is a nutrient and acts as a fertilizer, increasing the growth of plant life such as algae.

Total Suspended Solids (TSS): solids suspended in water including a wide variety of material such as silt and decaying plant matter.

Toxicity. Adverse effects on living organisms resulting from chemical exposure.

Treatment train or system. The combination of several treatment facilities with unique unit processes applied in a linear progression (also called "in series").

Turbidity. The cloudiness or haziness of a fluid caused by individual particles (suspended solids)) that are generally invisible to the naked eye. The measurement of turbidity is a key test of water quality.

Underdrain. Plastic pipes with holes drilled through the top, installed on the bottom of an infiltration facility, that are used to collect and remove excess runoff.

Qualifying Rain Event: Any rain event producing precipitation of 0.5 inch or more over the duration of the rain event.

Intermittent stream: An intermittent stream has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from rainfall is a supplemental source of water for stream flow.

Ordinary High Water Mark: that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation,

the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas.

Unit Operations. The treatment facilities in which the unit process occurs (i.e., wet pond or swale).

Unit Process. The specific mechanism of pollutant removal (i.e., sedimentation or vegetative uptake).

Vegetated filter strip. A facility designed to provide stormwater treatment of conventional pollutants (but not nutrients) through the process of biofiltration.

Vegetative (or Biological) Uptake. The processes by which nutrients and other dissolved chemicals are taken up by plants and algae. Chemicals may be metabolized or stored in plant tissues.

Uptake/Storage: Uptake and storage refer to the removal of organic and inorganic constituents by plants and microbes through nutrient uptake and bioaccumulation. Nutrient uptake converts required micro- and macro-nutrients into living tissue. In addition to nutrients, various algae and wetland and terrestrial plants accumulate organic and inorganic constituents in excess of their immediate needs (bioaccumulation). The ability of plants to accumulate and store metals varies greatly. Significant metal uptake by plants will not occur unless the appropriate species are selected.

Watershed. A geographic region within which water drains into a particular river, stream, or body of water.

Wetlands: are a subset of jurisdictional WUS and are jointly defined by the USACE and the U.S. Environmental Protection Agency (40 Code of Federal Regulations [CFR] 230.3) as those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

APPENDIX A: CONSTRUCTION BEST MANAGEMENT PRACTICES FIELD MANUAL

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APPENDIX B: STORM WATER PERMANENT BEST MANAGEMENT PRACTICES MANUAL

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APPENDIX C: DEVELOPING YOUR STORMWATER POLLUTION PREVENTION PLAN; A GUIDE FOR CONSTRUCTION SITES

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APPENDIX D: HAWAII NPDES GENERAL PERMIT AUTHORIZING DISCHARGES OF STORM WATER ASSOCIATED WITH CONSTRUCTION ACTIVITY AND DEPARTMENT OF HEALTH STANDARDS NPDES PERMIT CONDITIONS

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APPENDIX E: FHWA-CFLHD STANDARD DETAILS

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APPENDIX F: RAIN EVENT ACTION PLAN FORM

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APPENDIX G: IN-WATER POLLUTION PREVENTION PLAN SAMPLE

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