CHAPTER 5: Management Measures for Marinas and Recreational Boating

I. INTRODUCTION

A. What "Management Measures" Are

This chapter specifies management measures to protect coastal waters from sources of nonpoint pollution from marinas and recreational boating. "Management measures" are defined in section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) as economically achievable measures to control the addition of pollutants to our coastal waters, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives.

These management measures will be incorporated by States into their coastal nonpoint programs, which under CZARA are to provide for the implementation of management measures that are "in conformity" with this guidance. Under CZARA, States are subject to a number of requirements as they develop and implement their coastal nonpoint pollution control programs in conformity with this guidance and will have some flexibility in doing so. The application of these management measures by States to activities causing nonpoint pollution is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA).

B. What "Management Practices" Are

In addition to specifying management *measures*, this chapter also lists and describes management *practices* for illustrative purposes only. While State programs are required to specify management *measures* in conformity with this guidance, State programs need not specify or require the implementation of the particular management *practices* described in this document. However, as a practical matter, EPA anticipates that the management measures generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices listed in this document have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measures. EPA has also used some of these practices, or appropriate combinations of these practices, as a basis for estimating the effectiveness, costs, and economic impacts of achieving the management measures. (Economic impacts of the management measures are addressed in a separate document entitled *Economic Impacts of EPA Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.*)

EPA recognizes that there is often site-specific, regional, and national variability in the selection of appropriate practices, as well as in the design constraints and pollution control effectiveness of practices. The list of practices for each management measure is not all-inclusive and does not preclude States or local agencies from using other technically sound practices. In all cases, however, the practice or set of practices chosen by a State needs to achieve the management measure.

C. Scope of This Chapter

This chapter addresses categories of sources of nonpoint pollution from marinas and recreational boating that affect coastal waters. This chapter specifies 15 management measures grouped under two broad headings: (1) siting and design and (2) operation and maintenance.

Each category of sources is addressed in a separate section of this guidance. Each section contains (1) the management measure(s); (2) an applicability statement that describes, when appropriate, specific activities and locations for which the measure is suitable; (3) a description of the management measure's purpose; (4) the basis for the management measure's selection; (5) information on management practices that are suitable, either alone or in combination with other practices, to achieve the management measure; (6) information on the effectiveness of the management measure and/or of practices to achieve the measure; and (7) information on costs of the measure and/or practices to achieve the measure.

D. Relationship of This Chapter to Other Chapters and to Other EPA Documents

1. Chapter 1 of this document contains detailed information on the legislative background for this guidance, the process used by EPA to develop this guidance, and the technical approach used by EPA in this guidance.

2. Chapter 7 of this document contains management measures to protect wetlands and riparian areas that serve a nonpoint source abatement function. These measures apply to a broad variety of sources, including marinas and recreational boating sources.

3. Chapter 8 of this document contains information on recommended monitoring techniques to (1) ensure proper implementation, operation, and maintenance of the management measures and (2) assess over time the success of the measures in reducing pollution loads and improving water quality.

4. EPA has separately published a document entitled *Economic Impacts of EPA Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.*

5. NOAA and EPA have jointly published guidance entitled *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance.* This guidance contains details on how State Coastal Nonpoint Pollution Control Programs are to be developed by States and approved by NOAA and EPA. It includes guidance on the following:

   - The basis and process for EPA/NOAA approval of State Coastal Nonpoint Pollution Control Programs;
   - How NOAA and EPA expect State programs to provide for the implementation of management measures "in conformity" with this management measures guidance;
   - How States may target sources in implementing their Coastal Nonpoint Pollution Control Programs;
   - Changes in State coastal boundaries; and
   - Requirements concerning how States are to implement their Coastal Nonpoint Pollution Control Programs.

E. Problem Statement

Marinas and recreational boating are increasingly popular uses of coastal areas. The growth of recreational boating, along with the growth of coastal development in general, has led to a growing awareness of the need to protect waterways. In the Coastal Zone Management Act (CZMA) of 1972, as amended, Congress declared it to be national policy that State coastal management programs provide for public access to the coasts for recreational purposes. Clearly, boating and adjunct activities (e.g., marinas) are an important means of public access. When these facilities are poorly planned or managed, however, they may pose a threat to the health of aquatic systems and may pose other environmental hazards. Ensuring the best possible siting for marinas, as well as the best available design and construction practices and appropriate operation and maintenance practices, can greatly reduce nonpoint source (NPS) pollution from marinas.

Because marinas are located right at the water's edge, there is often no buffering of the release of pollutants to waterways. Adverse environmental impacts may result from the following sources of pollution associated with marinas and recreational boating:

- Poorly flushed waterways where dissolved oxygen deficiencies exist;
- Pollutants discharged from boats;
- Pollutants transported in storm water runoff from parking lots, roofs, and other impervious surfaces;
- The physical alteration or destruction of wetlands and of shellfish and other bottom communities during the construction of marinas, ramps, and related facilities; and
- Pollutants generated from boat maintenance activities on land and in the water.

The management measures described in this chapter are designed to reduce NPS pollution from marinas and recreational boating. Effective implementation will avoid impacts associated with marina siting, prevent the introduction of nonpoint source pollutants, and/or reduce the delivery of pollutants to water resources.

Pollution prevention should be at the fore of any NPS management strategy. It is expected that each coastal State's decision on implementation of these management measures will be based on a management strategy that balances the need for protecting the coastal environment and the need to provide adequate public access to coastal waters.

F. Pollutant Types and Impacts

A marina can have significant impacts on the concentrations of pollutants in the water, sediment, and tissue of organisms within the marina itself. Although sources of pollutants outside the marina are part of the problem, marina design, operation, and location appear to play crucial roles in determining whether local water quality is impacted (NCDEM, 1991).

Marina construction may alter the type of habitat found at the site. Alterations can have both negative and positive effects. For example, a soft-bottom habitat (i.e., habitat characterized by burrowing organisms and deposit feeders) could be replaced with a habitat characterized by fouling organisms attached to the marina pilings and bulkhead. These fouling organisms, however, may attract other organisms, including invertebrates and juvenile fish.

The presence of a marina is not necessarily an indicator of poor water quality. In fact, many marinas have good water quality. Despite this, they may still have degraded biological resources and contaminated sediments resulting from bioaccumulation in organisms and adhesion of pollutants to sediments. A brief summary of some of the impacts that can be associated with marina and boating activities is presented below.

1. Toxicity in the Water Column

Pollutants from marinas can result in toxicity in the water column, both lethal and sublethal, related to decreased levels of dissolved oxygen and elevated levels of metals and petroleum hydrocarbons. These pollutants may enter the water through discharges from boats or other sources, spills, or storm water runoff.

Low Dissolved Oxygen. The organics in sewage discharged from recreational boats require dissolved oxygen (DO) to decompose. The biological oxygen demand (BOD) of a waterbody is a measure of the DO required to decompose sewage and other organic matter (Milliken and Lee, 1990). Accumulation of organic material in sediment will result in a sediment oxygen demand (SOD) that can negatively impact water column DO. The effect of boat sewage on

DO can be intensified in temperate regions because the peak boating season coincides with the highest water temperatures and thus the lowest solubilities of oxygen in the water and the highest metabolism rates of aquatic organisms. (As temperature increases, dissolved oxygen levels decrease.) Cardwell and Koons (1981) recorded significant decreases in DO in several northwestern marinas in the late summer and early fall, which are the peak times of marina use. Nixon et al. (1973) measured lower DO levels in an area of marina development than in an adjacent undeveloped bay of similar size. An intensive study in several North Carolina marinas showed significant decreases in DO concentration compared to ambient concentrations in the receiving waterbody. These decreases in DO were thought to result from high SOD within the marinas and poor flushing resulting from improper marina design (NCDEM, 1990).

Metals. Metals and metal-containing compounds have many functions in boat operation, maintenance, and repair. Lead is used as a fuel additive and ballast and may be released through incomplete fuel combustion and boat bilge discharges (NCDEM, 1991). Arsenic is used in paint pigments, pesticides, and wood preservatives. Zinc anodes are used to deter corrosion of metal hulls and engine parts. Copper and tin are used as biocides in antifoulant paints. Other metals (iron, chrome, etc.) are used in the construction of marinas and boats.

Many of these metals/compounds are found in marina waters at levels that are toxic to aquatic organisms. Copper is the most common metal found at toxic concentrations in marina waters (NCDEM, 1990, 1991). Dissolved copper was detected at toxic concentrations at several marinas within the Chesapeake Bay (Hall et al., 1987). The input of copper via bottom paints and scrapings has been shown to be quite significant (Young et al., 1974). Tin in the form of butyltin, an extremely potent biocide, has been detected at toxic levels within marina waters nationwide (Stephenson et al., 1986; Maguire, 1986; Grovhoug et al., 1986; Stallard et al., 1987). The use of butyltins in bottom paint is now regulated, and butyltins cannot be used on nonaluminum recreational boats under 25 meters in length. High levels of zinc, chromium, and lead were also detected in waters within North Carolina marinas (NCDEM, 1990). Table 5-1 presents results of a recent study of boatyard hull pressure-washing wastewater in the Puget Sound area that revealed concentrations of metals and other pollutants that are of concern to environmental regulators (METRO, 1992a).

Petroleum Hydrocarbons. McMahon (1989) found elevated concentrations of hydrocarbons in marina waters and attributed them to refueling activities and bilge or fuel discharge from nearby boats.

2. Increased Pollutant Levels in Aquatic Organisms

Aquatic organisms can concentrate pollutants in the water column through biological activity. Copper and zinc concentrations in oysters were significantly higher in oysters in South Carolina and North Carolina marinas than at reference sites (NCDEM, 1991; SCDHEC, 1987). Increased levels of copper, cadmium, chromium, lead, tin, zinc, and PCBs were found in mussels from southern California marina waters (CARWQCB, 1989; Young et al., 1979). Three months after planting, concentrations of lead, zinc, and copper in oysters transplanted to several Australian marinas were two to three times higher than those of control sites (McMahon, 1989). Concentrations of copper in a green algae and the fouling community were significantly higher in a Rhode Island marina area than in adjacent control areas (Nixon et al., 1973). Several polynuclear aromatic hydrocarbons were detected in oyster tissue at marinas in South Carolina (Marcus and Stokes, 1985; Wendt et al., 1990).

3. Increased Pollutant Levels in Sediments

Many of the contaminants found in the storm water runoff of marinas do not dissolve well in water and accumulate to higher concentrations in sediments than in the overlying water. Contaminated sediments may, in turn, act as a source from which these contaminants can be released into the overlying waters. Benthic organisms—those organisms that live on the bottom or in the sediment—are exposed to pollutants that accumulate in the sediments and may be affected by this exposure or may avoid the contaminated area.

Metals. Copper is the major contaminant of concern because most common antifouling paint preparations contain cuprous oxide as the active biocide component (METRO, 1992a). In most cases metals have a higher affinity for sediments than for the water column and therefore tend to concentrate there. A recent Puget Sound area study of wastewater from boat hull pressure washing found that suspended solids accounted for 96 percent of the copper, 94 percent of the lead, and 83 percent of the zinc in the wastewater (see Table 5-1 for concentrations). Most of the metal concentrations were associated with particles less than 60 microns in size, resulting in their settling out of solution slowly (METRO, 1992a). Stallard et al. (1987) noted that the sediments of nearly every California marina tested had high concentration of butyltins. Marina sites in North Carolina had significantly higher levels of arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc than did reference sites (NCDEM, 1991). McMahon (1989) found significantly higher concentrations of copper, lead, zinc, and mercury in the sediments at a marina site than in the parent waterbody. Within the marina, higher levels of copper and lead were found near a maintenance area drain and fuel dock, suggesting the drain as a source of copper and lead and the fuel dock as a possible source of lead. Sediments at most stations within Marina Del Rey were sufficiently contaminated with copper, lead, mercury, and zinc to affect fish and/or invertebrates, especially at the larval or juvenile stage (Soule et al., 1991). Researchers thought that this contamination might account for the absence of more sensitive species and the low diversity within the marina. However, the extent of the sediment contamination resulting from marina-related activities was unclear.

Petroleum Hydrocarbons. Petroleum hydrocarbons, particularly polynuclear aromatic hydrocarbons (PAHs), tend to adsorb to particulate matter and become incorporated into sediments. They may persist for years, resulting in exposure to benthic organisms. Voudrias and Smith (1986) reported that sediments from two Virginia creeks with marinas contained significantly higher levels of hydrocarbons than did control sites. The North Carolina Division of Environmental Management (NCDEM, 1990) found PAHs in the sediments of six marinas, all of which had fuel docks. Nearby reference areas did not appear to be affected. Marcus et al. (1988) found an increase in PAHs in the sediments of two South Carolina marinas. Sources of petroleum hydrocarbons were identified as the origin of

Table 5-1. Boatyard Pressure-washing Wastewater Contaminants and Regulatory Limits in the Puget Sound Area (METRO, 1992)

				Permit Limit Values			
					Boatyard NPDES		
						Receiving Waters[f]	
Analytical Parameter	Units	Untreated Sample (average)[a]	Untreated Sample (high)	Sanitary Sewers (Metro)	Sanitary Sewers	Marine	Fresh
pH	pH	7.2	6.7 - 8.2	5.5 - 12.0	—[c]	—[d]	—[d]
Turbidity	ntu	469	1700	—[c]	—[c]	—[d]	—[d]
Suspended Solids	mg/L	800	3100	—[c]	—[c]	—[c]	—[c]
Oil/Grease	mg/L	—[b]	—[b]	100	—[c]	—[d]	—[d]
Copper	mg/L	55	190	8.0	2.4	0.006	0.018
Lead	mg/L	1.7	14	4.0	1.2	0.280	0.068
Zinc	mg/L	6.0	22	10.0	3.3	0.190	0.130
Tin	mg/L	0.49	1.4	—[e]	—[e]	—[e]	—[e]
Arsenic	mg/L	0.08	0.1	4.0	3.6	0.138	0.720

[a] Values are based on analysis of 18 samples.
[b] Oil and grease not detected by visible inspections.
[c] No limit set or known for this parameter.
[d] No monitoring requirements, but limits will be based on water-quality criteria.
[e] Tin regulated by restrictions on the application of tributyltin paints.
[f] Limit values based on 8/13/91 draft of the Boatyard General NPDES Permit.

sediment contamination within several Australian marinas; however, a well-flushed marina in this study did not have an increase in sediment hydrocarbons (McMahon, 1989). This finding supports the supposition that sufficient flushing within a marina basin prevents build-up of pollutants in marina sediments.

4. Increased Levels of Pathogen Indicators

Studies conducted in Puget Sound, Long Island Sound, Narragansett Bay, North Carolina, and Chesapeake Bay have shown that boats can be a significant source of fecal coliform bacteria in areas with high boat densities and low hydrologic flushing (NCDEM, 1990; Sawyer and Golding, 1990; Milliken and Lee, 1990; Gaines and Solow, 1990; Seabloom et al., 1989; Fisher et al., 1987). Fecal coliform levels in marinas and mooring fields become elevated near boats during periods of high boat occupancy and usage. NOAA identified boating activities (the presence of marinas, shipping lanes, or intracoastal waterways) as a contributing source in the closure to harvesting of millions of acres of shellfish-growing waters on the east coast of the United States (Leonard et al., 1989).

5. Disruption of Sediment and Habitat

Boat operation and dredging can destroy habitat; resuspend bottom sediment (resulting in the reintroduction of toxic substances into the water column); and increase turbidity, which affects the photosynthetic activity of algae and estuarine vegetation. Paulson and Da Costa (1991) demonstrated that propeller-induced flows can contribute significantly to bottom scour in shallow embayments and may have adverse effects on water clarity and quality. The British Waterways Board (1983) noted that propeller-driven boats may impact the aquatic environment and result in bank erosion. Waterways with shallow water environments would be affected as follows:

(1) The propeller would cut off or uproot water plants growing up from the bottom, and

(2) The propeller agitation of the water (propwash) would disturb the sediments, creating turbidity that would reduce the light available for photosynthesis of plants, impact feeding and clog the breathing mechanisms of aquatic animals, and smother animals and plants.

EPA (1974) noted a resuspension of solids from the bottom and disturbance to aquatic macrophytes following boating activity. Changes in turbidity were dependent on water depth, motor power, operational time and type, and nature of sediment deposits. The increase in turbidity was generally accompanied by an increase in organic carbon and phosphorus concentrations. However, the possible contribution of these nutrients to eutrophication was not determined. The biological communities of rivers may be impacted by boat traffic, which can increase turbidity; resuspend sediments that move into backwaters; create changes in waves, velocity, and pressure; and increase shoreline erosion (USFWS, 1982).

Dredging may alter the marina and the adjacent water by increasing turbidity, reducing the oxygen content of the water, burying benthic organisms, causing disruption and removal of bottom habitat, creating stagnant areas, and altering water circulation (Chmura and Ross, 1978). Some of these impacts (e.g., turbidity and reduced DO) are temporary and without long-term adverse effects. Dredging is addressed under CWA section 404 and associated regulations and is therefore not discussed further in this chapter.

6. Shoaling and Shoreline Erosion

Shoaling and shoreline erosion result from the physical transport of sediment due to waves and/or currents. These waves and currents may be natural (wind-induced, rainfall runoff, etc.) or human-induced (alterations in current regimes, boat wakes, etc.).

The British Waterways Board (1983) noted that when vessel-generated waves reach the shallow margins of a waterway, they can erode the banks and the bed, tending to wash away fringing plants and their associated animal life. The Waterways Board also found that a substantial volume of the sediment that results in shoaling comes from bank erosion and that removal of this material by dredging is a costly recurrent expense, especially where boat traffic causes extensive bank erosion. Factors influencing vessel-generated shoreline erosion include the distance of the boat from shore, boat speed, side slopes, sediment type, and depth of the waterway (Camfield et al., 1980; Sorensen, 1986; Zabawa and Ostrom, 1980).

G. Other Federal and State Marina and Boating Programs

1. NPDES Storm Water Program

The storm water permit program is a two-phase program enacted by Congress in 1987 under section 402(p) of the Clean Water Act. Under Phase I, National Pollutant Discharge Elimination System (NPDES) permits are required to be issued for municipal separate storm sewers serving large or medium-sized populations (greater than 250,000 or 100,000 people, respectively), and for storm water discharges associated with industrial activity such as certain types of marinas. Permits are also to be issued, on a case-by-case basis, if EPA or a State determines that a storm water discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. EPA published a rule implementing Phase I on November 16, 1990.

a. Which marinas are regulated by the NPDES Storm Water Program?

Under the NPDES Storm Water Program, discharge permits are required for point source discharges of storm water from certain types of marinas. A point source discharge of storm water is a flow of rainfall runoff in some kind of discrete conveyance (a pipe, ditch, channel, swale, etc.).

If a marina is primarily in the business of renting boat slips, storing boats, cleaning boats, and repairing boats, and generally performs a range of other marine services, it is classified under the storm water program (using the Standard Industrial Classification (SIC) system developed by the Office of Management and Budget) as a SIC 4493. Marinas classified as SIC 4493 are the type that may be regulated under the storm water program and may be required to obtain a storm water discharge permit.

A marina that is classified as a SIC 4493 is required to obtain an NPDES storm water discharge permit if vehicle maintenance activities such as vehicle (boat) rehabilitation, mechanical repairs, painting, fueling, and lubrication or equipment cleaning operations are conducted at the marina. The storm water permit will apply only to the point source discharges of storm water from the maintenance areas at the marinas. Operators of these types of marinas should consult the water pollution control agency of the State in which the marina is located to determine how to obtain a storm water discharge permit.

b. Which marinas are not regulated by the NPDES Storm Water Program?

Marinas classified as SIC 4493 that are *not* involved in equipment cleaning or vehicle maintenance activities are not covered under the storm water program. Likewise, a marina, regardless of its classification and the types of activities conducted, that has no point source discharges of storm water, is also not regulated under the NPDES storm water program. In addition, some marinas are classified SIC code 5541 - marine service stations and are also not regulated under the NPDES Storm Water Program. These types of marinas are primarily in the business of selling fuel *without vehicle maintenance or equipment cleaning operations.*

c. What marina activities are covered by this guidance?

EPA has not yet promulgated regulations that would designate additional storm water discharges, beyond those regulated in Phase I, that will be required to be regulated in Phase II. Therefore, marina discharges that are not covered under Phase I, including those discharges that potentially may be ultimately covered by Phase II of the storm water permits program, are covered by this management measures guidance and will be addressed by the Coastal Nonpoint Pollution Control Programs. Any storm water discharge at a marina that ultimately is issued an NPDES permit will become exempt from this guidance and from the Coastal Nonpoint Pollution Control Program at the time that the permit is issued.

2. Other Regulatory Programs

The management measures for marinas do not address discharge of sanitary waste from vessels. They do, however, specify a measure to require that new marinas be designed to include pumpout stations and other facilities to handle sanitary waste from marine toilets, also referred to as marine sanitation devices (MSDs), and another measure to ensure that these facilities are properly maintained.

Vessels are not required to be equipped with an MSD. If a boat does have an MSD, however, the MSD has to meet certain standards set by EPA as required by CWA section 312. In addition to EPA standards for MSDs, EPA may allow a State to prohibit all discharges (treated or untreated) from MSDs, thus declaring the area a "no-discharge zone." Any State may apply to the EPA Administrator for designation of a "no-discharge zone" in some or all of the waters of the State; however, EPA must ensure that these waters meet certain tests before granting the application.

The siting and permitting process to which marinas are subject varies from State to State. State and Federal agencies both play a role in this process. Under section 10 of the Rivers and Harbors Act of 1899, the U.S. Army Corps of Engineers (USACE) regulates all work and structures in navigable waters of the United States. Under section 404 of the Clean Water Act, USACE permits are issued or denied to regulate discharges of dredged or fill materials in navigable waters of the United States, including wetlands.

All coastal States with Federally-approved coastal zone management programs can review Federal permit applications, and some States regulate dredge and fill, marshlands, or wetlands permitting for marina development. All States with Federally-approved coastal programs have the authority to object to section 10/section 404 permits if the proposed action is inconsistent with the State's coastal zone management program. Some States require permits for the use of State water bottomlands. States have authority under the Clean Water Act to issue section 401 water quality certifications for Federally-permitted actions as part of their water quality standards program.

The Food and Drug Administration (FDA) has established fecal coliform standards for certified shellfish-growing waters. Each coastal State regulates its own shellfish sanitation program under the National Shellfish Sanitation Program. States must participate if they wish to export shellfish across State lines. Various approaches are used to comply.

Some States also have a State coastal zone management permit providing them authority over development activities in areas located within their defined coastal zone. Alternatively, or in addition to this permitting authority, some States have regulatory planning authority in given areas of the coast, allowing them to influence the siting of marinas, if not their actual design and construction.

Finally, Massachusetts has developed a Harbor Planning Program, and other States (e.g., Connecticut, Rhode Island, New York, and Oregon) are developing similar programs. Municipalities participating in the program develop Harbor Management Plans. The plans must be consistent with approved coastal zone management plans, and they offer benefits such as giving municipalities greater influence over licensing of State tidelands and priority consideration for grants. The plans recommend comprehensive, long-term management programs that help municipalities balance conservation and development, address pollution impacts on a cumulative rather than piecemeal basis, and resolve conflicts over water-dependent and non-water-dependent uses of the waterfront.

H. Applicability of Management Measures

The management measures in this chapter are intended to be applied by States to control impacts to water quality and habitat from marina siting, construction (both new and expanding marinas), and operation and maintenance, as well as boat operation and maintenance. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source (NPS) programs in conformity with the management measures and will have some flexibility in doing so. The application of these management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance.*

The management measures for marinas are applicable to the facilities and their associated shore-based services that support recreational boats and boats for hire. The following operations/facilities are covered by the management measures of this chapter:

- Any facility that contains 10 or more slips, piers where 10 or more boats may tie up, or any facility where a boat for hire is docked;

- Boat maintenance or repair yards that are adjacent to the water;

- Any Federal, State, or local facility that involves recreational boat maintenance or repair that is on or adjacent to the water;

- Public or commercial boat ramps;

- Any residential or planned community marina with 10 or more slips; and

- Any mooring field where 10 or more boats are moored.

Many States already use a 5- to 10-slip definition for marinas. The 10-slip definition for marinas is also based on Federal legislation that implements MARPOL (the International Convention for the Prevention of Pollution from Ships). This legislation requires adequate waste disposal facilities for ships at facilities with 10 or more slips. This guidance is not intended to address shipyards where extensive repair and maintenance of larger vessels occur. Such facilities are subject to NPDES point source and storm water permitting requirements.

Certain types of changes or additions to existing marinas may produce insignificant differences in impacts from such marinas, while other types of changes and expansions may have a far greater effect. Activities that alter the design, capacity, purpose, or use of the marina are subject to the siting and design management measures. The States are to define: (1) activities that significantly change the physical configuration or construction of the marina, (2) activities that significantly change the number of vessels accommodated, or (3) the operational changes that significantly change the potential impacts of the marina. Potential changes to marinas may be treated in the same manner as new marinas; i.e., the changes to the marina would be subject to applicable siting and design management measures.

The management measures for siting and design are applicable to new marinas. Application of the management measures to expanding marinas should be done on a case-by-case basis and should hinge on the potential for the expansion to impact water quality and important habitat. For example, an expanding marina would not be required to implement the flushing, water quality assessment, or shoreline stabilization management measures if the expansion involved only an increase in the number of parking spaces. The storm water runoff management measure is the only siting and design measure that is always applicable to existing and expanding marinas, as well as new marinas.

One method that has been used successfully by several States to determine whether an alteration/expansion is significant is to set a marina perimeter when the marina is constructed. Thereafter, alterations that occur within that perimeter (such as dock reconfiguration) are considered not significant. Another method that States have used is to set a limit, such as a 25 percent increase in the number of slips or a set number of slips (e.g., an increase of more than five slips is considered significant). Rhode Island has successfully implemented a combination of these methods (Rhode Island Coastal Resources Management Program, Section 300.4).

Changes to a marina may also result from catastrophic natural disasters such as hurricanes and severe flooding. It is possible, in smaller marinas, that efforts to rebuild need not be subject to all siting and design management measures.

II. SITING AND DESIGN

Siting and design are among the most significant factors affecting a marina's potential for water quality impacts. The location of a marina—whether it is open (located directly on a river, bay, or barrier island) or semi-enclosed (located on an embayment or other protected area)—affects its circulation and flushing characteristics. Circulation and flushing can also be influenced by the basin configuration and orientation to prevailing winds. Circulation and flushing play important roles in the distribution and dilution of potential contaminants. The final design is usually a compromise that will provide the most desirable combination of marina capacity, services, and access, while minimizing environmental impacts, dredging requirements, protective structures, and other site development costs. The objective of the marina siting and design management measures is to ensure that marinas and ancillary structures do not cause direct or indirect adverse water quality impacts or endanger fish, shellfish, and wildlife habitat both during and following marina construction.

Many factors influence the long-term impact a marina will have on water quality within the immediate vicinity of the marina and the adjacent waterway. Initial marina site selection is the most important factor. Selection of a site that has favorable hydrographic characteristics and requires the least amount of modification can reduce potential impacts. Because marina development can result in reduced levels of dissolved oxygen, many waters with average dissolved oxygen concentrations barely at or below State standards may be unsuitable for marina development.

A. Marina Flushing Management Measure

Site and design marinas such that tides and/or currents will aid in flushing of the site or renew its water regularly.

1. Applicability

This management measure is intended to be applied by States to new and expanding[1] marinas. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

The term *flushing* or *residence time* is often misused in that a single number (e.g., 10 days) is sometimes given to describe the flushing time of an estuary or harbor. In actuality, the flushing time ranges from zero days at the boundary to possibly several weeks, depending on location within the marina waterbody.

Maintaining water quality within a marina basin depends primarily on flushing as determined by water circulation within the basin (Tsinker, 1992). If a marina is not properly flushed, pollutants will concentrate to unacceptable levels in the water and/or sediments, resulting in impacts to biological resources (McMahon, 1989; NCDEM, 1990, 1991). In tidal waters, flushing is primarily due to tidal advective mixing and is controlled by the movement of the tidal prism into and out of the marina waterbody. A large tidal prism relative to the mean total volume of the waterbody indicates a large potential for flushing because more of the "old" water has a chance to become mixed with the "new" water outside the boundary or opening to the waterbody.

In nontidal coastal waters, such as the Great Lakes, wind drives circulation in the adjacent waterbody, causing a velocity shear between the marina basin and the adjacent waterbody and thereby producing one or more circulation cells (vortices). Such cells can have a flushing effect on water within a marina. The current created by local wind conditions is influenced by its persistence in terms of velocity and direction. The depth of the affected water layer is controlled by temperature and how the salinity changes with depth. Several hours of consistent wind are required for full development of wind-driven currents. These currents can be 2 percent of the wind's velocity and are generally downwind in most shallow areas (Tobiasson and Kollmeyer, 1991). In many situations wind-driven currents will provide adequate flushing of marina basins.

The degree of flushing necessary to maintain water quality in a marina should be balanced with safety, vessel protection, and sedimentation. Wave energy should be dissipated adequately to ensure that boater safety and protection of vessels are not at risk. The protected nature of marina basins can result in high sedimentation rates in waters containing high concentrations of suspended solids. Methods for assessing and mitigating sedimentation rates are available (NRC, 1987).

[1] Refer to Section I.H (General Applicability) for additional information on expansions of existing marinas.

3. Management Measure Selection

The measure was selected because it has been shown that adequate flushing will greatly reduce or eliminate the potential for stagnation of water in a marina and will help maintain biological productivity and aesthetics (Tsinker, 1992; SCCC, 1984). Presented below are some illustrative examples of flushing guidelines in different coastal regions and different conditions. In areas where tidal ranges do not exceed 1 meter, as in the southeastern United States, a flushing reduction (the amount of a conservative substance that is flushed from the basin) of 90 percent over a 24-hour period has been recommended. For example, a flushing analysis for a proposed marina/canal on the St. Johns River, Florida, was conducted to predict how an effluent would disperse and to determine the configuration that would provide for maximum flushing of a hypothetical conservative pollutant (Tetra Tech, 1988). The selected design provided the recommended flushing reduction of 90 percent over a 24-hour period. This study showed that employing modeling to demonstrate how to achieve the recommended flushing rate is effective at avoiding adverse water quality and other environmental impacts. In the Northwest, a minimum flushing reduction of 70 percent per day was judged to be adequate (Cardwell and Koons, 1981). The 70 percent value, which represents the overall mean flushing rate for the marina basin, was based on the prevailing 1.82-meter tidal range for a 24-hour period. However, if the marina was in a protected area, such as an estuary or embayment, where tidal ranges never attain 1.82 meters, then a minimum flushing reduction of approximately 85 percent per day was recommended.

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

a. Site and design new marinas such that the bottom of the marina and the entrance channel are not deeper than adjacent navigable water unless it can be demonstrated that the bottom will support a natural population of benthic organisms.

Existing water depths can affect the entire marina layout and design. Therefore, if depth information is not available, bathymetric surveys should be conducted in the proposed marina basin area as well as in those areas that will be used as channels, whether existing or proposed (Schluchter and Slotta, 1978). Flushing rates in marinas can be maximized by proper design of the entrance channel and basins. For example, in areas of minimal or no tides, marina basin and channel depths should be designed to gradually increase toward open water to promote flushing (USEPA, 1985a). Otherwise, isolated deep holes where water can stagnate may be created (SCCC, 1984).

Good flushing alone does not guarantee that a marina's deepest waters will be renewed on a regular basis. Several studies have concluded that deep canals and holes deeper than adjacent waters are not adequately flushed by tidal action or by wind-generated forces and thus cause stagnant or semi-stagnant conditions (Walton, 1983; Barada and Partington, 1972). Lower layers in canals and basins can act as traps for fine sediment and organic detritus and exhibit low dissolved oxygen concentrations. Lower-layer stagnation can occur in holes of depths less than 10 feet (Murawski, 1969). The low DO concentrations, resulting from an oxygen demand exerted by resuspended sediments and decaying organic matter, can impact aquatic life in the warmer months when the normal DO concentration is lower because of higher temperatures (Sherk, 1971). Fine sediments trapped in deep holes may form a thin surface ooze, which gives poor internal oxygen circulation and leads to oxygen reduction both within the sediments and in the overlying water (USEPA, 1976).

b. Design new marinas with as few segments as possible to promote circulation within the basin.

Flushing efficiency for a marina is inversely proportional to the number of segments. For example, a one-segment marina will not flush as well as a marina in open water, a two-segment marina will not flush as well as a one-

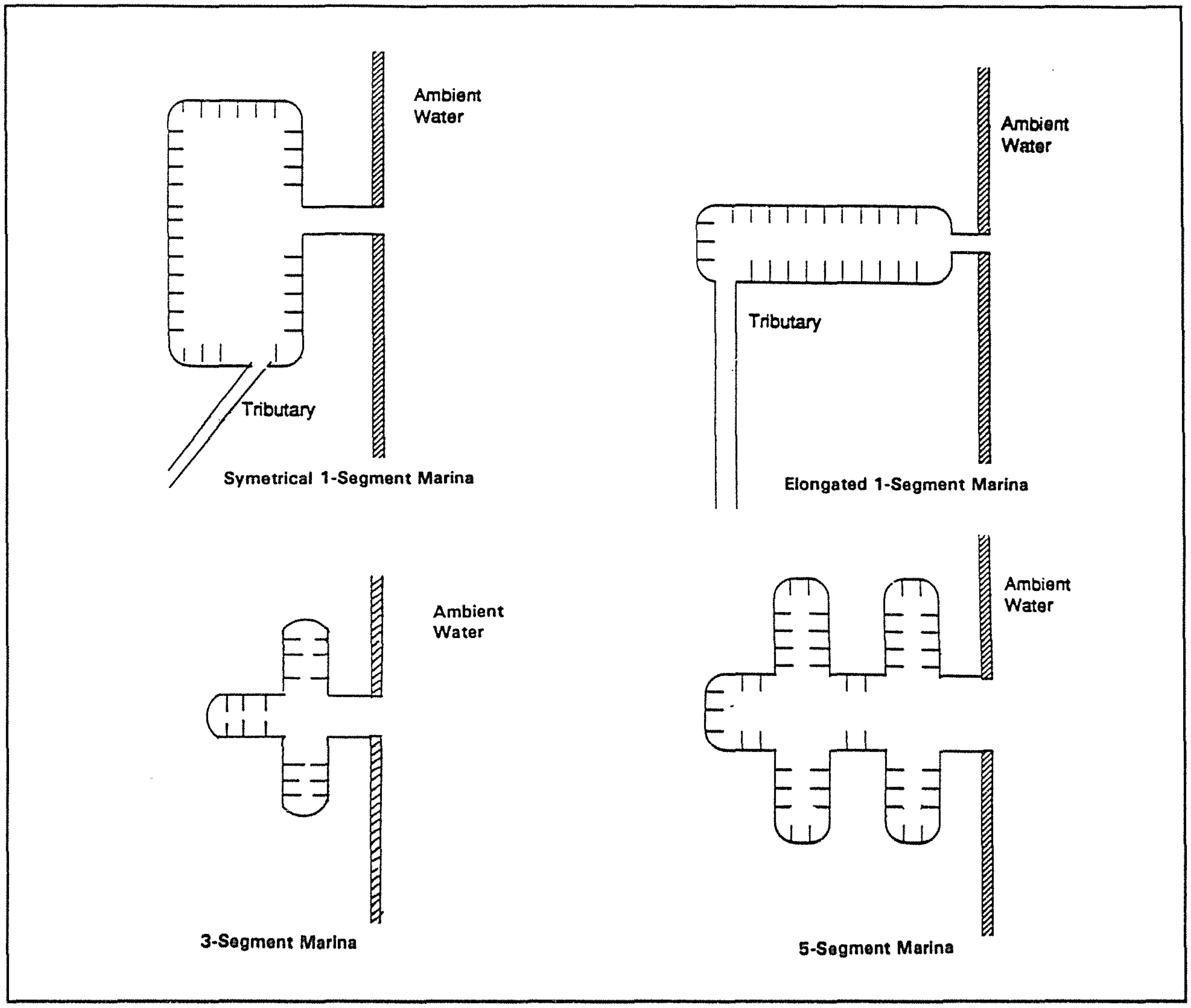

Figure 5-1. Example marina designs (adapted from DNREC, 1990).

segment marina, and so forth. Figure 5-1 presents examples of marinas with one segment and more than one segment. The physical configuration of the proposed marina as determined by the orientation of the marina toward the natural water flow can have a significant effect on the flushing capacity of the waterway. The ideal situation is one in which the distance between the exchange boundary and the inner portion of the basin is minimized. As the shape of the basin becomes more elongated (i.e., more than one segment) with respect to total surface area, the tidal advective or other dispersive mixing processes become more confined along a single flow path, and it takes longer for a water particle originating in the inner part of the basin to travel the greater distance to the boundary.

The marina's aspect ratio (the ratio of its length to its breadth) should be used as a guideline for marina basin design with respect to flushing. This ratio should be greater than 0.33 and less than 3.0, preferably between 0.5 and 2.0 (Cardwell and Koons, 1981). For rectangular marinas with one entrance connected directly to the source waterbody, the length-to-breadth ratio should be between 0.5 and 3.0 to eliminate secondary circulation cells where mixing and tidal flushing are reduced (McMahon, 1989).

Marina configurations that promote flushing exhibit, in general, better dissolved oxygen conditions than those with restrictions or stagnant areas such as improper entrance channel design, bends, and square corners (NCDEM, 1990). These areas also tend to trap sediment and debris. If debris are allowed to collect and settle to the bottom, an oxygen demand will be imposed on the water and water quality will suffer. Therefore, square corners should be avoided in critical downwind or similar areas where this is most likely to be a problem. If square corners are unavoidable because of other considerations, then points of access should be provided in those corners to allow for easy cleanout of accumulated debris.

In tidal waters, marina design should replace conventional rectangular boat basin geometry with curvilinear geometry to eliminate the stagnation effects of sharp-edged corners and to exploit the natural hydraulic patterns of flow and prevent the occurrence of areas where flushing is negligible (Cardwell and Koons, 1981). By combining these elements in the design of a marina, analytical studies have suggested that a strong internal basin circulation system could develop, resulting in acceptable water quality levels (Layton, 1991).

c. Consider other design alternatives in poorly flushed waterbodies (open marina basin over semi-enclosed design; wave attenuators over a fixed structure) to enhance flushing.

In selecting a marina site and developing a design, consideration of the need for efficient flushing of marina waters should be a prime factor along with safety and vessel protection. For example, sites located on open water or at the mouth of creeks and tributaries usually have higher flushing rates. These sites are generally preferable to sites located in coves or toward the heads of creeks and tributaries, locations that tend to have lower flushing rates.

In poorly flushed waterbodies, special arrangements may be necessary to ensure adequate overall flushing. In these areas, selection of an open marina design and/or the use of wave attenuators should be considered. Open marina designs have no fabricated or natural barriers, which tend to restrict the exchange of water between ambient water and water within the marina area. Wave attenuators improve flushing rates because water exchange is not restricted. They are also attractive because they do not interfere with the bottom ecology or aesthetic view. Other advantages include their easy removal and minimization of potential interference with fish migration and shoreline processes (Rogers et al., 1982).

The effectiveness of wave attenuators is usually dependent on their mass (Tobiasson and Kollmeyer, 1991). The greater the horizontal and draft dimensions, the greater their displacement and effectiveness. Floating wave attenuators have limitations on their use in extreme wave fields, and site-specific studies should be performed as to their suitability.

d. Design and locate entrance channels to promote flushing.

Entrance channel alignment should follow the natural channel alignment as closely as possible to increase flushing. Any bends that are necessary should be gradual (Dunham and Finn, 1974). In areas where the tidal range is small, it is recommended that the marina's entrance be designed as wide as possible to promote flushing while still providing adequate protection from waves (USEPA, 1985a). In areas where the tidal range is large, however, a single narrow entrance channel, if properly designed, has proven to provide adequate flushing (Layton, 1991).

Entrance channel design and placement can alleviate potential water quality problems. In tidal and nontidal waters, marina flushing rates are enhanced by wind action when entrance channels are aligned parallel to the direction of prevailing winds because wind-generated currents can mix basin water and facilitate circulation between the basin and the adjacent waterway (Christensen, 1986).

Shoaling may be significant in areas of significant bed load transport if the entrance channel is located perpendicular to the waterway. Increased shoaling could require extensive maintenance dredging of the channel or create a sill at the entrance to the marina basin. Shoaling at the marina entrance can lead to water quality problems by reducing flushing and water circulation within the basin (Tetra Tech, 1988; USEPA, 1985a). In Panama City, Florida, a study of bathymetric surveys before and after the construction of an artificial inlet showed that the areas of deposition and erosion in the natural bay rapidly changed as a result of alterations of channel positions and depths (Johnston, 1981).

The orientation and location of a solitary entrance can impact marina flushing rates and should be given consideration along with other factors impacting flushing. When a marina basin is square or rectangular, a single entrance at the center of a marina produces better flushing than does a single corner-located asymmetric entrance (Nece, 1981). This results in part because the jet entering the marina on the flood tide is able to circumnavigate a greater length of the sub-basin perimeter associated with each of the two gyres than it could in a single-gyre basin with an asymmetric entrance. If the marina basin is circular, an off-center entrance channel will promote better circulation. Off-center entrance channels also promote better circulation in circular canals.

e. Establish two openings, where appropriate, at opposite ends of the marina to promote flow-through currents.

Where water-level fluctuations are small, alternatives in addition to the ones previously discussed should be considered to ensure adequate water exchange and to increase flushing rates (Dunham and Finn, 1974). An elongated marina situated parallel to a tidal river can be adequately flushed using two entrances to establish a flow-through current so that wind-generated currents or tidal currents move continuously through the marina. In situations where both openings cannot be used for boat traffic, a smaller outlet onto an adjacent waterbody can be opened solely to enhance flushing. In other situations a buried pipeline has been used to promote flushing.

f. Designate areas that are and are not suitable for marina development; i.e., provide advance identification of waterbodies that do and do not experience flushing adequate for marina development.

For example, the physical characteristics of some small tidal creeks result in poor flushing and increased susceptibility to water quality problems (Klein, 1992). These characteristics include:

- Bottom configuration — Flushing is retarded when a depression exists that is lower than the entrance to the waterway.
- Entrance configuration — A constricted entrance will decrease flushing.
- Tributary inflow — Higher freshwater inflow will increase flushing.
- Tidal range — Increased tidal range will increase flushing.
- Shape of the waterway — As the configuration of a waterway becomes more convoluted and irregular, flushing tends to decrease.

B. Water Quality Assessment Management Measure

Assess water quality as part of marina siting and design.

1. Applicability

This management measure is intended to be applied by States to new and expanding[2] marinas. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

Assessments of water quality may be used to determine whether a proposed marina design will result in poor water quality. This may entail predevelopment and/or postdevelopment monitoring of the marina or ambient waters, numerical or physical modeling of flushing and water quality characteristics, or both. Cost impacts may preclude a detailed water quality assessment for marinas with 10 to 49 slips (See *Economic Impacts of EPA Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.*) A preconstruction inspection and assessment can still be expected, however. Historically, water quality assessments have focused on two parameters: dissolved oxygen (DO) and pathogen indicators. The problems resulting from low DO in surface waters have been recognized for over a century. The impacts of low DO concentrations are reflected in an unbalanced ecosystem, fish mortality, and odor and other aesthetic nuisances. DO levels may be used as a surrogate variable for the general health of the aquatic ecosystem (Thomann and Mueller, 1987). Coastal States use pathogen indicators, such as fecal coliform bacteria (*Escherichia coli*) and enterococci, as a surrogate variable for assessing risk to public health through ingestion of contaminated water or shellfish (USEPA, 1988) and through bathing (USEPA, 1986).

Dissolved Oxygen. Three important factors support the use of DO as an indicator of water quality associated with marinas. First, low DO is considered to pose a significant threat to aquatic life. For example, fish and invertebrate kills due to low DO are well known and documented (Cardwell and Koons, 1981). Second, DO is among the few variables that have been measured historically with any consistency. A historical water quality baseline is extremely useful for predicting the impacts of a proposed marina. Third, DO is fundamentally important in controlling the structure—and, in some areas, the productivity—of biological communities.

Pathogen Indicators. Marinas in the vicinity of harvestable shellfish beds represent potential sources for bacterial contamination of the shellfish. Siting and construction of a marina or other potential source of human sewage contiguous to beds of shellfish may result in closure of these beds. Also, nearby beaches and waters used for bathing should be considered.

Fecal coliform bacteria, *Escherichia coli*, and enterococci are used as indicators of the pathogenic organisms (viruses, bacteria, and parasites) that may be present in sewage. These indicator organisms are used because no reliable and

[2] Refer to Section I.H (General Applicability) for additional information on expansions of existing marinas.

cost-effective test for pathogenic organisms exists. Water quality assessments can be used to ensure that water quality standards supporting a designated use are not exceeded. For example, in waters approved for shellfish harvesting, a marina water quality assessment could be used to document potential fecal coliform concentrations in the water column in excess of the standard of 14 organisms MPN (most probable number) per 100 milliliters of water. This standard should not be exceeded in areas where the exceedance would result in the closure of harvestable or productive shellfish beds. Many States have adopted EPA's 1986 ambient water quality criteria for bacteria, which recommend *E. coli* and enterococci as indicators of pathogens for freshwater and marine bathing.

3. Management Measure Selection

Selection of this measure was based on the widespread use and proven effectiveness of water quality assessments in the siting and design of marinas. The North Carolina Department of Environmental Management conducted a postdevelopment study to characterize the water quality conditions of several marinas and to provide data that can be used to evaluate future marina development (NCDEM, 1990). The sampling program demonstrated that marina water quality monitoring studies are effective at assessing potential water quality impacts from coastal marinas. Water quality assessments have been used successfully at a variety of other proposed marina locations nationwide to determine potential water quality impacts (USEPA, 1992b). Many States require water quality assessments of proposed marina development (Appendix 5A). Marinas with 10 to 49 slips may not be able to afford monitoring or modeling. (See *Economic Impacts of EPA Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.*) In such instances a preconstruction inspection and assessment can still be performed. Dredging requires a River and Harbor Act section 10 permit from the U.S. Army Corps of Engineers (USACE). If there is discharge into waters of the United States after dredging, then a CWA section 404 permit is required. A CWA section 401 Water Quality Certification is required from the State before a section 404 permit is issued by the USACE.

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

Two effective techniques are available to evaluate water quality conditions for proposed marinas. In the first technique, a water quality monitoring program that includes predevelopment, during-development, and postdevelopment phases can be used to assess the water quality impacts of a marina. In the second approach, effective assessment can be accomplished through numerical modeling that includes predevelopment and postconstruction model applications.

Numerical modeling can be used to study impacts associated with several alternatives and to select an optimum marina design that avoids and minimizes impacts to both water quality and habitats existing at the site (e.g., Rive St. Johns Canal study and Willbrook Island marina). A combination of field surveys and numerical modeling studies may be necessary to identify all environmental concerns and to avoid or minimize marina impacts on both water quality conditions and nearby shellfish habitat.

a. Use a water quality monitoring methodology to predict postconstruction water quality conditions.

A primary objective for use of a water quality assessment is to ensure that the 24-hour average dissolved oxygen concentration and the 1-hour (or instantaneous) minimum dissolved oxygen concentration both inside the proposed marina and in adjacent ambient waters will not violate State water quality standards or preclude designated uses.

The first step in a marina water quality assessment should be the evaluation and the characterization of existing water quality conditions. Before an analysis of the potential impacts of future development is made, it should be determined whether current water quality is acceptable, marginal, or substandard. The best way to assess existing water quality is to measure it. Acceptable water quality data may already have been collected by various government organizations. Candidate organizations include the U.S. Geological Survey, the USACE, State and local water quality control and monitoring agencies, and engineering and oceanographic departments of local universities.

The second step in a marina water quality assessment is to set design standards in terms of water quality. In most States, the water quality is graded based on DO content, and a standard exists for the 24-hour average concentration and an instantaneous minimum concentration. A State's water quality standard for DO during the critical season may be used to set limits of acceptability for good water quality.

The best way to assess marina impacts on water quality is to design a sampling strategy and physically measure dissolved oxygen levels. During the sampling, sediment oxygen demand and other data that may be used to estimate dissolved oxygen levels using numerical modeling procedures can be collected (USEPA, 1992c, 1992d). A postdevelopment field program may include dye-release and/or drogue-release studies (to verify circulation patterns) and a water quality monitoring program. Data collected from such studies may be used to assist in the prediction of water quality or circulation at other potential marina sites.

Sampling programs are effective methods to evaluate the potential water quality impacts from proposed marinas. The main objective of a preconstruction sampling program is to characterize the water surrounding the area in the vicinity of the proposed marina. Another objective of a preconstruction sampling program is to provide necessary information for modeling investigations (e.g., Tetra Tech, 1988).

b. Use a water quality modeling methodology to predict postconstruction water quality conditions.

Water quality monitoring can be expensive, and therefore a field monitoring approach may not be practical. The use of a numerical model may be the most economical alternative. However, all models require some field data for proper calibration. A better and more cost-effective approach would be a combination of both water quality monitoring and numerical modeling (Tetra Tech, 1988).

Modeling techniques are used to predict flushing time and pollutant concentrations in the absence of site-specific data. A distinct advantage of numerical models over monitoring studies is the ability to easily perform sensitivity analyses to establish a set of design criteria. Limits of water quality acceptability, flushing rates, and sedimentation rates must be known before quantifying the limit of geometric parameters to comply with these standards. Numerical models can be used to evaluate different alternative designs to determine the configuration that would provide for maximum flushing of pollutants. Models can also be used to perform sensitivity analysis on the selected optimum design.

In 1982, preconstruction numerical modeling studies were conducted to investigate whether a proposed marina in South Carolina would meet the State water quality standards after construction. Modeling results indicated that the proposed Wexford Marina would meet water quality standards (Cubit Engineering, 1982). The marina was approved and constructed. Follow-up monitoring studies were conducted to evaluate preconstruction model predictions (USEPA, 1986). The monitoring results indicated that shellfish harvesting standards were being met, thereby validating the preconstruction modeling study.

EPA Region 4 recently completed an in-depth report on marina water quality models (USEPA, 1992c). The primary focus of the study was to provide guidance for selection and application of computer models for analyzing the potential water quality impacts (both DO and pathogen indicators) of a marina. EPA reviewed a number of available methods and classified them into three categories: simple methods, mid-range models, and complex models. Simple methods are screening techniques that provide only information on the average conditions in the marina. Screening methods do not provide spatial or time-varying water quality predictions, and therefore it is recommended that these methods be used with open marina designs and/or marinas sited in areas characterized by good flushing rates and good water quality conditions (USEPA, 1992c). In addition, simple models are not suitable where marina flushing is controlled by the prevailing wind, requiring the application of more advanced models, such as WASP4.

In poorly flushed areas and in marinas with a complex design, a more advanced method will identify those areas where water quality standards may be violated. The complex methods are also capable of predicting spatial and time-variant water quality conditions and provide the complete water quality picture inside a proposed marina. In general, advanced models are more effective and more appropriate than simple screening methods in assessing environmental impacts associated with marina siting and design (USEPA, 1992c).

Costs associated with applying a numerical model or conducting a water quality monitoring program range from 0.1 to 2.0 percent of the total marina development project cost. Table 5-2 provides cost information by marina, size, State, and year built. These factors should all be considered when comparing a particular cost associated with a specific item. For example, costs associated with the water quality monitoring program for Barbers Point Harbor and Marina complex were estimated at $56,000. On the other hand, the cost of the water quality monitoring program for the Beacons Reach marina, North Carolina, was $3,000. It was only when a full environmental assessment was conducted (e.g., North Point and Barbers Point marina complex) that costs were higher. In addition, several models have been recommended as appropriate tools to assess potential water quality impacts from coastal marinas (USEPA, 1992c, 1992d). The cost associated with applying the simple model is on the order of $1,000, whereas the cost associated with the advanced model is in the range of $25,000 to $100,000. Siting and design practices to reduce environmental impacts were frequently part of a larger design/environmental study. Costs for a total environmental assessment of a proposed marina ranged from 1 percent to 5 percent of the total project cost.

c. *Perform preconstruction inspection and assessment.*

A preconstruction inspection and assessment may be affordable in place of detailed water quality monitoring or modeling for marinas with 10 to 49 slips. The River and Harbor Act of 1899 section 10 and Clean Water Act section 404 permit application process requires applicants to present to the USACE information necessary for a water quality assessment. An expert knowledgeable in water quality and hydrodynamics may assess potential impacts using available information and site inspection.

Table 5-2. Cost Summary of Selected Marina Siting Practices (USEPA, 1992b)

Marina/Project Name and Location	Years	Scope of Work	Cost (x $1000)
North Point Marina Illinois (1,493 slips)	1983-1989	Full environmental assessment	100
		Construction cost	39,000
Point Roberts Marina Washington (1,000 slips)	1976-1978	Environmental studies (physical and numerical modeling, littoral drift, and biological studies)	300
		Postconstruction water quality monitoring program (including dye release and drogue)	10
		Construction cost	6,000
Barbers Point Harbor and Marina Complex (Retrofit) Hawaii	1981-1985	Physical model	650
		Numerical model (both 2D and 3D)	100
		Botanical survey	15
		Baseline water quality monitoring program	56
		Total construction	140,000
Marina Water Quality Modeling Study	1990	Numerical model applications to 3 Southeast marinas	30
		Data collection	22
Rive St. Johns Canal Florida	1988	Littoral studies and data collection	20
		Numerical model study	30
North Carolina Coastal Marina Water Quality Assessment	1989	Water quality monitoring program[a]	3
		Dye study[a]	3
		Numerical modeling studies	0.5
Willbrook Island Marina (200 slips) South Carolina	1990	Water quality modeling study	10
Coastal Water Quality Assessment (NCDEM) North Carolina	1989	Monitoring program[a]	3
		Numerical modeling application[b]	0.5
		Dye study (flushing)[c]	3
Wexford Marina South Carolina	1982 and 1986	Numerical model application	—[d]
		Numerical model application	—[d]

[a] Cost estimate is per marina site.
[b] Simple screening model.
[c] This program was conducted by NCDEM personnel.
[d] Not available.

C. Habitat Assessment Management Measure

Site and design marinas to protect against adverse effects on shellfish resources, wetlands, submerged aquatic vegetation, or other important riparian and aquatic habitat areas as designated by local, State, or Federal governments.

1. Applicability

This management measure is intended to be applied by States to new and expanding[3] marinas where site changes may impact on wetlands, shellfish beds, submerged aquatic vegetation (SAV), or other important habitats. The habitats of nonindigenous nuisance species, such as some clogging vegetation or zebra mussels, are not considered important habitats. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

Coastal marinas are often located in estuaries, one of the most diverse of all habitats. Estuaries contain many plant and animal communities that are of economic, recreational, ecological, and aesthetic value. These communities are frequently sensitive to habitat alteration that can result from marina siting and design. Biological siting and design provisions for marinas are based on the premise that marinas should not destroy important aquatic habitat, should not diminish the harvestability of organisms in adjacent habitats, and should accommodate the same biological uses (e.g., reproduction, migration) for which the source waters have been classified (Cardwell et al., 1980). Important types of habitat for an area, such as wetlands, shellfish beds, and submerged aquatic vegetation (SAV), are usually designated by local, State, and Federal agencies. In most situations the locations of all important habitats are not known. Geographic information systems are used to map biological resources in Delaware and show promise as a method of conveying important habitat and other siting information to marina developers and environmental protection agencies (DNREC, 1990).

3. Management Measure Selection

The selection of this measure was based on its widespread use in siting and design and the fact that proper siting and design can reduce short-term impacts (habitat destruction during construction) and long-term impacts (water quality, sedimentation, circulation, wake energy) on the surrounding environment (USEPA, 1992b). Currently, 50 percent of the coastal States minimize adverse impacts caused by siting and design by requiring a habitat assessment prior to siting a marina, and an additional 40 percent require a habitat assessment under special conditions (Appendix 5A).

[3] See Section I.H (General Applicability) for additional information on expansions of existing marinas.

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

a. Conduct surveys and characterize the project site.

The first step in achieving compatibility between coastal development and coastal resources is to properly characterize the proposed project site. The site's physical properties and water quality characteristics must be assessed. To minimize potential impacts, available habitat and seasonal use of the site by benthos, macroinvertebrates, and ichthyofauna should be evaluated. Once these data are assembled, it becomes possible to identify environmental risks associated with development of the site. Through site-design modifications, preservation of critical or unique habitat, and biological/chemical/physical monitoring, it is possible to minimize the direct and indirect impacts associated with a specific waterfront development (USEPA, 1985a). To properly evaluate development applications for projects at the periphery of critical or endangered habitat areas, it may be necessary to conduct on-site visits and surveys to determine the distribution of critical habitat such as spawning substrate and usage by spawning fish.

Based on data compiled primarily by the New Jersey Department of Environmental Protection (NJDEP) prior to construction, it was concluded that a large proposed marina (Port Liberte) could have a serious environmental impact on resident and transient fish and macroinvertebrates. Loss of unique habitat, water quality degradation, and disturbance of contaminated sediments were some of the more severe anticipated impacts. Following a comprehensive NJDEP review process, the developer modified the site plan and phased construction activities, thereby satisfying the concerns of the various environmental regulatory agencies and minimizing potential direct and indirect impacts (Souza et al., 1990). Follow-up monitoring established that the management practices were effective in avoiding impacts to important fishery habitat.

b. Redevelop coastal waterfront sites that have been previously disturbed; expand existing marinas or consider alternative sites to minimize potential environmental impacts.

Proper marina site selection is a practice that can minimize adverse impacts on nearby habitats. For example, the selected site for North Point Marina in Illinois was not a suitable environment for either floral or faunal habitat because of high erosion rates, high ground-water conditions, and the high potential for flooding (Braam and Jansen, 1991). Despite the surrounding environment, this site was thought to be suitable for marina development because the site had been previously disturbed. Within existing urban harbors where the shorelines have been modified previously by bulkheading and filling, there will be many opportunities to site recreational boating facilities with minimal adverse environmental consequences (Goodwin, 1988).

Alternative site analysis may be used to demonstrate that a chosen site is the most economic and environmentally suitable. Alternative site/design analysis has been found effective at reducing potential impacts from many proposed marinas. The proposed Rive St. Johns Canal, Willbrook Island, and John Wayne marinas used this practice and demonstrated the effectiveness of analyzing alternative sites and designs to minimize environmental impacts. For example, eight design alternatives were considered for the John Wayne marina. The selected alternative reduced tideland alteration, biological destruction, and stream diversion. This was accomplished by moving the marina basin nearly 1,000 feet north of the original site and reducing the basin capacity (Holland, 1986). Five alternatives were considered for the Rive St. Johns Canal. The selected site avoided impacts to wetland habitats and has better flushing characteristics. The Willbrook study considered five alternatives, and the site selected successfully minimized impacts to submerged aquatic vegetation and wetlands.

c. *Employ rapid bioassessment techniques to assess impacts to biological resources.*

Rapid bioassessment techniques, when fully developed, will provide cost-effective biological assessments of potential marina development sites. Rapid bioassessment uses biological criteria and is based on comparing the community assemblages of the potential development site to an undisturbed reference condition. Biological criteria or biocriteria describe the reference condition of aquatic communities inhabiting unimpaired waterbodies (USEPA, 1992a). These methods consist of community-level assessments designed to evaluate the communities based on a variety of functional and structural attributes or metrics. Rapid bioassessment protocols for freshwater streams and rivers were published in 1989 for macroinvertebrates and fish to provide States with guidelines for conducting cost-effective biological assessments (USEPA, 1989). Development of similar protocols for application in estuaries and near coastal areas is under way (USEPA, 1992a).

Scores from rapid bioassessments may be used to determine the biological integrity of a site. Sites that are comparable to pristine conditions, with complete assemblages of species, should not be developed as marinas because of the unavoidable impacts associated with such development. The level of effort required to characterize a site will depend on the specific protocol (level of detail required and organisms used) employed. The time needed to perform a rapid bioassessment in freshwater streams varied from 1.5-3 hours to 5-10 hours for benthos and 3 to 17 hours for fish (USEPA, 1989).

d. *Assess historic habitat function (e.g., spawning area, nursery area, migration pathway) to minimize indirect impacts.*

Washington State issued siting and tidal height provisions (WDF, 1971, 1974) to ensure that bulkheads do not destroy spawning of surf smelt habitat and increase the vulnerability of juvenile salmon. In addition, marina breakwaters may disrupt the migration pattern of migratory fish, such as salmon. The design of marinas should consider the migration, survival, and the harvestability of food fish and shellfish.

e. *Minimize disturbance to indigenous vegetation in the riparian area.*

A riparian area is defined 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.[4]

Riparian areas are generally more productive habitat, in both diversity and biomass, than adjacent uplands because of their unique hydrologic condition. Many important processes occur in the riparian zone, including the following:

- Because of their linear form along waterways, riparian areas process large fluxes of energy and materials from upstream systems as well as from ground-water seepage and upland runoff.
- They can serve as effective filters, sinks, and transformers of nutrients, eroded soils, and other pollutants.
- They often appear to be nutrient transformers that have a net import of inorganic nutrient forms and a net export of organic forms.

Chapter 7 of this document, which also requires protection of riparian areas when they have significant nonpoint pollution control value, contains a more detailed discussion of riparian functions.

[4] This definition is adapted from the definition offered previously by Mitsch and Gosselink (1986) and Lowrance et al. (1988).

f. Encourage the redevelopment or expansion of existing marina facilities that have minimal environmental impacts instead of new marina development in habitat areas that local, State, or Federal agencies have designated important.

One method to avoid new marina development in areas containing important habitat is the purchase of development rights of existing marinas or important habitat. In the case of preserving an existing marina (thus avoiding the impacts associated with developing new marinas), the government pays the difference (if there is one) between the just value and the water-dependent value and owns the rights to develop the property for other uses. This approach provides instant liquidity for the marina owner, who keeps the profits derived from all marina assets even though the government may have paid 80 to 90 percent of the value of the land. This would in theory offset the inability to sell the marina for non-water-dependent activities and decrease marina development in areas containing important habitat. The purchase of development rights and conservation easements for land containing important habitat or NPS control values is discussed in Chapter 4. In the Broward County (Florida) Comprehensive Plan, expansion of existing marina facilities is preferred over development of new facilities (Bell, 1990).

g. Develop a marina siting policy to discourage development in areas containing important habitat as designated by local, State, or Federal agencies.

Establishing a marina siting policy is an efficient and effective way to control habitat degradation and water pollution impacts associated with marinas. Creating such a policy involves:

- Establishing goals for coastal resource use and protection;
- Cataloging coastal resources; and
- Analyzing existing conditions and problems, as well as future needs.

A siting policy benefits the environment, the public, regulatory agencies, and the marina industry. Examples of such benefits include:

- Impacts to and destruction of environmentally sensitive areas (such as wetlands, fish nursery areas, and shellfish beds) are avoided by directing development to sites more appropriate for marina development;
- Coastal resources (such as submerged aquatic vegetation and beaches) are protected;
- Cumulative impacts from numerous pollution sources are more easily assessed;
- Coastal development and economic growth are balanced with environmental protection, and the continued viability of water-dependent uses is ensured;
- The needs of the marina industry and rights of public access are accounted for;
- The permitting process is streamlined;
- Regulatory efforts are coordinated; and
- Interjurisdictional consistency is improved.

Many States already address coastal resource and development needs through coastal zone management plans, growth management plans, critical area programs, and other means. The following examples illustrate the high level of acceptance such planning has achieved and the variety of program types upon which a marina siting policy could be built:

- Twelve States have established critical area programs that protect public health and safety, the quality of natural features, scenic value, recreational opportunities, and the historical and cultural significance of coastal areas (Myers, 1991).

- North Carolina has a water use classification system to assist in the implementation of land use policies. Coastal areas are designated for preservation, conservation, or development (Clark, 1990).

- Massachusetts has a Harbor Management Program, wherein municipalities devise specific harbor management plans consistent with State goals (Massachusetts Coastal Zone Management, 1988).

- The Narragansett Bay Project, part of EPA's National Estuary Program, recognizes land use planning as the key to accomplishing many goals, including controlling NPS pollution, protecting and restoring habitat, and preserving public access and recreational opportunities (Myers, 1991).

- The Cape Cod Commission found that unplanned growth over the last several decades has limited public access, displaced marinas and boatyards in favor of non-water-dependent uses, encroached on fishermen's access, degraded water quality, destroyed habitat, and created use conflicts (Cape Cod Commission, 1991).

D. Shoreline Stabilization Management Measure

Where shoreline erosion is a nonpoint source pollution problem, shorelines should be stabilized. Vegetative methods are strongly preferred unless structural methods are more cost effective, considering the severity of wave and wind erosion, offshore bathymetry, and the potential adverse impact on other shorelines and offshore areas.

1. Applicability

This management measure is intended to be applied by States to new and expanding[5] marinas where site changes may result in shoreline erosion. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

The establishment of vegetation as a primary means of shore protection has shown the greatest success in low-wave-energy areas where underlying soil types provide the stability required for plants and where conditions are amenable to the sustaining of plant growth. Under suitable conditions, an important advantage of vegetation is its relatively low initial cost. The effectiveness of vegetation for shore stabilization varies with the amount of wave reduction provided by the physiography and offshore bathymetry of the site or with the degree of wave attenuation provided by structural devices. Identification of the cause of the erosion problem is essential for selecting the appropriate technique to remedy the problem. Methods for determining the potential effectiveness of stabilizing a site with indigenous vegetation are presented in Chapter 7.

Some structural methods to stabilize shorelines and navigation channels are bulkheads, jetties, and breakwaters. They are designed to dissipate incoming wave energy. While structures can provide shoreline protection, unintended consequences may include accelerated scouring in front of the structure, as well as increased erosion of unprotected downstream shorelines.

Among structural techniques, gabions, riprap, and sloping revetments dissipate incoming wave energy more effectively and result in less scouring. Bulkheads are appropriate in some circumstances, but where alternatives are appropriate they should be used first. Costs and design considerations of these and other structural methods for controlling shoreline erosion are presented in Chapter 6.

[5] Refer to Section I.H (General Applicability) for additional information on expansions of existing marinas.

3. Management Measure Selection

Selection of this measure was based on the demonstrated effectiveness of vegetation and structural methods to mitigate shoreline erosion and the resulting turbidity and shoaling (see Chapters 6 and 7). Also, it is in the best interest of marina operators to minimize shoreline erosion because erosion may increase sedimentation and the frequency of dredging in the marina basin and channel(s).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

Detailed information on practices and the cost and effectiveness of structural and vegetative practices can be found in Chapters 6 and 7, respectively.

E. Storm Water Runoff Management Measure

Implement effective runoff control strategies which include the use of pollution prevention activities and the proper design of hull maintenance areas.

Reduce the average annual loadings of total suspended solids (TSS) in runoff from hull maintenance areas by 80 percent. For the purposes of this measure, an 80 percent reduction of TSS is to be determined on an average annual basis.

1. Applicability

This management measure is intended to be applied by States to new and expanding[6] marinas, and to existing marinas for *at least* the hull maintenance areas.[7] If boat bottom scraping, sanding, and/or painting is done in areas other than those designated as hull maintenance areas, the management measure applies to those areas as well. This measure is not applicable to runoff that enters the marina property from upland sources. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

The principal pollutants in runoff from marina parking areas and hull maintenance areas are suspended solids and organics (predominately oil and grease). Toxic metals from boat hull scraping and sanding are part of, or tend to become associated with, the suspended solids (METRO, 1992a). Practices for the control of these pollutants can be grouped into three types: (1) filtration/infiltration, (2) retention/detention, and (3) physical separation of pollutants. A further discussion of storm water runoff controls can be found in Chapter 4.

The proper design and operation of the marina hull maintenance area is a significant way to prevent the entry of toxic pollutants from marina property into surface waters. Recommended design features include the designation of discrete impervious areas (e.g., cement areas) for hull maintenance activities; the use of roofed areas that prevent rain from contacting pollutants; and the creation of diversions and drainage of off-site runoff away from the hull maintenance area for separate treatment. Source controls that collect pollutants and thus keep them out of runoff include the use of sanders with vacuum attachments, the use of large vacuums for collecting debris from the ground, and the use of tarps under boats that are being sanded or painted.

The perviousness of non-hull maintenance areas should be maximized to reduce the quantity of runoff. Maximizing perviousness can be accomplished by placing filter strips around parking areas. Swales are strongly recommended for the conveyance of storm water instead of drains and pipes because of their infiltration and filtering characteristics.

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[6] Refer to Section I.H (General Applicability) for additional information on expansions of existing marinas.

[7] Hull maintenance areas are areas whose primary function is to provide a place for boats during the scraping, sanding, and painting of their bottoms.

Technologies capable of treating runoff that has been collected (e.g., wastewater treatment systems and holding tanks) may be used in situations where other practices are not appropriate or pretreatment is necessary. The primary disadvantages of using such systems are relatively high costs and high maintenance requirements. Some marinas are required to pretreat storm water runoff before discharge to the local sewer system (Nielsen, 1991). Washington State strongly recommends that marinas pretreat hull-cleaning wastewater and then discharge it to the local sewer system (METRO, 1992b).

The annual TSS loadings can be calculated by adding together the TSS loadings that can be expected to be generated during an average 1-year period from precipitation events less than or equal to the 2-year/24-hour storm. The 80 percent standard can be achieved, by reducing over the course of the year, 80 percent of these loadings. EPA recognizes that 80 percent cannot be achieved for each storm event and understands that TSS removal efficiency will fluctuate above and below 80 percent for individual storms.

3. Management Measure Selection

The 80 percent removal of TSS was selected because chemical wastewater treatment systems, sand filters, wet ponds, and constructed wetlands can all achieve this degree of pollutant removal if they are designed properly and the site is suitable. Source controls can also reduce final TSS concentrations in runoff. Table 5-3 presents summary information on the effectiveness, cost, and suitability of the practices listed below. The discussion under each practice presents factors to be considered when selecting a specific practice(s) for a particular marina site.

The 80 percent removal of TSS is applicable to the hull maintenance area only. Although pollutants in runoff from the remaining marina property are to be considered in implementing effective runoff pollution prevention and control strategies for all marinas, existing marinas may be unable to economically treat storm water runoff by retention/detention or filtration/infiltration technologies because of treatment system land requirements and the likely need to collect and transfer runoff from marina shoreline areas (at lower elevations) to upland areas for treatment. Also, marina property may be developed to such an extent that space is not available to build the detention/ retention structures. In other situations, the soil type and groundwater levels may not allow sufficient infiltration for trenches, swales, filter strips, etc. The measure applies to all new and existing marina hull maintenance areas because it allows for runoff control of a smaller, more controlled area and also because the runoff from these hull maintenance areas contain higher levels of toxic pollutants (CDEP, 1991; and METRO, 1992a).

In addition, many of the available practices are currently being employed by States to control runoff from marinas and other urban nonpoint sources (Appendix 5A).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source; location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

a. Design boat hull maintenance areas to minimize contaminated runoff.

Boat hull maintenance areas can be designed so that all maintenance activities that are significant potential sources of pollution can be accomplished over dry land and under roofs (where practical), allowing the collection and proper disposal of debris, residues, solvents, spills, and storm water runoff. Boat hull maintenance areas can be specified with signs, and hull maintenance should not be allowed to occur outside these areas. The use of impervious surfaces (e.g., cement) in hull maintenance areas will greatly enhance the collection of sandings, paint chips, etc. by vacuuming or sweeping.

Table 5-3. Stormwater Management Practice Summary Information

Practice - Characteristics	Pollutants Controlled	Removal Efficiencies (%)	Use with Other Practices	Cost	Retrofit Suitability	References	Pretreatment of Runoff Recommended
Sand Filter	TSS TP TN Fecal Col Metals	60-90 0-80 20-40 40 40-80	Yes	$1 - 11 per ft^3 of runoff	Medium	City of Austin, 1990; Schueler 1991; Tull 1990	Yes
Wet Pond	TSS TP TN COD Pb Zn Cu	50-90 20-90 10-90 10-90 10-95 20-95 38-90	Yes	$349-823 per acre treated; 3-5 of capital cost per year	Medium	Schueler, 1987, 1991; USEPA, 1986	Yes, but not necessary
Constructed Wetlands	TSS TP SP TN NO_3 COD Pb Zn	50-90 0-80 30-65 0-40 5-95 20-80 30-95 30-80	Yes	See Chapter 7	Medium		Yes
Infiltration Basin/Trench	TSS TP TN BOD Bacteria Metals	50-99 50-100 50-100 70-90 75-98 50-100	Yes	Of capital costs: Basins = 3-13 Trenches = 5-15	Medium	Schueler, 1987, 1991	Yes
Porous Pavement	TSS TP TN COD Pb Zn	60-90 60-90 60-90 60-90 60-90 60-90	No	Incremental cost: $40,051-78,288 per acre	Low	Schueler, 1987; SWRPC, 1991; Cahill Associates, 1991	
Vegetated Filter Strip	TSS TP TN COD Metals	40-90 30-80 20-60 0-80 20-80	Combine with practices for MM	Seed: $200-1000 per acre; Seed & mulch: $800-3500 per acre; Sod: $4500-48,000 per acre	High	Schueler et al., 1992	No
Grassed Swale	TSS TP TN Pb Zn Cu Cd	20-40 20-40 10-30 10-20 10-20 50-60 50	Combine with practices for MM	Seed: $4.50-8.50 per linear ft; Sod: $8-50 per linear ft	High	SWRPC, 1991; Schueler, 1987, 1991; Honer, 1988; Wanielistra and Yousef, 1986	No

Table 5-3. (Continued)

Practice - Characteristics	Pollutants Controlled	Removal Efficiencies (%)	Use with Other Practices	Cost	Retrofit Suitability	References	Pretreatment of Runoff Recommended
Swirl Concentrator	TSS BOD		Yes		High	WPCF, 1989; Pisano, 1989; USEPA, 1982	No
Catch Basins	TSS COD	60-97 10-56	Yes	$1100-3000	High	WPCF, 1989; Richards, 1981; SWRPA, 1991	No
Catch Basin with Sand Filter	TSS TN COD Pb Zn	70-90 30-40 40-70 70-90 50-80	High	$10,000 per drainage acre		Shaver, 1991	No
Adsorbents in Drain Inlets	Oil	High	Yes	$85-93 for 10 pillows		Silverman, 1989; Industrial Products and Lab Safety, 1991	No
Holding Tank	All	100 for first flush	Yes			WPCF, 1989	No
Boat Maintenance Area Design	All	Minimizes area of pollutant dispersal	Yes	Low	High	IEP, 1992	No
Oil-grit Separators	TSS	10-25	No		High	Steel and McGhee, 1979; Romano, 1990; Schueler, 1987; WPCF, 1989	No

b. Implement source control practices.

Source control practices prevent pollutants from coming into contact with runoff. Sanders with vacuum attachments are effective at collecting hull paint sandings (Schlomann, 1992). Encouraging the use of such sanders can be accomplished by including the price of their rental in boat haul-out and storage fees, in effect making their use by marina patrons free. Vacuuming impervious areas can be effective in preventing pollutants from entering runoff. A schedule (e.g., twice per week during the boating season) should be set and adhered to. Commercial vacuums are available for approximately $765 to $1065 (Dickerson, 1992), and approximately one machine is needed at a marina of 250 slips or smaller. Tarpaulins may be placed on the ground prior to placement of a boat in a cradle or stand and subsequent sanding/painting. The tarpaulins will collect paint chips, sanding, and paint drippings and should be disposed of in a manner consistent with State policy.

c. Sand Filter

Sand filters (also known as filtration basins) consist of layers of sand of varying grain size (grading from coarse sand to fine sands or peat), with an underlying gravel bed for infiltration or perforated underdrains for discharge of treated water. Figure 5-2 shows a conceptual design of a sand filter system. Pollutant removal is primarily achieved by "straining" pollutants through the filtering media and by settling on top of the sand bed and/or a pretreatment pool.

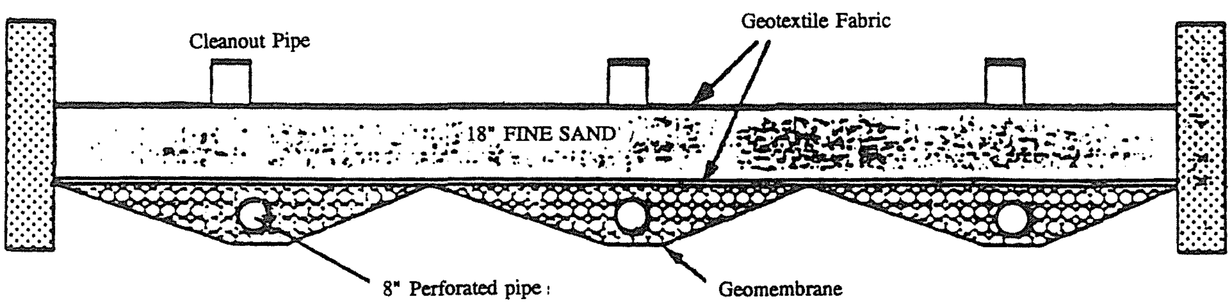

Figure 5-2. Conceptual design of a sand filter system (Austin, Texas, 1991).

Detention time is typically 4 to 6 hours (City of Austin, 1990), although increased detention time will increase effectiveness (Schueler et al., 1992). Sand filters may be used for drainage areas from 3 to 80 acres (City of Austin, 1990). Sand filters may be used on sites with impermeable soils since the runoff filters through filter media, not native soils. The main factors that influence removal rates are the storage volume, filter media, and detention time. Three different designs may be appropriate for marina sites: off-line sedimentation/filtration basins, on-line sand/sod filtration basins, and on-line sand basins. Performance monitoring of these designs produced average removal rates of 85 percent for sediment, 35 percent for nitrogen, 40 percent for dissolved phosphorous, 40 percent for fecal coliform, and 50 percent to 70 percent for trace metals (Schueler et al., 1992).

Sand filters become clogged with particulates over time. In general, clogging occurs near the runoff input to the sand filter. Frequent manual maintenance is required of sand filters, primarily raking, surface sediment removal, and removal of trash, debris, and leaf litter. Sand filters appear to have excellent longevity because of their off-line design and the high porosity of sand as a filtering medium (Schueler et al., 1992). Construction costs have been estimated at $1.30 to $10.50 per cubic foot of runoff treated (Tull, 1990). Significant economies of scale exist as sand filter size increases (Schueler et al., 1992). Maintenance costs are estimated to be approximately 5 percent of construction cost per year (Austin DPW, 1991, in Schueler et al., 1992).

d. Wet Pond

Wet ponds are basins designed to maintain a permanent pool of water and temporary storage capacity for storm water runoff (see Figure 5-3). The permanent pool enhances pollutant removal by promoting the settling of particulates, chemical coagulation and precipitation, and biological uptake of pollutants and is normally 1/2 to 1 inch in depth per impervious acre. Wet ponds are typically not used for drainage areas less than 10 acres (Schueler, 1987). Pond liners are required if the native soils are permeable or if the bedrock is fractured. Design parameters of concern include geometry, wet pond depth, area ratio, volume ratio, and flood pool drawdown time. Ponds may be designed to include shallow wetlands, thereby enhancing pollutant removal. Pollutant removal ranges are presented in Table 5-3. Removal rates of greater than 80 percent for total suspended solids were achieved in many studies (Schueler et al., 1992). Pollutant removal is primarily a function of the ratio of pond volume to watershed size (USEPA, 1986).

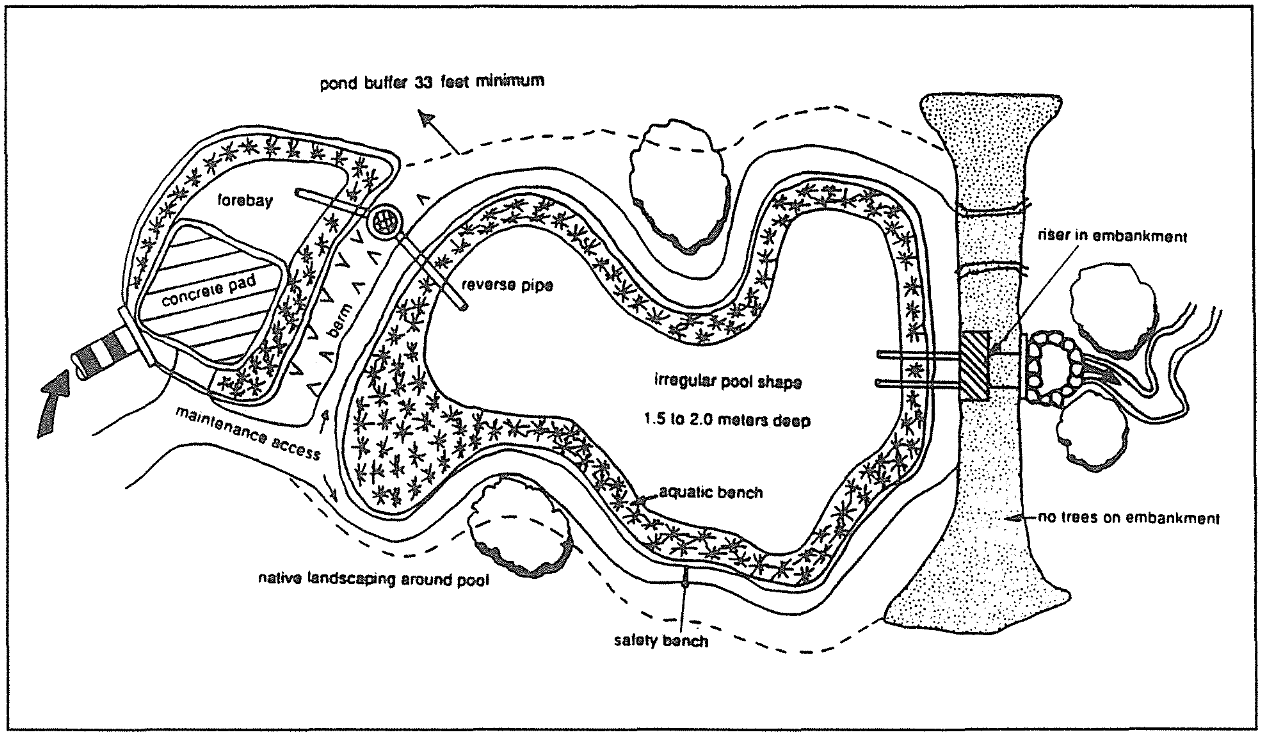

Figure 5-3. Schematic design of an enhanced wet pond system (Schueler, 1991).

A low level of routine maintenance, including tasks such as mowing of side slopes, inspections, and clearing of debris from outlets, is required. Wet ponds can be expected to lose approximately 1 percent of their runoff storage capacity per year as a result of sediment accumulation. To maintain the pollutant removal capacity of the pond, periodic removal of sediment is necessary. A recommended sediment cleanout cycle is every 10 to 20 years (British Columbia Research Corp., 1991). With proper maintenance and replacement of inlet and outlet structures every 25 to 50 years, wet ponds should last in excess of 50 years (Schueler, 1987). A review of capital costs for wet ponds revealed costs of $349 to $823 per acre treated and annual maintenance costs of 3 percent to 5 percent of the capital cost (Schueler, 1987).

e. *Constructed Wetland*

A complete discussion of created wetlands can be found in Chapter 7. Summary information on pollutant removal efficiencies, cost, etc. is presented in Table 5-3.

f. *Infiltration Basin/Trench*

Infiltration practices suitable for storm water treatment include basins and trenches. Figures 5-4 and 5-5 show examples of infiltration basins and trenches. Like porous pavement, infiltration practices reduce runoff by increasing ground-water recharge. Prior to infiltration, runoff is stored temporarily at the surface, in the case of infiltration basins, or in subsurface stone-filled trenches.

Infiltration devices should drain within 72 hours of a storm event and should be dry at other times. The maximum contributing drainage area should not exceed 5 acres for an individual infiltration trench and should range from 2 to 15 acres for an infiltration basin (Schueler et al., 1992).

Pretreatment to remove coarse sediments and PAHs is necessary to prevent clogging and diminished infiltration capacity over time. The application of infiltration devices is severely restricted by soils, water table, slope, and

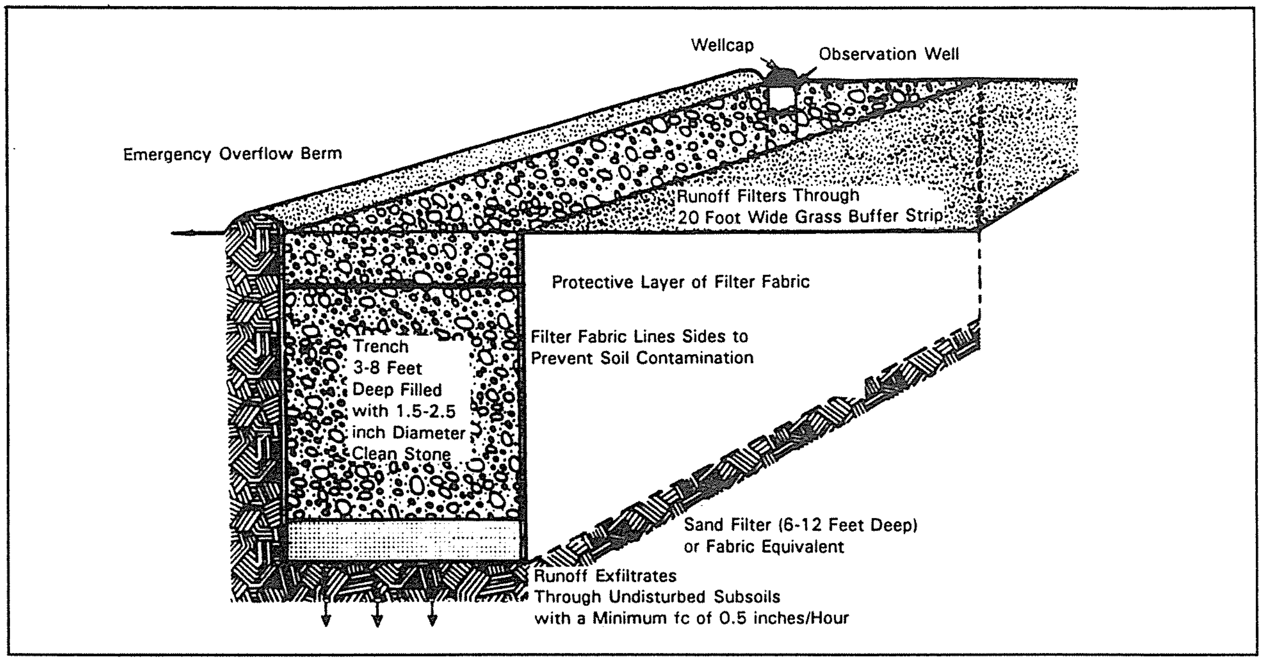

Figure 5-4. Schematic design of a conventional infiltration trench (Schueler, 1987).

contributing area conditions. The sediment load from marina hull maintenance areas may limit the applicability of infiltration devices in these areas. Infiltration devices are not practical in soils with field-verified infiltration rates of less than 1/2 inch per hour (Schueler et al., 1992). Soil borings should be taken well below the proposed bottom of the trench to identify any restricting layers and the depth of the water table. Removal of soluble pollutants in

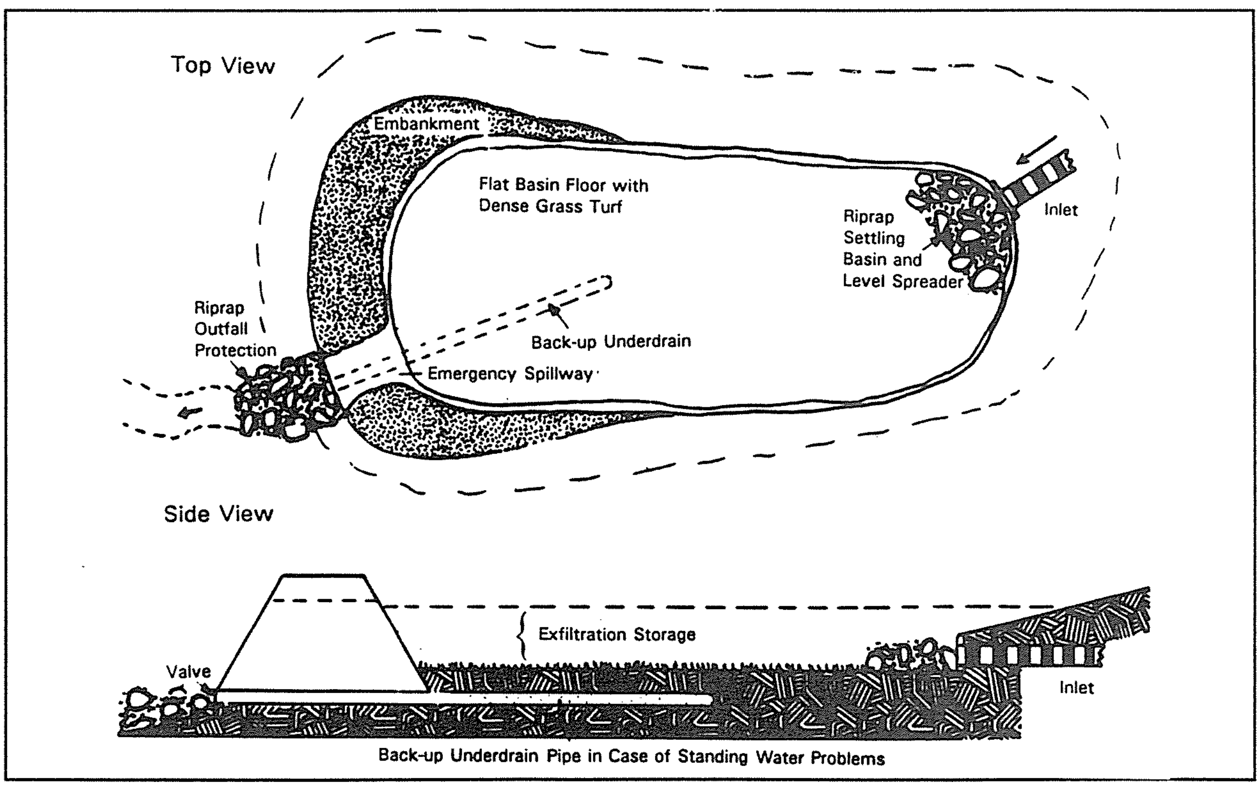

Figure 5-5. Schematic design of an infiltration basin (Schueler, 1987).

infiltration devices relies heavily on soil adsorption, and removal efficiencies are lowered in sandy soils with limited binding capacity. Schueler (1987) reported a sediment removal efficiency of 95 percent, 60 percent to 75 percent removal of nutrients, and 95 percent to 99 percent removal of metals using a 2-year design storm. Other effectiveness data are presented in Table 5-3.

Infiltration basins and trenches have had high failure rates in the past (Schueler et al., 1992). A geotechnical investigation and design of a sound and redundant pretreatment system should be required before construction approval. Routine maintenance requirements include inspecting the basin after every major storm for the first few months after construction and annually thereafter to determine whether scouring or excessive sedimentation is reducing infiltration. Infiltration basins must be mowed twice annually to prevent woody growth. Tilling may be required in late summer to maintain infiltration capacities in marginal soils (Schueler, 1987). Field studies indicate that regular maintenance is not done on most infiltration trenches/basins, and 60 percent to 70 percent were found to require maintenance. Based on longevity studies, replacement or rehabilitation may be required every 10 years (Schueler et al., 1992). Proper maintenance of pretreatment structures may result in increased longevity. Reported costs for infiltration devices (Table 5-3) varied considerably based on runoff storage volume. Annual maintenance costs varied from 3 percent to 5 percent of capital cost for infiltration basins and from 5 percent to 10 percent for infiltration trenches.

g. Chemical and Filtration Treatment Systems

Chemical treatment of wastewater is the addition of certain chemicals that causes small solid particles to adhere together to form larger particles that settle out or can be filtered. Filtration systems remove suspended solids by forcing the liquid through a medium, such as folded paper in a cartridge filter (METRO, 1992b). A recent study showed that such treatment systems can remove in excess of 90 percent of the suspended solids and 80 percent of most toxic metals associated with hull pressure-washing wastewater (METRO, 1992a). The degree of treatment necessary may be dependent on whether the effluent can be discharged to a sewage treatment system. The cost of a homemade system for a small boatyard to treat 100 gallons a day was estimated at $1,560. The cost of larger commercial systems capable of treating up to 10,000 gallons a day was estimated at $3000 to $50,000 plus site preparation. The solid waste generated by these treatment systems may be considered hazardous waste and may be subject to disposal restrictions.

h. Vegetated Filter Strip

A complete discussion of vegetated filter strips can be found in Chapter 7. Summary information on pollutant removal efficiencies, cost, etc. is presented in Table 5-3.

i. Grassed Swale

Grassed swales are low-gradient conveyance channels that may be used in marinas in place of buried storm drains. To effectively remove pollutants, the swales should have relatively low slope and adequate length and should be planted with erosion-resistant vegetation. Swales are not practical on very flat grades or steep slopes or in wet or poorly drained soils (SWRPC, 1991). Grassed swales can be applied in areas where maximum flow rates are not expected to exceed 1.5 feet per second (Horner et al., 1988). The main factors influencing removal efficiency are vegetation type, soil infiltration rate, flow depth, and flow travel time. Properly designed and functioning grassed swales provide pollutant removal through filtering by vegetation of particulate pollutants, biological uptake of nutrients, and infiltration of runoff. Schueler (1987) suggests the use of check dams in swales to slow the water velocity and provide a greater opportunity for settling and infiltration. Swales are designed to deal with concentrated flow under most conditions, resulting in low pollutant removal rates (SWRPC, 1991). Removal rates are most likely higher under low-flow conditions when sheet flow occurs. This may help to explain that the reported percent removal for TSS varied from 0 to greater than 90 percent (W-C, 1991). Wanielista and Yousef (1986) stated that swales are a useful component in a storm water management system and removal efficiencies can be improved by designing swales to infiltrate and retain runoff. Swales should be used only as part of a storm water management system and may be used with the other practices listed under this management measure.

Maintenance requirements for grassed swales include mowing and periodic sediment cleanout. Surveys by Horner et al. (1988) and in the Washington area indicate that the vast majority of swales operate as designed with relatively minor maintenance. The primary maintenance problem was the gradual build-up of soil and grass adjacent to roads, which prevents the entry of runoff into swales. The cost of a grassed swale will vary depending on the geometry of the swale (height and width) and the method of establishing the vegetation (see Table 5-3). Construction costs for grassed swales are typically less than those for curb-and-gutter systems. Regular maintenance costs for conventional swales are minimal. Cleanout of sediments trapped behind check dams and spot vegetation repair may be required (Schueler et al., 1992).

j. Porous Pavement

Porous pavement has a layer of porous top course covering an additional layer of gravel. A crushed stone-filled ground-water recharge bed is typically installed beneath these top layers. The runoff infiltrates through the porous asphalt layer and into the underground recharge bed. The runoff then exfiltrates out of the recharge bed into the underlying soils or into a perforated pipe system (see Figure 5-6). When operating properly, porous pavement can replicate predevelopment hydrology, increase ground-water recharge, and provide excellent pollutant removal (up to 80 percent of sediment, trace metals, and organic matter). The use of porous pavement is highly constrained and requires deep and permeable soils, restricted traffic, and suitable adjacent land uses. Pretreatment of runoff is necessary to remove coarse particulates and prevent clogging and diminished infiltration capacity.

The major advantages of porous pavement are (1) it may be used for parking areas and therefore does not use additional site space and (2) when operating properly, it provides high long-term removal of solids and other pollutants. However, significant problems exist in the use of porous pavement. Porous pavement sites have a high failure rate (75 percent) (Schueler et al., 1992). High sediment loads and oil result in clogging and eventual failure of the system. Therefore, porous pavement is not recommended for treatment of runoff from hull cleaning/ maintenance areas. Porous pavement is appropriate for low-intensity parking areas where restrictions on use (no heavy trucks) and maintenance (no deicing chemicals, sand, or improper resurfacing) can be enforced. Quarterly vacuum sweeping and/or jet hosing is needed to maintain porosity. Field data, however, indicate that this routine maintenance practice is not frequently followed (Schueler et al., 1992).

The cost of porous pavement should be measured as the incremental cost, or the cost beyond that required for conventional asphalt pavement (up to 50 percent more). To determine the full value of porous pavement, however, the savings from reducing land consumption and eliminating storm systems such as curbs, inlets, and pipes should be considered (Cahill Associates, 1991). Also, the additional cost of directing pervious area runoff around porous pavement should be considered. Maintenance of porous pavement consists of quarterly vacuum sweeping and may be 1 percent to 2 percent of the original construction costs (Schueler et al., 1992). Other maintenance costs include rehabilitation of clogged systems. In a Maryland study, 75 percent of the porous pavement systems surveyed had partially or totally clogged within 5 years. Failure was attributed to inadequate construction techniques, low permeable soils and/or restricting layers, heavy vehicular traffic, and resurfacing with nonporous pavement materials (Schueler et al., 1992).

k. Oil-Grit Separators

Oil-grit separators (see Figure 5-7) may be used to treat water from small areas where other measures are infeasible and are applicable where activities contribute large loads of grease, oil, mud, sand, and trash to runoff (Steel and McGhee, 1979). Oil-grit separators are mainly suitable for oil droplets 150 microns in diameter or larger. Little is known regarding the oil droplet size in storm water; however, droplets less than 150 microns in diameter may be more representative of storm water (Romano, 1990). Basic design criteria include providing 200-400 cubic feet of oil storage per acre of area directed to the structure. The depth of the oil storage should be approximately 3-4 feet, and the depth of grit storage should be approximately 1.5-2.5 feet minimum under the oil storage. Application is limited to highly impervious catchments that are 2 acres or smaller.

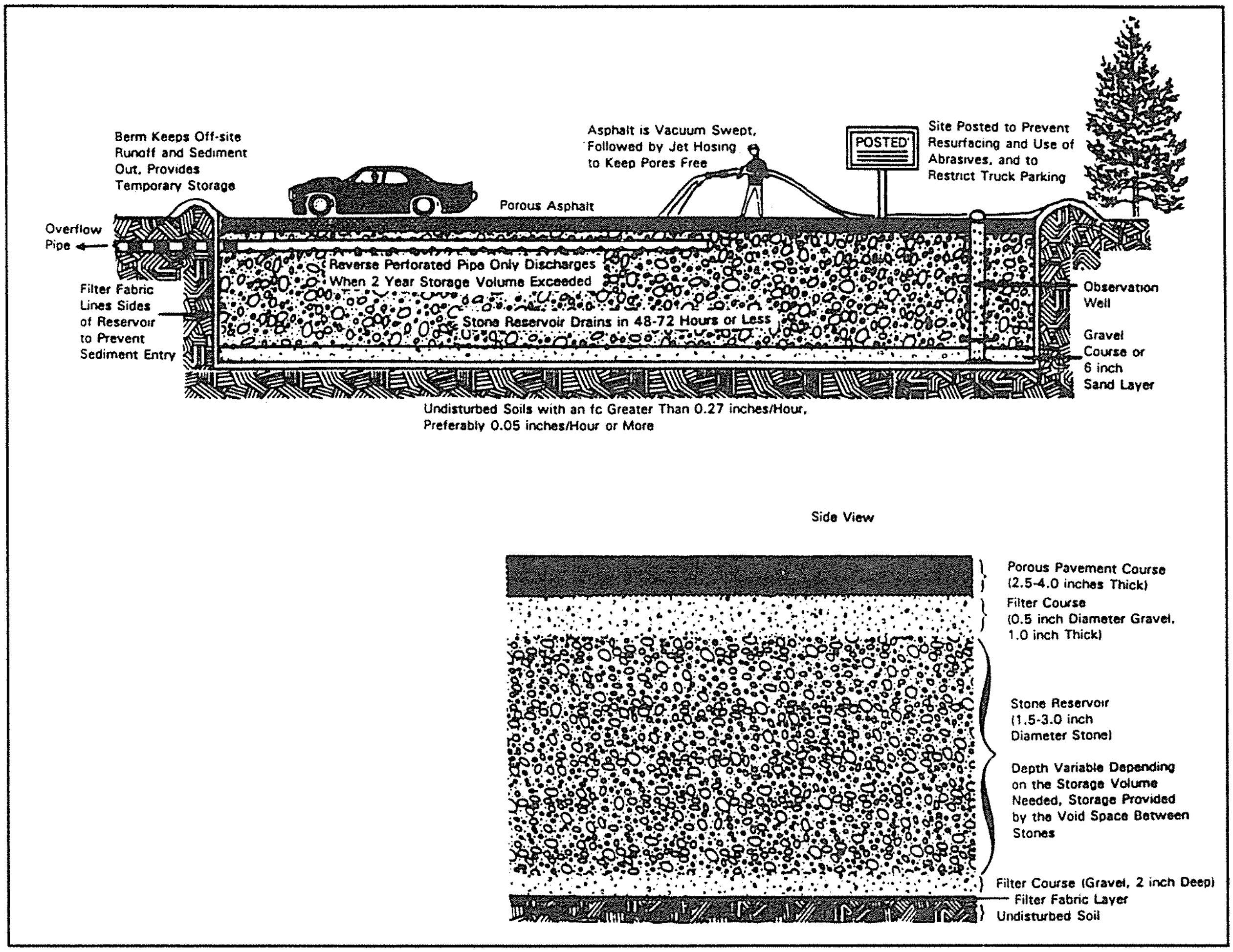

Figure 5-6. Schematic design of a porous pavement system (Schueler, 1987).

Actual pollutant removal occurs only when the chambers are cleaned out. Re-suspension limits long-term removal efficiency if the structure is not cleaned out. Periodic inspections and maintenance of the structure should be done at least twice a year (Schueler, 1987). With proper maintenance, the oil/grit separator should have at least a 50-year life span.

I. Holding Tanks

Simply put, holding tanks act as underground detention basins that capture and hold storm water until it can receive treatment. There are generally two classes of tanks: first flush tanks and settling tanks (WPCF, 1989). First flush tanks are used when the time of concentration of the impervious area is 15 minutes or less. The contents of the tank are transported via pumpout or gravity to another location for treatment. Excess runoff is discharged via the upstream overflow outlet when the tank is filled. Settling tanks are used when a pronounced first flush is not expected. A settling tank is similar to a primary settling tank in that only treated flow is discharged. The load to the clarifier overflow is usually restricted to about 0.2 ft^3/sec/ac of impervious area. If the inflow exceeds this, upstream overflows are activated. Settling tanks require periodic cleaning.

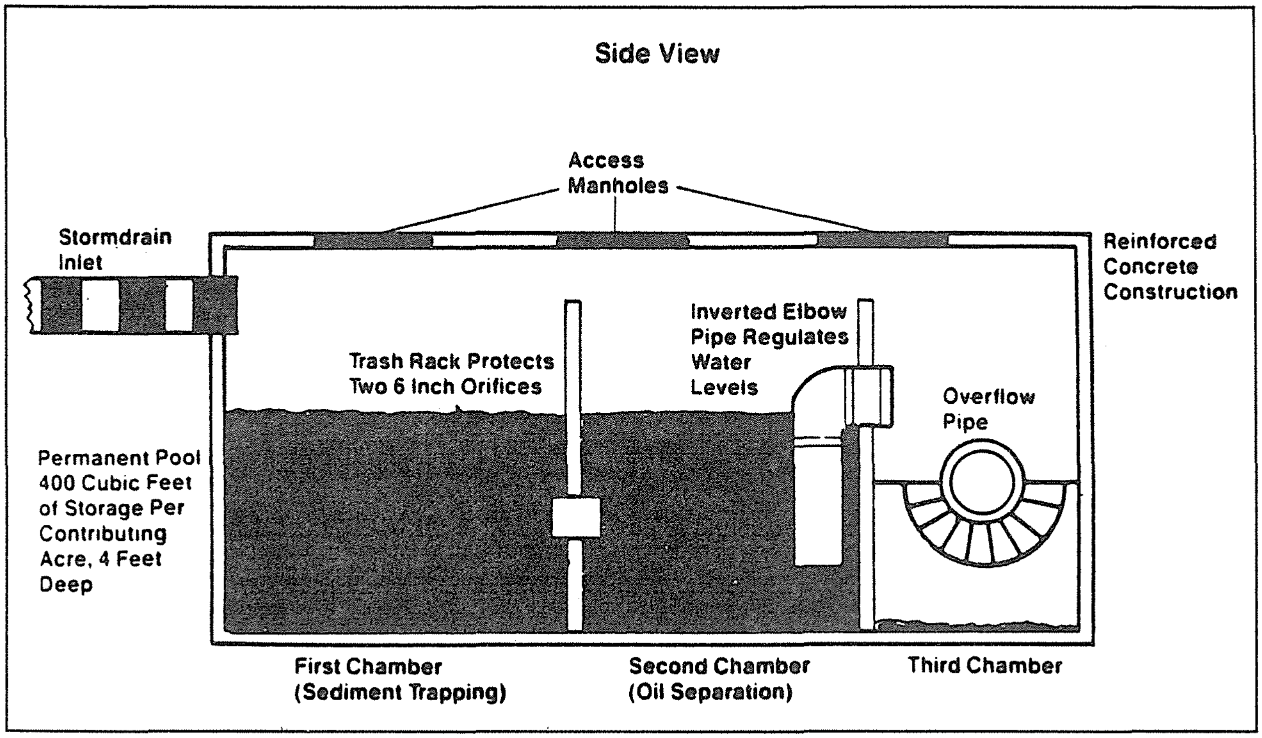

Figure 5-7. Schematic design of a water quality inlet/oil grit separator (Schueler, 1987).

m. Swirl Concentrator

A swirl concentrator is a small, compact solids separation device with no moving parts. During wet weather the unit's outflow is throttled, causing the unit to fill and to self-induce a swirling vortex. Secondary flow currents rapidly separate first flush settleable grit and floatable matter (WPCF, 1989). The pollutant matter is concentrated for treatment, while the cleaner, treated flow discharges to receiving waters. Swirl concentrators are intended to operate under high-flow regimes and may be used in conjunction with settling tanks. EPA published a design manual for swirl and helical bend pollution control devices (USEPA, 1982). However, monitoring data reveal that swirls built in accordance with this manual should be operated at lesser flows than the design indicates to achieve the desired efficiency (Pisano, 1989). Total suspended solids and BOD concentration removal efficiencies in excess of 60 percent have been reported, particularly under first flush conditions (WPCF, 1989). In another report removal effectiveness of total suspended solids from current U.S. swirls varied from a low of 5.2 percent to a high of 36.7 percent excluding first flush, 32.6 percent to 80.6 percent for first flush only, and 16.4 percent to 33.1 percent for entire storm events (Pisano, 1989). Removal efficiencies are dependent on the initial concentrations of pollutants, flow rate, size of structure, when the sumps in the catchments were cleaned, and other parameters (WPCF, 1989; and Pisano, 1989).

n. Catch Basins

Catch basins with flow restrictors may be used to prevent large pulses of storm water from entering surface waters at one time. They provide some settling capacity because the bottom of the structure is typically lowered 2 to 4 feet below the outlet pipe. Above- and below-ground storage is used to hold runoff until the receiving pipe can handle the flow. Temporary surface ponding may be used to induce infiltration and reduce direct discharge. Overland flow can be induced from sensitive areas to either sink discharge points or other storage locations. Catch basins with flow restrictors are not very effective at pollutant removal by themselves (WPCF, 1989) and should be used in conjunction with other practices. Removal efficiencies for larger particles and debris are high and make catch basins attractive as pretreatment systems for other practices. The traps of catch basins require periodic cleaning and maintenance.

Cleaning catch basins can result in large pulses of pollutants in the first subsequent storm if the method of cleaning results in the disturbance and breaking up of residual matter and some material is left in the catch basin (Richards et al., 1981). With proper maintenance, a catch basin should have at least a 50-year life span (Schueler et al., 1992).

o. *Catch Basin with Sand Filter*

A catch basin with sand filter consists of a sedimentation chamber and a chamber filled with sand. The sedimentation chamber removes coarse particles, helps to prevent clogging of the filter medium, and provides sheet flow into the filtration chamber. The sand chamber filters smaller-sized pollutants. Catch basins with sand filters are effective in highly impervious areas, where other practices have limited usefulness. The effectiveness of the sediment chamber for removal of the different particles depends on the particles' settling velocity and the chamber's length and depth. The effectiveness of the filtration medium depends on its depth.

Catch basins with sand filters should be inspected at least annually, and periodically the top layer of sand with deposition of sediment should be removed and replaced. In addition, the accumulated sediment in the sediment chamber should be removed periodically (Shaver, 1991). With proper maintenance and replacement of the sand, a catch basin with sand filter should have at least a 50-year life span (Schueler et al., 1992).

p. *Adsorbents in Drain Inlets*

While there is some tendency for oil and grease to sorb to trapped particles, oil and grease will not ordinarily be captured by catch basins, holding tanks, or swirl concentrators. Adsorbent material placed in these structures in a manner that will allow sufficient contact between the adsorbent and the storm water will remove much of the oil and grease load of runoff (Silverman and Stenstrom, 1989). In addition, the performance of oil-grit separators could be enhanced through the use of adsorbents. An adsorbent/catch basin system that treats the majority of the grease and oil in storm water runoff could be designed, and annual replacement of the adsorbent would be sufficient to maintain the system in most cases (Silverman et al., 1989). Manufacturers report that their products are able to sorb 10 to 25 times their weight in oil (Industrial Products, 1991; Lab Safety, 1991). The cost of 10 pillows, 24 inches by 14 inches by 5 inches (total weight 24 pounds), is approximately $85 to $93 (Lab Safety, 1991).

F. Fueling Station Design Management Measure

Design fueling stations to allow for ease in cleanup of spills.

1. Applicability

This management measure is intended to be applied by States to new and expanding[8] marinas where fueling stations are to be added or moved. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

Spillage is a source of petroleum hydrocarbons in marinas (USEPA, 1985a). Most petroleum-based fuels are lighter than water and thus float on the water's surface. This property allows for their capture if petroleum containment equipment is used in a timely manner.

3. Management Measure Selection

Selection of this measure is based on the preference for pollution prevention in the design of marinas rather than reliance on control of material that is released without forethought as to how it will be cleaned up. The possibility of spills during fueling operations always exists. Therefore, arrangements should be made to contain pollutants released from fueling operations to minimize the spread of pollutants through and out of the marina.

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

a. Locate and design fueling stations so that spills can be contained in a limited area.

The location and design of the fueling station should allow for booms to be deployed to surround a fuel spill. Pollutant reduction effectiveness and the cost of the design of fueling areas are difficult to quantify. When designing a new marina, the additional costs of ensuring that the design incorporates effective cleanup considerations should be minimal.

[8]Refer to Section I.H (General Applicability) for additional information on expansions of existing marinas.

b. *Design a Spill Contingency Plan.*

A Spill Contingency Plan must be developed for fuel storage and dispensation areas. The plan must meet local and State requirements and must include spill emergency procedures, including health and safety, notification, and spill containment and control procedures. Marina personnel must be properly trained in spill containment and control procedures.

c. *Design fueling stations with spill containment equipment.*

Appropriate containment and control materials must be stored in a clearly marked, easily accessible cabinet or locker. The cabinet or locker must contain absorbent pads and booms, fire extinguishers, a copy of the Spill Contingency Plan, and other equipment deemed suitable. Easily used effective oil spill containment equipment is readily available from commercial suppliers. Booms that can be strung around the spill, absorb up to 25 times their weight in petroleum products, and remain floating after saturation are available at a cost of approximately $160 for four booms 8 inches in diameter and 10 feet long with a weight of 40 pounds (Lab Safety, 1991). Oil-absorbent sheets, rolls, and pillows are also available at comparable prices.

G. Sewage Facility Management Measure

Install pumpout, dump station, and restroom facilities where needed at new and expanding marinas to reduce the release of sewage to surface waters. Design these facilities to allow ease of access and post signage to promote use by the boating public.

1. Applicability

This management measure is intended to be applied by States to new and expanding[9] marinas in areas where adequate marine sewage collection facilities do not exist. Marinas that do not provide services for vessels that have marine sanitation devices (MSDs) do not need to have pumpouts, although dump stations for portable toilets and restrooms should be available. This measure does not address direct discharges from vessels covered under CWA section 312. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

Three types of onshore collection systems are available: fixed point systems, portable/mobile systems, and dedicated slipside systems. Information on the installation and operation of sewage pumpout stations is available from the State of Maryland (MDDNR, 1991).

EPA Region I determined that, in general, a range of one pumpout facility per 300-600 boats with holding tanks (type III MSDs) should be sufficient to meet the demand for pumpout services in most harbor areas (USEPA, 1991b). EPA Region 4 suggested one facility for every 200 to 250 boats with holding tanks and provided a formula for estimating the number of boats with holding tanks (USEPA, 1985a). The State of Michigan has instituted a no-discharge policy and mandates one pumpout facility for every 100 boats with holding tanks.

According to the 1989 American Red Cross Boating Survey, there were approximately 19 million recreational boats in the United States (USCG, 1990). About 95 percent of these boats were less than 26 feet in length. A very large number of these boats used a portable toilet, rather than a larger holding tank. Given the large percentage of smaller boats, facilities for the dumping of portable toilet waste should be provided at marinas that service significant numbers of boats under 26 feet in length.

Two of the most important factors in successfully preventing sewage discharge are (1) providing "adequate and reasonably available" pumpout facilities and (2) conducting a comprehensive boater education program (USEPA, 1991b). The Public Education Management Measure presents additional information on this subject. One reason that pumpout use in Puget Sound is higher than that in other areas could be the extensive boater education program established in that area.

[9] Refer to Section I.H (General Applicability) for additional information on expansions of existing marinas.

Chemicals from holding tanks may retard the normal functioning of septic systems. Information on septic systems can be found in Chapter 4. Neither the chemicals nor the concentration of marine wastes has proven to be a problem for properly operating public sewage treatment plants.

3. Management Measure Selection

Measure selection is based on the need to reduce discharges of sanitary waste and the fact that most coastal States and many localities already require the installation of pumpout facilities and restrooms at all or selected marinas (Appendix 5A). Other States encourage the installation and use of pumpouts through grant programs and boater education.

In a Long Island Sound study, only about 5 percent of the boats were expected to use pumpouts. Given the low documented usage by boaters at marinas with pumpouts, the time, inconvenience, and cost associated with pumpouts were determined to be more of a deterrent to use than was lack of availability of facilities (Tanski, 1989). A Puget Sound study found that 35 percent of the boats responding to a survey had holding tanks (type III MSDs). Eighty percent of these boats had y-valves that allowed illegal discharge. About half of these boats used pumpouts. The boaters surveyed felt that the most effective methods to ensure proper disposal of boat waste would be the improvement of waste-disposal facilities and boater education (Cheyne and Carter, 1989). Another Puget Sound study found that the problem of marine sewage waste could best be addressed through containment of wastes onboard the vessel and subsequent onshore disposal through the provision of adequate numbers of clean, accessible, economical, and easily used pumpout stations (Seabloom et al., 1989). Designation and advertisement of no-discharge zones can also increase boater use of pumpout facilities (MDDNR, 1991).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

a. Fixed-Point Systems

Fixed-point collection systems include one or more centrally located sewage pumpout stations (see Figure 5-8). These stations are generally located at the end of a pier, often on a fueling pier so that fueling and pumpout operations can be combined. A boat requiring pumpout services docks at the pumpout station. A flexible hose is connected to the wastewater fitting in the hull of the boat, and pumps or a vacuum system move the wastewater to an onshore holding tank, a public sewer system, a private treatment facility, or another approved disposal facility. In cases where the boats in the marina use only small portable (removable) toilets, a satisfactory disposal facility could be a dump station.

b. Portable Systems

Portable/mobile systems are similar to fixed-point systems and in some situations may be used in their place at a fueling dock. The portable unit includes a pump and a small storage tank. The unit is connected to the deck fitting on the vessel, and wastewater is pumped from the vessel's holding tank to the pumping unit's storage tank. When the storage tank is full, its contents are discharged into a municipal sewage system or a holding tank for removal by a septic tank pumpout service. In many instances, portable pumpout facilities are believed to be the most logistically feasible, convenient, accessible (and, therefore, used), and economically affordable way to ensure proper disposal of boat sewage (Natchez, 1991). Portable systems can be difficult to move about a marina and this factor should be considered when assessing the correct type of system for a marina. Another portable/mobile pumpout unit that is an emerging technology and is popular in the Great Salt Pond in Block Island, New York, is the radio-

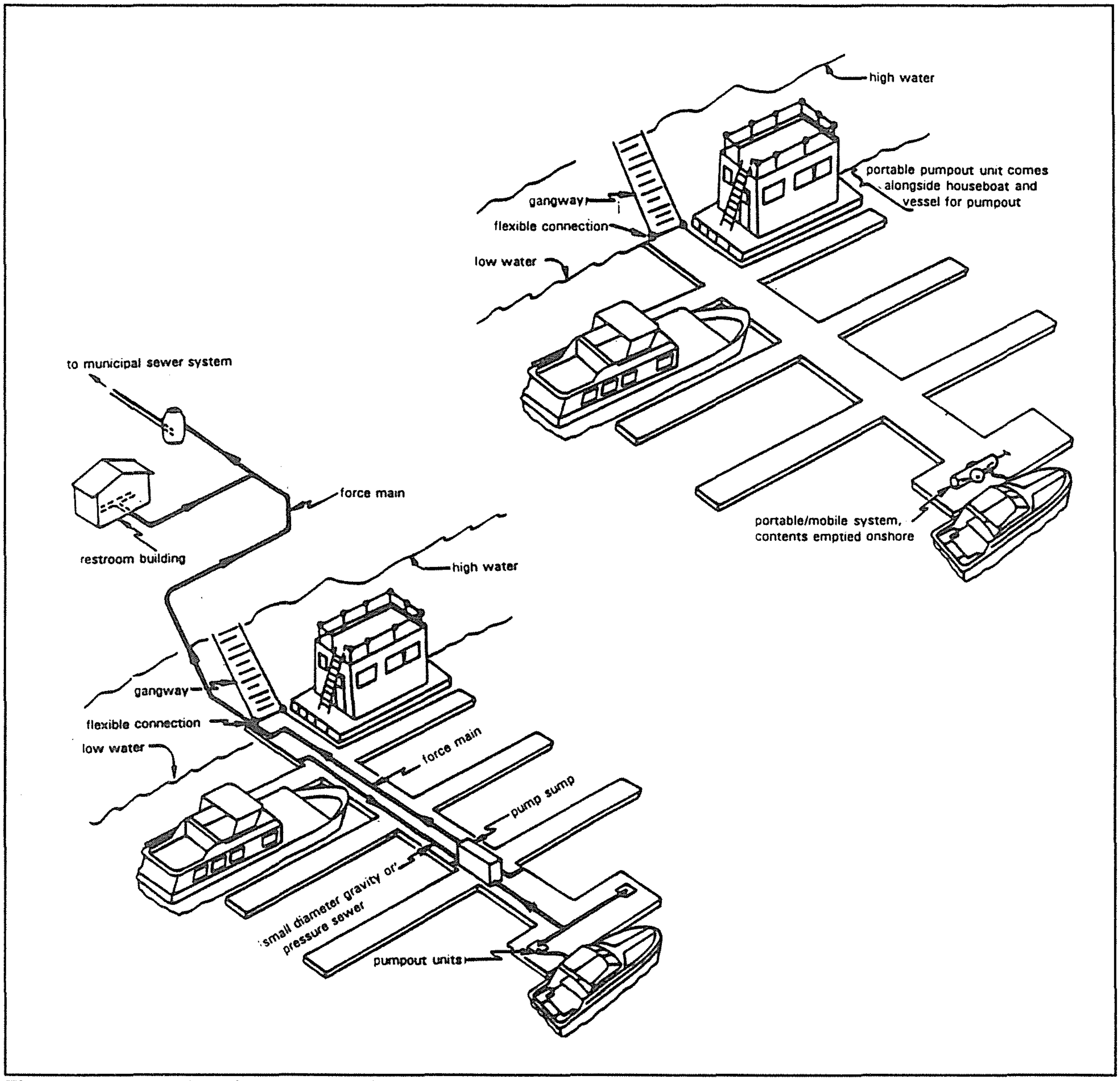

Figure 5-8. Examples of pumpout devices.

dispatched pumpout boat. The pumpout boat goes to a vessel in response to a radio-transmitted request, pumps the holding tank, and moves on to the next requesting vessel. This approach eliminates the inconvenience of lines, docking, and maneuvering vessels in high-traffic areas.

Costs associated with pumpouts vary according to the size of the marina and the type of pumpout system. Table 5-4 presents 1985 cost information for three marina sizes and two types of pumpout systems (USEPA, 1985a). More recent systems are less expensive, with a homemade portable system costing less than $250 in parts and commercial portable units available for between $2,000 and $4,000 (Natchez, 1991).

c. *Dedicated Slipside Systems*

Dedicated slipside systems provide continuous wastewater collection at a slip. Slipside pumpout should be provided to live-aboard vessels. The remainder of the marina can still be served by either marina-wide or mobile pumpout systems.

Table 5-4. Annual Per Slip Pumpout Costs for Three Collection Systems[a] (USEPA, 1985a)

	Marina-Wide	Portable/Mobile	Slipside
Small Marina (200 slips)			
Capital Costs	15[b]	15[c]	102[b]
O&M Costs	110	200	50
Total Cost/Slip/Year	125	215	152
Medium Marina (500 slips)			
Capital Costs	17	10	101
O&M Costs	90	160	40
Total Cost/Slip/Year	107	170	141
Large Marina (2000 slips)			
Capital Costs	16	10	113
O&M Costs	80	140	36
Total Cost/Slip/Year	96	150	149

[a] 1985 data; all figures in dollars.
[b] Based on 12% interest, 15 years amortization.
[c] 12% interest, 15 years on piping; 12% interest, 15 years on portable units.

d. *Adequate Signage*

Marina operators should post ample signs prohibiting the discharge of sanitary waste from boats into the waters of the State, including the marina basin, and also explaining the availability of pumpout services and public restroom facilities. Signs should also fully explain the procedures and rules governing the use of the pumpout facilities. An example of an easily understandable sign that has been used to advertise the availability of pumpout facilities is presented in Figure 5-9 (Keko, Inc., 1992).

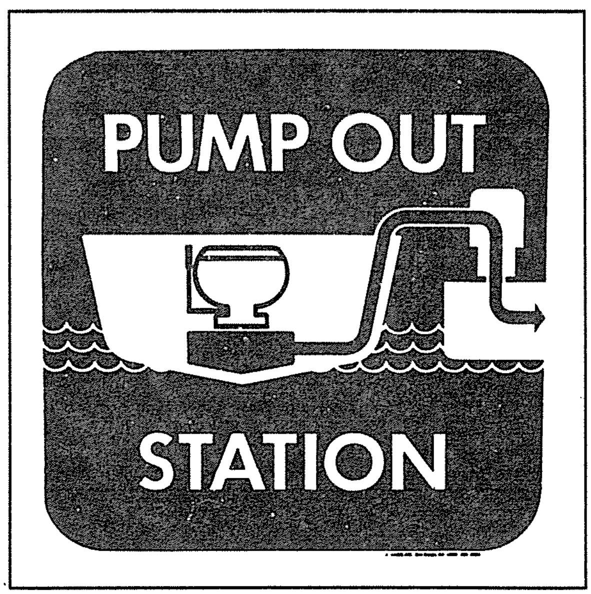

Figure 5-9. Example signage advertising pumpout availability (Keko, Inc., 1992).

III. MARINA AND BOAT OPERATION AND MAINTENANCE

During the course of normal marina operations, various activities and locations in the marina can generate polluting substances. Such activities include waste disposal, boat fueling, and boat maintenance and cleaning; such locations include storage areas for materials required for these activities and hull maintenance areas (METRO, 1992a; Tobiasson and Kollmeyer, 1991). Of special concern are substances that can be toxic to aquatic biota, pose a threat to human health, or degrade water quality.[1] Paint sandings and chippings, oil and grease, fuel, detergents, and sewage are examples (METRO, 1992a; Tobiasson and Kollmeyer, 1991).

It is important that marina operators and patrons take steps to control or minimize the entry of these substances into marina waters. For the most part, this can be accomplished with simple preventative measures such as performing these activities on protected sites, locating servicing equipment where the risk of spillage is reduced (see Siting and Design section of this chapter), providing adequate and well-marked disposal facilities, and educating the boating public about the importance of pollution prevention. The benefit of effective pollution prevention to the marina operator can be measured as the relative low cost of pollution prevention compared to potentially high environmental clean-up costs (Tobiasson and Kollmeyer, 1991).

For those planning to build a marina, attention to the environmental concerns of marina operation during the marina design phase will significantly reduce the potential for generating pollution from these activities. For existing marinas, minor changes in operations, staff training, and boater education should help protect marina waters from these sources of pollution. The management measures that follow address the control of pollution from marina operation and maintenance activities.

[1]See Section I.F for further discussion.

A. Solid Waste Management Measure

Properly dispose of solid wastes produced by the operation, cleaning, maintenance, and repair of boats to limit entry of solid wastes to surface waters.

1. Applicability

This management measure is intended to be applied by States to new and expanding[2] marinas. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

Marina operators are responsible for determining what types of wastes will be generated at the marina and ensuring proper disposal. Marina operators are thus responsible for the contents of their dumpsters and the management of solid waste on their property. Hazardous waste should never be placed in dumpsters. Liquid waste should not be mixed with solid waste but rather disposed of properly by other methods (see Liquid Waste Management Measure).

3. Management Measure Selection

This measure was selected because marinas have shown the ability to minimize the entry of solid waste into surface waters through implementation of some or all of the practices. Marinas generate a variety of solid waste through the activities that occur on marina property and at their piers. If adequate disposal facilities are not available there is a potential for disposal of solid waste in surface waters or on shore areas where the material can wash into surface waters. Marina patrons and employees are more likely to properly dispose of solid waste if given adequate opportunity and disposal facilities. Under Federal law, marinas and port facilities must supply adequate and convenient waste disposal facilities for their customers (NOAA, 1988).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

[2]Refer to Section I.H (General Applicability) for additional information on expansions of existing marinas.

a. Perform boat maintenance/cleaning above the waterline in such a way that no debris falls into the water.

This subject is also addressed under the Boat Cleaning Management Measure later in this chapter.

b. Provide and clearly mark designated work areas for boat repair and maintenance. Do not permit work outside designated areas.

c. Clean hull maintenance areas regularly to remove trash, sandings, paint chips, etc.

Vacuuming is the preferred method of collecting these wastes.

d. Perform abrasive blasting within spray booths or plastic tarp enclosures to prevent residue from being carried into surface waters. If tarps are used, blasting should not be done on windy days.

e. Provide proper disposal facilities to marina patrons. Covered dumpsters or other covered receptacles are preferred.

While awaiting transfer to a landfill, dumpsters in which items such as used oil filters are stored should be covered to prevent rain from leaching material from the dumpster onto the ground.

f. Provide facilities for the eventual recycling of appropriate materials.

Recycling of nonhazardous solid waste such as scrap metal, aluminum, glass, wood pallets, paper, and cardboard is recommended wherever feasible. Used lead-acid batteries should be stored on an impervious surface, under cover, and sent to or picked up by an approved recycler. Receipts should be retained for inspection.

B. Fish Waste Management Measure

Promote sound fish waste management through a combination of fish-cleaning restrictions, public education, and proper disposal of fish waste.

1. Applicability

This management measure is intended to be applied by States to marinas where fish waste is determined to be a source of water pollution. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

Fish waste can result in water quality problems at marinas with large numbers of fish landings or at marinas that have limited fish landings but poor flushing. The amount of fish waste disposed of into a small area such as a marina can exceed that existing naturally in the water at any one time. Fish waste decomposes, which requires oxygen. In sufficient quantity, disposal of fish waste can thus be a cause of dissolved oxygen depression as well as odor problems (DNREC, 1990; McDougal et al., 1986).

3. Management Measure Selection

This measure was selected because marinas have shown the ability to prevent fish-waste-induced water quality or aesthetic problems through implementation of the identified practices. Marinas that cater to patrons who fish a large amount can produce a large amount of fish waste at the marina from fish cleaning. If adequate disposal facilities are not available, there is a potential for disposal of fish waste in areas without enough flushing to prevent decomposition and the resulting dissolved oxygen depression and odor problems. Marina patrons and employees are more likely to properly dispose of fish waste if told of potential consequences and provided adequate and convenient disposal facilities. States require, and many marinas have already implemented, this management measure (Appendix 5A).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

a. *Establish fish-cleaning areas.*

Particular areas can be set aside or designated for the cleaning of fish, and receptacles can be provided for the waste. Boaters and fishermen should be advised to use only these areas for fish cleaning, and the waste collected in the receptacles should be disposed of properly.

b. *Issue rules governing the conduct and location of fish-cleaning operations.*

Marinas can issue rules regarding the cleaning of fish at the marina, depending on the type of services offered by the marina and its clientele. Marinas not equipped to handle fish wastes may prohibit the cleaning of fish at the marina; those hosting fishing competitions or having a large fishing clientele should establish fish-cleaning areas with specific rules for their use and should establish penalties for violation of the rules.

c. *Educate boaters regarding the importance of proper fish-cleaning practices.*

Boaters should be educated about the problems created by discarding their fish waste into marina waters, proper disposal practices, and the ecological advantages of cleaning their fish at sea and discarding the wastes into the water where the fish were caught. Signs posted on the docks (especially where fish cleaning has typically been done) and talks with boaters during the course of other marina operations can help to educate boaters about marina rules governing fish waste and its proper disposal.

d. *Implement fish composting where appropriate.*

A law passed in 1989 in New York forbids discarding fish waste, with exceptions, into fresh water or within 100 feet of shore (White et al., 1989). Contaminants in some fish leave few alternatives for disposing of fish waste, so Cornell University and the New York Sea Grant Extension Program conducted a fish composting project to deal with the over 2 million pounds of fish waste generated by the salmonid fishery each year. They found that even with this quantity of waste, if composting was properly conducted the problems of odor, rodents, and maggots were minimal and the process was effective (White et al., 1989). Another method of fish waste composting described by the University of Wisconsin Sea Grant Institute is suitable for amounts of compost ranging from a bucketful to the quantities produced by a fish-processing plant (Frederick et al., 1989).

C. Liquid Material Management Measure

Provide and maintain appropriate storage, transfer, containment, and disposal facilities for liquid material, such as oil, harmful solvents, antifreeze, and paints, and encourage recycling of these materials.

1. Applicability

This management measure is intended to be applied by States to marinas where liquid materials used in the maintenance, repair, or operation of boats are stored. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

This management measure minimizes entry of potentially harmful liquid materials into marina and surface waters through proper storage and disposal. Marina operators are responsible for the proper storage of liquid materials for sale and for final disposal of liquid wastes, such as waste fuel, used oil, spent solvents, and spent antifreeze. Marina operators should decide how liquid waste material is to be placed in the appropriate containers and disposed of and should inform their patrons.

3. Management Measure Selection

This measure was selected because marinas have shown the ability to prevent entry of liquid waste into marina and surface waters. Marinas generate a variety of liquid waste through the activities that occur on marina property and at their piers. If adequate disposal facilities are not available, there is a potential for disposal of liquid waste in surface waters or on shore areas where the material can wash into surface waters. Marina patrons and employees are more likely to properly dispose of liquid waste if given adequate opportunity and disposal facilities. The practices on which the measure is based are available. Many coastal States already have mandatory or voluntary programs that satisfy this management measure (Appendix 5A).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

a. Build curbs, berms, or other barriers around areas used for the storage of liquid material to contain spills. Store materials in areas impervious to the type of material stored.

To contain spills, curbs or berms should be installed around areas where liquid material is stored. The berms or curbs should be capable of containing 10 percent of the liquid material stored or 110 percent of the largest container, whichever is greater (WADOE, 1991). There should not be drains in the floor. Implementation of this practice will prevent spilled material from directly entering surface waters. The cost of 6-inch cement curbs placed around a cement pad is $10 to $14 per linear foot (Means, 1990). The cost of a temporary spill dike capable of absorbing 50 liters of material (5 inches in diameter and 30 feet long) is approximately $110 (Lab Safety, 1991).

b. Separate containers for the disposal of waste oil; waste gasoline; used antifreeze; and waste diesel, kerosene, and mineral spirits should be available and clearly labeled.

Waste oil includes waste engine oil, transmission fluid, hydraulic fluid, and gear oil. A filter should be drained before disposal by placing the filter in a funnel over the appropriate waste collection container. The containers should be stored on an impermeable surface and covered in a manner that will prevent rainwater from entering the containers. Containers should be clearly marked to prevent mixing of the materials with other liquids and to assist in their identification and proper disposal. Waste should be removed from the marina site by someone permitted to handle such waste, and receipts should be retained for inspection.

Care should be taken to avoid combining different types of antifreeze. Standard antifreeze (ethylene glycol, usually identifiable by its blue or greenish color) should be recycled. If recycling is not available, propylene-glycol-based anti-freeze should be used because it is less toxic when introduced to the environment. Propylene glycol is often a pinkish hue (Gannon, 1990). Many States, including Maryland, Washington, and Oregon, have developed programs to encourage the proper disposal of used antifreeze.

Fifty-five-gallon closed-head polyethylene or steel drums approved for shipping hazardous and nonhazardous materials are available commercially at a cost of approximately $50 each. Open-head steel drums (approximately $60 each) with self-closing steel drum covers (approximately $90 each) may also be used (Lab Safety, 1991). A package of five labels that may be affixed to drums (10 inches by 10 inches) costs approximately $10.

c. Direct marina patrons as to the proper disposal of all liquid materials through the use of signs, mailings, and other means.

If individuals within a marina collect, contain, and dispose of their own liquid waste, signs and education programs (see Public Education Management Measure) should direct them to proper recycling and disposal options.

D. Petroleum Control Management Measure

Reduce the amount of fuel and oil from boat bilges and fuel tank air vents entering marina and surface waters.

1. Applicability

This management measure is intended to be applied by States to boats that have inboard fuel tanks. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

Fuel and oil are commonly released into surface waters during fueling operations through the fuel tank air vent, during bilge pumping, and from spills directly into surface waters and into boats during fueling. Oil and grease from the operation and maintenance of inboard engines are a source of petroleum in bilges.

3. Management Measure Selection

This measure was selected because (1) the practices have shown the ability to minimize the introduction of petroleum from fueling and bilge pumping and thus prevent a visible sheen on the water's surface and (2) New York State requires the installation of fuel/air separators on new boats. Boaters and fuel station attendants often inadvertently spill fuel when "topping off" fuel tanks. They know the tank is full when fuel comes out of the mandatory air vent. This is preventable by the use of attachments on the air vent that suppress overflowing. Boat bilges have automatic and manual pumps that empty directly to marina or surface waters. When activated, these pumps often cause direct discharge of oil and grease from operation and maintenance of inboard engines. Oil-absorbing bilge pads contain oil and grease and prevent their discharge.

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

a. *Use automatic shut-off nozzles and promote the use of fuel/air separators on air vents or tank stems of inboard fuel tanks to reduce the amount of fuel spilled into surface waters during fueling of boats.*

During the fueling of inboard tanks fuel can be spilled into surface waters due to overfilling the fuel tank. An automatic shut-off nozzle is partially effective in reducing the potential for overfilling, but often during fueling operations fuel overflows from the air vent on the fuel tank of the boat. Attachments for vents on fuel tanks, which act as fuel/air separators, are available commercially. These devices release air and vapor but contain overflowing fuel. The State of New York passed a law in 1990 that requires that all boats sold in New York after January 1, 1994, have air vents on their fuel tanks that are designed to prevent fuel overflows or spills. The commercial cost of these devices is approximately $85 per unit. Marinas can make these units available in their retail stores and post notices describing their spill prevention benefits and availability.

b. Promote the use of oil-absorbing materials in the bilge areas of all boats with inboard engines. Examine these materials at least once a year and replace as necessary. Recycle them if possible, or dispose of them in accordance with petroleum disposal regulations.

Marina operators can advertise the availability of such oil-absorbing material or can include the cost of installation of such material in yearly dock fees. Marina operators can also insert a clause in their leasing agreements that boaters will use oil-absorbing material in their bilges. Pillows/pads that absorb oils and petroleum-based products and not water are available. These pillows/pads absorb up to 12 times their weight in oil and cost approximately $40 for a package of 10 (Lab Safety, 1991).

E. Boat Cleaning Management Measure

For boats that are in the water, perform cleaning operations to minimize, to the extent practicable, the release to surface waters of (a) harmful cleaners and solvents and (b) paint from in-water hull cleaning.

1. Applicability

This management measure is intended to be applied by States to marinas where boat topsides are cleaned and marinas where hull scrubbing in the water has been shown to result in water or sediment quality problems. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

This measure minimizes the use and release of potentially harmful cleaners and bottom paints to marina and surface waters. Marina employees and boat owners use a variety of boat cleaners, such as teak cleaners, fiberglass polishers, and detergents. Boats are cleaned over the water or onshore adjacent to the water. This results in a high probability of some of the cleaning material entering the water. Boat bottom paint is released into marina waters when boat bottoms are cleaned in the water.

3. Management Measure Selection

This measure was selected because marinas have shown the ability to prevent entry of boat cleaners and harmful solvents as well as the release of bottom paint into marina and surface waters. The practices on which the measure is based are available, minimize entry of harmful material into marina waters, and still allow boat owners to clean their boats.

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

a. Wash the boat hull above the waterline by hand. Where feasible, remove the boat from the water and perform cleaning where debris can be captured and properly disposed of.

b. Detergents and cleaning compounds used for washing boats should be phosphate-free and biodegradable, and amounts used should be kept to a minimum.

c. Discourage the use of detergents containing ammonia, sodium hypochlorite, chlorinated solvents, petroleum distillates, or lye.

d. Do not allow in-the-water hull scraping or any process that occurs underwater to remove paint from the boat hull.

The material removed from boat hulls treated with antifoulant paint contains high levels of toxic metals (see Table 5-1).

F. Public Education Management Measure

Public education/outreach/training programs should be instituted for boaters, as well as marina owners and operators, to prevent improper disposal of polluting material.

1. Applicability

This management measure is intended to be applied by States to all environmental control authorities in areas where marinas are located. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

The best method of preventing pollution from marinas and boating activities is to educate the public about the causes and effects of pollution and methods to prevent it. One of the primary reasons for the success of existing programs is the widespread support for these efforts. Measuring the efficiency of the separate practices of public education and outreach programs can be extremely difficult. Programs need to be examined in terms of long-term impacts.

Creating a public education program should involve user groups and the community in all phases of program development and implementation. The program should be suited to a specific area and should use creative promotional material to spread its message. General information on how to educate and involve the public can be found in *Managing Nonpoint Pollution: An Action Plan Handbook for Puget Sound Watersheds* (PSWQA, 1989) and *Dealing with Annex V - Reference Guide for Ports* (NOAA, 1988).

3. Management Measure Selection

Measure selection is based on low cost (Table 5-5), proven effectiveness, availability, and widespread use by many States (Appendix 5A).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

Table 5-5. Approximate Costs for Educational and Promotional Material (NOAA, 1988)

Item	Quantity	Cost
Brochures	10,000	2,100
Posters	5,000	500
Decals	6,000	900
Coloring Books	3,000	1,000
Stickers	20,000	450
Signs (wood)	20	800
Litter bags	8,000	1,400
Litter bags (beach cleanup)	2,000	free
Slide shows	5	250
Photo displays	9	1,000
Sweatshirts	288	2,200
Hats	432	1,100
Notices	40	25
Videotaped programs (copies)	4	200
Radio PSAs (copies, 7 announcements)	25	250
TV Public Service Announcements (copies)	6	200
Advertisements, newspaper	2	350
Advertisements, TV	2 weeks	200
Total		12,925

NOTE: Additional costs (about $2500) were involved in the development of the TV and radio public service announcements and brochures and in the acquisition of the rights to some art and photographic materials.

a. Signage

Interpretive and instructional signs placed at marinas and boat-launching sites are a key method of disseminating information to the boating public. The Chesapeake Bay Commission recommended that Bay States develop and implement programs to educate the boating public to stimulate increased use of pumpout facilities (CBC, 1989). The commission found that "boater education on this issue can be substantially expanded at modest expense."

Appropriate signage to direct boaters to the nearest pumpout facility to alert boaters to its presence would very likely stimulate increased used of pumpout facilities. Signs can be provided to marinas and posted in areas where recreational boats are concentrated. Ten-inch-square aluminum signs are available commercially for approximately $12 each (Lab Safety, 1991).

b. Recycling/Trash Reduction Programs

A New Jersey marina issued reusable tote bags with the marina's name printed on the side. The bags were used repeatedly to transport groceries and to store recyclable materials for proper disposal (Bleier, 1991). Newport, Oregon, instituted a recycling program that was not immediately successful but has since achieved increased boater compliance (Bleier, 1991). The Louisiana and New Hampshire Sea Grant Programs both instituted successful public education programs designed to reduce the amount of marine debris discarded into surface waters (Doyle and Barnaby, 1990). The $17,000 cost of the New Hampshire demonstration program included project organization, distribution of a season's supply of trash bags, advertising material, and project monitoring. More than 90 percent of the 91 participating boats indicated that they had made a commitment to reducing marine pollution.

c. Pamphlets or Flyers, Newsletters, Inserts in Billings

The Washington State Parks and Recreation Commission designed a multifaceted public education program and is working with local governments and boating groups to implement the program and evaluate its effectiveness. The program encourages the use of MSDs and pumpout facilities, discourages impacts to shellfish areas, and provides information to boaters and marina operators about environmentally sound operation and maintenance activities. The Commission has prepared written materials, given talks to boating groups, participated in events such as boat shows, and developed signs for placement at marinas and boat launches. Printed material includes a map of pumpout facilities, a booklet on boat pollution, a pamphlet on plastic debris, and articles on the effects of boating activities. Written material can be made available at marinas, supply stores, or other places frequently visited by boaters. Approximate costs of some educational and promotional materials used in a Newport, Oregon, program are presented in Table 5-5 (NOAA, 1988). Written material describing the importance of boater cooperation in solving the problems associated with marine discharges could be included with annual boat registration forms, and cooperative programs involving State environmental agencies and boaters' organizations could be established.

d. Meetings/Presentations

Presentations at local marinas or other locations are a good way to discuss issues with boaters and marina owners and operators. The New Moon Project in Puget Sound is a public education program that is attempting to increase use of portable sewage pumpouts. This effort has included workshops and seminars for boaters, marina operators, and harbor masters. The presentations have produced interest from marina operators who want to participate and boaters who want additional material (NYBA, 1990). Presentations can also present the positive aspects of marinas and successful case studies of pollution prevention and control.

G. Maintenance of Sewage Facilities Management Measure

Ensure that sewage pumpout facilities are maintained in operational condition and encourage their use.

1. Applicability

This management measure is intended to be applied by States to marinas where marine sewage disposal facilities exist. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

The purpose of this measure is to reduce the release of untreated sewage into marina and surface waters.

3. Management Measure Selection

This measure was selected because it is effective in preventing failure of pumpouts and discourages improper disposal of sanitary wastes. Also, many pumpouts are not properly maintained, limiting their use. The Maryland Department of Natural Resources (MDDNR, 1991) provides operation and maintenance information on pumpouts to marina owners and operators in an effort to increase availability and use of pumpouts. Many other States inspect pumpout facilities to ensure that they are in operational condition (Appendix 5A).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

- a. *Arrange maintenance contracts with contractors competent in the repair and servicing of pumpout facilities.*

- b. *Develop regular inspection schedules.*

- c. *Maintain a dedicated fund for the repair and maintenance of marina pumpout stations. (Government-owned facilities only)* *d. Add language to slip leasing agreements mandating the use of pumpout facilities and specifying penalties for failure to comply.*

e. Place dye tablets in holding tanks to discourage illegal disposal.

Boating activities that result in excessive fecal coliform bacteria levels can be addressed through the placement of a dye tablet in the holding tanks of all boats entering the adversely impacted waterbody. This practice was employed in Avalon Harbor, California, after moored boats were determined to be the source of problem levels of fecal coliform bacteria. Upon entering the harbor, a harbor patrol officer boards each vessel and places dye tablets in all sanitary devices. The officer then flushes the devices to ensure that the holding tanks do not leak. During the first 3 years of implementation, this practice detected 135 violations of the no-discharge policy and was extremely successful at reducing pollution levels (Smith et al., 1991). One tablet in approximately 60 gallons of water will give a visible dye concentration of one part per million. The cost of the tablets is approximately $30 per 200 tablets (Forestry Suppliers, 1992).

H. Boat Operation Management Measure (applies to boating only)

Restrict boating activities where necessary to decrease turbidity and physical destruction of shallow-water habitat.

1. Applicability

This management measure is intended to be applied by States in non-marina surface waters where evidence indicates that boating activities are impacting shallow-water habitats. Under the Coastal Zone Act Reauthorization Amendments of 1990, States are subject to a number of requirements as they develop coastal nonpoint source programs in conformity with this measure and will have some flexibility in doing so. The application of management measures by States is described more fully in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, published jointly by the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

2. Description

Boat operation can resuspend bottom sediment, resulting in the reintroduction of toxic substances into the water column. It can increase turbidity, which affects the photosynthetic activity of algae and submerged aquatic vegetation (SAV). SAV provides habitat for fish, shellfish, and waterfowl and plays an important role in maintaining water quality through assimilating nutrients. It also reduces wave energy, protecting shorelines and bottom habitats from erosion. Replacing SAV once it has been uprooted or eliminated from an area is difficult, and the science of replacing it artificially is not well-developed. It is therefore important to protect existing SAV. Boat operation may also cut off or uproot SAV, damage corals and oyster reefs, and cause other habitat destruction. The definition of shallow-water habitat should be determined by State policy and should be dependent upon the ecological importance and sensitivity to direct and indirect disruption of the habitats found in the State.

3. Management Measure Selection

This measure was selected because some areas are not suitable for boat traffic due to their shallow water depth and the ecological importance and sensitivity to disruption of the types of habitats in the area. Excluding boats from such areas will minimize direct habitat destruction. Establishing no-wake zones will minimize the indirect impacts of increased turbidity (e.g., decreased light availability).

4. Practices

As discussed more fully at the beginning of this chapter and in Chapter 1, the following practices are described for illustrative purposes only. State programs need not require implementation of these practices. However, as a practical matter, EPA anticipates that the management measure set forth above generally will be implemented by applying one or more management practices appropriate to the source, location, and climate. The practices set forth below have been found by EPA to be representative of the types of practices that can be applied successfully to achieve the management measure described above.

a. *Exclude motorized vessels from areas that contain important shallow-water habitat.*

Many areas of shallow SAV exhibit troughs (areas of no vegetation) due to the action of boat propellers. This can result in increased erosion of the SAV due to the loss of bottom cover cohesion. SAV should be protected from boat or propeller damage because of its high habitat value.

b. *Establish and enforce no-wake zones to decrease turbidity.*

No-wake zones should be used in place of speed zones in shallow surface waters for reducing the turbidity caused by boat traffic. Motorboats traveling at relatively slow speeds of 6 to 8 knots in shallow waters can be expected to produce waves at or near the maximum size that can be produced by the boats. The height of a wave is directly proportional to the depth of water in which the wave will disturb the bottom (e.g., a taller wave will disturb the bottom of water deeper than a shorter wave). Bottom sediments composed of fine material will be resuspended and result in turbidity. In areas of high boat traffic, boat-induced turbidity can reduce the photosynthetic activity of SAV. Chapter 6 contains additional information on how to implement this practice.

IV. GLOSSARY

Bathymetric: Pertaining to the depth of a waterbody.

Bed load transport: Sediment transport along the bottom of a waterbody due to currents.

Benthic: Associated with the sea bottom.

Biocriteria: Biological measures of the health of an environment, such as the incidence of cancer in benthic fish species.

BOD: Biochemical oxygen demand; the quantity of dissolved oxygen used by microorganisms in the biochemical oxidation of organic matter and oxidizable inorganic matter by aerobic biological action.

Circulation cell: See *gyre.*

Conservative pollutant: A pollutant that remains chemically unchanged in the water.

Critical habitat: A habitat determined to be important to the survival of a threatened or endangered species, to general environmental quality, or for other reasons as designated by the State or Federal government.

DO: Dissolved oxygen; the concentration of free molecular oxygen in the water column.

Drogue-release study: A study of currents and circulation patterns using objects, or drogues, placed in the water at the surface or at specified depths.

Dye-release study: A study of dispersion using nontoxic dyes.

Exchange boundary: The boundary between one waterbody, e.g., a marina, and its parent waterbody; usually the marina entrance(s).

Fecal coliform: Bacteria present in mammalian feces, used as an indicator of the presence of human feces, bacteria, viruses, and pathogens in the water column.

Fixed breakwater: A breakwater constructed of solid, stationary materials.

Floating breakwater: A breakwater constructed to possess a limited range of movement.

Flushing time: Time required for a waterbody, e.g., a marina, to exchange its water with water from the parent waterbody.

Gyre: A mass of water circulating as a unit and separated from other circulating water masses by a boundary of relatively stationary water.

Hydrographic: Pertaining to ground or surface water.

Ichthyofauna: Fish.

Macrophytes: Plants visible to the naked eye.

Mathematical modeling: Predicting the performance of a design based on mathematical equations.

Micron: Micrometer; one-one millionth (0.000001) of a meter.

NCDEM DO model: A mathematical model for calculating dissolved oxygen concentrations developed by the North Carolina Division of Environmental Management (NCDEM).

No-discharge zone: An area where the discharge of polluting materials is not permitted.

NPDES: National Pollutant Discharge Elimination System. A permitting system for point source polluters regulated under section 402 of the Clean Water Act.

Numerical modeling: See *mathematical modeling*.

Nutrient transformers: Biological organisms, usually plants, that remove nutrients from water and incorporate them into tissue matter.

Organics: Carbon-containing substances such as oil, gasoline, and plant matter.

PAH: Polynuclear aromatic hydrocarbon; multiringed carbon molecules resulting from the burning of fossil fuels, wood, etc.

Physical modeling: Using a small-scale physical structure to simulate and predict the performance of a full-scale structural design.

Rapid bioassessment: An assessment of the environmental degradation of a waterbody based on a comparison between a typical species assemblage in a pristine waterbody and that found in the waterbody of interest.

Removal efficiency: The capacity of a pollution control device to remove pollutants from wastewater or runoff.

Residence time: The length of time water remains in a waterbody. Generally the same as *flushing time*.

Riparian: For the purposes of this report, riparian refers to areas adjoining coastal waterbodies, including rivers, streams, bays, estuaries, coves, etc.

Sensitivity analysis: Modifying a numerical model's parameters to investigate the relationship between alternative [marina] designs and water quality.

Shoaling: Deposition of sediment causing a waterbody or location within a waterbody to become more shallow.

Significant: A quantity, amount, or degree of importance determined by a State or local government.

SOD: Sediment oxygen demand; biochemical oxygen demand of microorganisms living in sediments.

Suspended solids: Solid materials that remain suspended in the water column.

Tidal prism: The difference in the volume of water in a waterbody between low and high tides.

Tidal range: The difference in height between mean low tide and mean high tide.

Velocity shear: Friction created by two masses of water moving in different directions or at different speeds in the same direction.

WASP4 model: A generalized modeling system for contaminant fate and transport in surface waters; can be applied to BOD, DO, nutrients, bacteria, and toxic chemicals.

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Appendix 5A

Summary of Coastal States Marina Programs

APPENDIX 5A: SUMMARY OF COASTAL STATES MARINA PROGRAMS

STATE	Marina water quality (WQ) study required	Critical habitat assessment required prior to marina siting	Stormwater runoff regulations included in the State code for marinas	Pumpouts mandated? Enforced? How many units? Criteria	Authority for over-site of expansions[a]	Boat maintenance materials handling	Public education programs for boaters	Speed zones or no-wake zones for erosion
AL	Only where marinas basins are constructed out of upland.	Yes	No	Yes for new or expanding marinas	Dept. of Env. Mgmt. reviews	No	Yes, but minimal	Only for safety purposes
AK	No; just a USACE permit and local ordinances	Yes; very important for commercial fish species	No	No	Yes	No	No, but Coast Guard has pollution prevention program	Yes
CA	Yes; the CA Envir. Quality Act, similar to NEPA, is implemented on a regional level	Under the CA Coastal Act; Env. Impact Report written	At the local level; not at the State level	Water Resources Ctrl Board; yes, at least one pump-out facility in marina	CA Envir. Quality Act; must perform EIR, handled at the local level	Encouraged	Yes; very extensive, Dept. of Boating and Waterways	Local jurisdictions provide local control
CT	Yes for large projects or if circulation may be affected	Yes; developers are given guidance	Yes for new and expanding but not small marinas	Yes	Encouraged	Yes	Yes	Only for safety purposes

[a]The U.S. Army Corps of Engineers reviews all construction activity in navigable waters.

APPENDIX 5A: SUMMARY OF COASTAL STATES MARINA PROGRAMS, Continued

STATE	Marina water quality (WQ) study required	Critical habitat assessment required prior to marina siting	Stormwater runoff regulations included in the State code for marinas	Pumpouts mandated? Enforced? How many units? Criteria	Authority for over-site of expansions[a]	Boat maintenance materials handling	Public education programs for boaters	Speed zones or no-wake zones for erosion
DE	Yes for new marinas	Yes for new marinas and expansions	Yes	>100 slips must have pumpout; <25 not required; 25-100 allowed to share	Yes	BMPs required	Yes	Yes
FL	Yes	Yes	Yes for new development, not marina-specific	Yes for new marinas	Yes	Minimal	Yes	Yes
GA	No unless problem is found	Yes for shellfish	Yes only for dry stack storage	Yes	Yes	Yes	No; trade association does this	Yes
HA	Yes	Yes	No	No	Yes if expansion is part of a new plan	No	Yes	Only for safety purposes
ME	No	Sometimes	No	Yes	Yes	Yes	Yes	No

[a]The U.S. Army Corps of Engineers reviews all construction activity in navigable waters.

APPENDIX 5A: SUMMARY OF COASTAL STATES MARINA PROGRAMS, Continued

STATE	Marina water quality (WQ) study required	Critical habitat assessment required prior to marina siting	Stormwater runoff regulations included in the State code for marinas	Pumpouts mandated? Enforced? How many units? Criteria	Authority for over-site of expansions[a]	Boat maintenance materials handling	Public education programs for boaters	Speed zones or no-wake zones for erosion
MD	Yes in some cases; monitoring may be required	Sometimes	Yes for new development, not marina-specific	Yes	Yes	Encouraged	Yes	Yes
MA	Yes in some cases	Sometimes	No	Yes	Yes	Yes	Yes	Only for safety purposes
MI	No	Yes	No	Yes	Yes	Encouraged	No	Yes at local level
MS	Yes in some cases	Sometimes	No	Yes	Yes	No	Yes	Yes
NH	No	No	Yes, treated the same as other development	Yes	Yes	No	No	Yes
NJ	Yes	Yes	Yes, treated the same as other development	Yes for >25 slips	Yes	Yes	Yes	Only for safety purposes

[a]The U.S. Army Corps of Engineers reviews all construction activity in navigable waters.

APPENDIX 5A: SUMMARY OF COASTAL STATES MARINA PROGRAMS, Continued

STATE	Marina water quality (WQ) study required	Critical habitat assessment required prior to marina siting	Stormwater runoff regulations included in the State code for marinas	Pumpouts mandated? Enforced? How many units? Criteria	Authority for oversite of expansions[a]	Boat maintenance materials handling	Public education programs for boaters	Speed zones or no-wake zones for erosion
NY	No	Sometimes	Yes, treated the same as other development	No, except on case-by-case permit condition	Yes	Yes	Yes	Yes; no-wake at local level
NC	Yes	Yes	Yes, treated the same as other development	Yes for >25 slips	Yes for >20% increase	Yes	Yes	Only for safety purposes
OR	Not required at the state level	Encouraged by U.S. Fish and Wildlife Service	Yes, treated the same as other development	Yes; have no-discharge zones already	Yes	Not mandatory; very common to see liquid waste receptacles	Yes, by the Oregon State Marine Board	Yes
RI	Yes in degraded water	Yes	Yes	Yes; at least 1 pumpout for every 500 vessels over 25 feet	Yes	Yes	Yes	Yes
SC	Yes	Sometimes	Yes	Yes for new and expanding	Yes	Yes	Yes	Yes

[a]The U.S. Army Corps of Engineers reviews all construction activity in navigable waters.

APPENDIX 5A: SUMMARY OF COASTAL STATES MARINA PROGRAMS, Continued

STATE	Marina water quality (WQ) study required	Critical habitat assessment required prior to marina siting	Stormwater runoff regulations included in the State code for marinas	Pumpouts mandated? Enforced? How many units? Criteria	Authority for over-site of expansions[a]	Boat maintenance materials handling	Public education programs for boaters	Speed zones or no-wake zones for erosion
TX	No	No	No	No	Not available	No	No	Addressed at local level
VA	Yes	Yes	Yes, treated the same as other development	Yes for new and expanding	Yes	No	Yes	Addressed at local level
WA	Required by some local governments; as required for general NPDES permitting for boatyards	Yes	Yes	No, but could be imposed at the local level	Requires approval by the WA Department of Ecology	Yes	Yes	Yes

[a]The U.S. Army Corps of Engineers reviews all construction activity in navigable waters.