APPENDIX F
OIL CONTROL STRUCTURES

1.0 Introduction

This appendix provides information for the design of oil control structures.

2.0 Oil Control Structures

Oil control Structures are used to remove free, dispersed and sorbed oil. This type of treatment is most effective in situations where relatively high concentrations of oil and grease occur in storm runoff such as in parking lots, high traffic areas and spill response activities. They do not function well at low concentrations of oil, therefore their use along roads is limited to high traffic highways. Oil control facilities are common pretreatment devices to prevent oil from impairing the function of the primary downstream BMP.

2.1 Oil/Water Separators

Oil/water separators are usually underground vaults that take advantage of density differences to separate light oil and dense sediment from stormwater. Oil/water separators are used generally as a pretreatment device to prevent oil from impairing the function of a downstream best management practice (BMP).

Oil/water separators should be used:

1. For vehicle storage and maintenance yards, fueling areas, and high-use parking and rest areas.
2. Upstream of the primary stormwater treatment facility.
3. Off-line to ensure that only the water quality design storm is treated and to prevent flushing by high flow events.
4. Only for treating oil contaminated runoff from impervious areas.

Oil/water separators have several limitations:

1. They should not be used for removal of dissolved or emulsified oils such as coolants and soluble lubricants.
2. They should not be used in situations where detergents are used to cleanse paved areas because such cleansers chemically stabilize oil and prevent flotation.

2.1.1 Baffle Type Oil/Water Separators

Baffle type oil/water separators use watertight vaults that have multiple compartments (bays) separated by baffles extending down from the top of the vault. The baffles prevent oil that floats to the surface from flowing out of the separator. Oil that collects at the surface is typically removed by floating skimmers, although more sophisticated mechanical skimmers can be used. Baffles are also installed at the bottom of the vault to trap oily settled material that accumulates.

Key features of a baffle type oil/water separator are shown in Figure 1. The forebay traps and collects sediments, encourages plug flow, and reduces turbulence prior to the oil separation bay. The oil separation bay traps oil as it floats to the surface and also collects any carryover sediment. The treated runoff exiting the oil separation bay enters the afterbay for discharge into the downstream conveyance system.

Flow spreading, sediment-retaining, and oil-retaining baffles are provided; these must be removable unless additional access ports are provided for maintenance.

Pollutant Removal Efficiency

Baffle type oil/water separators can meet a performance goal of 10 to 15 milligrams per liter in the treated runoff if designed to remove oil droplets 60 microns and larger.

Design Criteria for Baffle Type Oil/Water Separators

This subsection describes the features of baffle type oil/water separators and the design criteria that apply specifically to these installations.

Vaults must meet the following criteria:

a) Water depth (D) = 3 to 8 feet to minimize turbulence
b) Width (W) of vault = 6 to 20 feet
c) Depth to width ratio (r) = 0.3 to 0.5
d) Length to width ratio (L/W) = 5:1 minimum
e) Forebay length (L_f) = 1/3 to 1/2 of vault length
f) Forebay horizontal area must be greater than 20 square feet per 10,000 square feet of impervious drainage area
g) Afterbay length (L_a) = 8 feet minimum

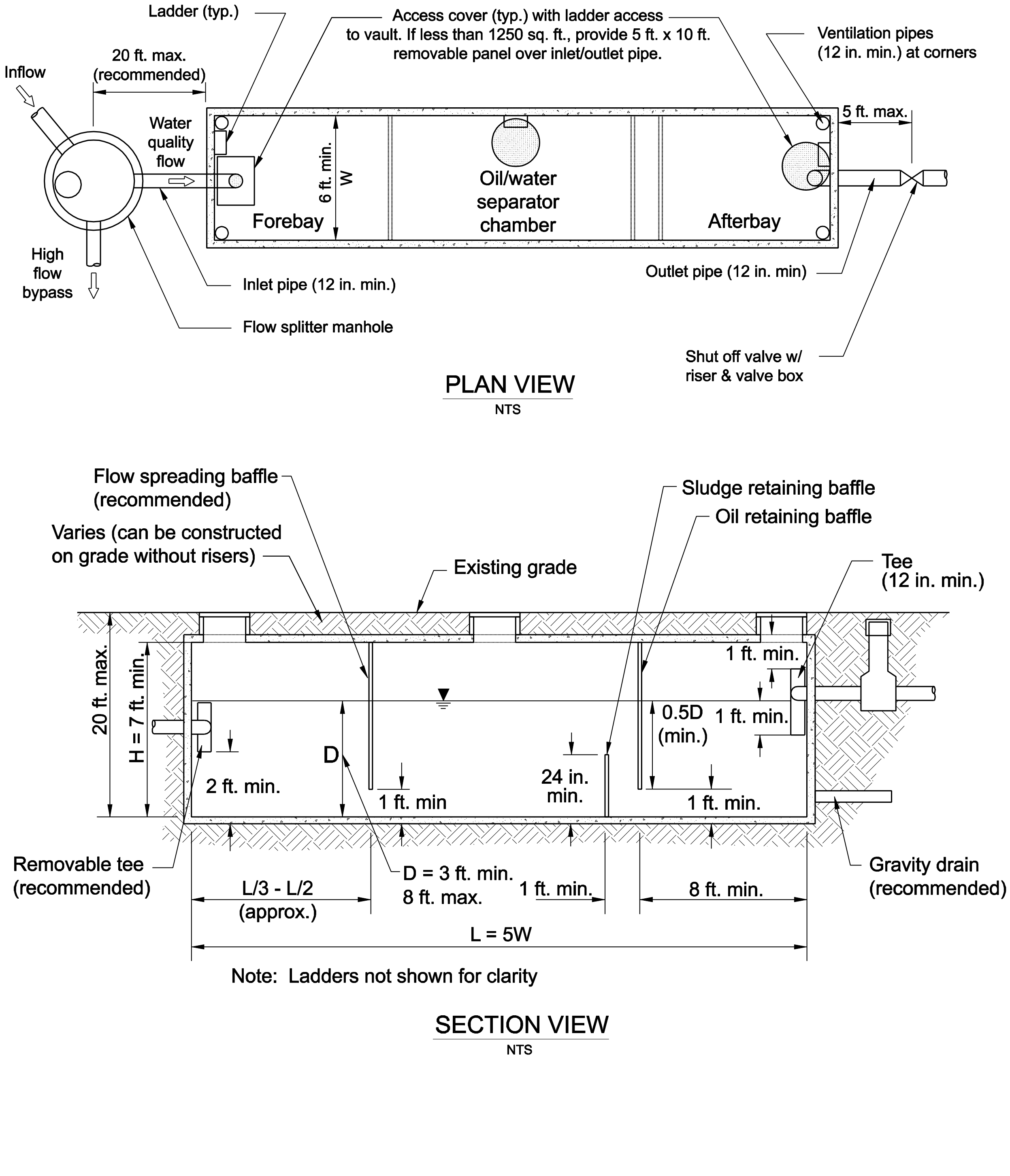

Figure 1 Baffle Type Oil/Water Separator

Vault features

1. **Oil retaining baffles** (top baffles) must be located at least ¼ of the total separator length from the outlet. They also must extend down at least 50 percent of the design water height and at least 1 foot from the separator bottom.

2. **Ventilation pipes** (minimum 12-inches in diameter or equivalent) must be provided in all four corners of vaults to allow for ventilation for maintenance personnel. Ventilation must also be provided to assure that pressure or vacuum does not occur within the vault due to fluctuations in the water surface elevation. Often this ventilation is provided by the holes in a standard manhole cover or the openings in a grate cover.

3. **Absorbent booms and/or skimmers** must be installed in the afterbay when needed.

4. **Shut-off valve** must be included along the outlet pipe.

5. Provide a **gravity drain** if grade allows for maintenance. The drain invert must be placed 6-inches above the bottom of vault to prevent sediment laden water from escaping when the vault is drained.

Design Procedure for Baffle Type Oil/Water Separators

Design steps for sizing baffle type separators are as follows:

Step 1 – Determine water quality design storm. See Section 14.10.2.

Step 2 - Determine Contributing Area. Flow to oil/water separators should come from an area that is almost entirely impervious.

Step 2a – Determine the water quality peak flow. Use hydrology guidance in Chapter 7 and the design recurrence interval from step 1.

Step 3 – Establish design oil rise rate.

Use 0.033 feet per minute unless an alternative site-specific value is calculated using Stokes law.

Step 4 – Determine design horizontal velocity.

The design horizontal velocity is assumed to be uniform within the separator bay. The design horizontal velocity is calculated from the following equation:

$$V_h = 15V_o$$

Where:

V_h = design horizontal velocity in feet per minute
V_o = design oil rise rate in feet per minute

The value (15) is a dimensionless ratio based on American Petroleum Institute (API) criteria. For a design oil rise rate of 0.033-feet per minute, the design horizontal velocity is thus 0.495-feet per minute (0.008-feet per second).

Step 5 - Calculate the minimum vertical cross sectional area of the separator using the following equation:

$$A_c = \frac{Q}{V_h}$$

Where:

A_c = minimum cross sectional area in square feet
Q = water quality design flow in cubic feet per second
V_h = design horizontal velocity in feet per second

Step 6 – Calculate the water depth using the following equation:

$$D = (rA_c)^{0.5}$$

Where:

D = Water depth in feet
r = Depth-to-width ratio, dimensionless (must be 0.3 to 0.5)

and A_c is determined from Step 5.

Step 7 – Calculate the width of the separator vault using the following equation:

$$W = \frac{A_c}{D}$$

Where:

D	=	Water depth in feet
W	=	Vault width in feet

and A_c is determined from Step 5.

Step 8 – Calculate the minimum length of the separator vault:

$$L_{min} = FD\frac{V_h}{V_o}$$

Where:

L_{min}	=	minimum vault length in feet
F	=	turbulence and short circuiting factor, dimensionless

and other variables are defined in Steps 5 and 7.

The turbulence factor is a function of V_h/V_o and varies from approximately 1.30 to 1.75. For a V_h/V_o of 15, F has a value of 1.65. See reference 4 for additional information. Thus, the above equation reduces to the following:

$$L_{min} = 24.75D$$

Step 9 – Check the vault length-to-width ratio.

In order to minimize hydraulic disturbances from the forebay and afterbay, the vault length must be at least five times its width (W).

Step 10 – Select the length of the forebay and afterbay.

The length of the forebay should meet the following condition:

$$L_f = \frac{L}{3} \text{ to } \frac{L}{2}$$

Where:

L_f	=	length of forebay in feet

L = length of vault in feet (L is greater than or equal to L_{min})

The length of the afterbay should meet the following condition:

$$L_a = \frac{L}{4}$$

Where:

L_a = length of the afterbay in feet

The minimum afterbay length (L_a) is 8 feet.

Step 11 – Calculate the horizontal surface area (WL_f) of the vault forebay.

The forebay horizontal area must be greater than 20 square feet per 10,000 square feet of impervious drainage area. The length of the forebay may be increased without having to increase the overall length of the vault.

Step 12 – Confirm that all dimensions meet the required criteria.

2.1.2 Coalescing Plate Oil/Water Separators

Coalescing plate oil/water separators use watertight vaults that have multiple compartments or bays. These units are commercially available from several manufacturers. The reader is referred to the various manufacturers for more detailed information on coalescing plate oil/water separators.

The key features of a coalescing plate oil/water separator are shown in Figure 2. The forebay traps and collects sediments, encourages plug flow, and reduces turbulence prior to the oil separation bay. The oil separation bay contains a series of inclined plates (plate pack) to separate oil from the stormwater runoff. These plates are typically inclined from the horizontal 45 to 60 degrees. The treated runoff exiting the oil separation bay enters the afterbay for discharge into the downstream conveyance system.

Oil removal occurs as stormwater flows horizontally through a coalescing plate separator and encounters the plate pack. As oil rises toward the surface, it contacts the underside of one of the inclined plates and accumulates on the surface. Eventually, the accumulation becomes thick enough to migrate along the surface of the plate. When it reaches the edge of the plate, it breaks free and rises rapidly as a large droplet to the surface of the unit. This coalescing of small oil droplets into larger ones increases treatment effectiveness; thus, vault size is smaller than that of a baffle type separator.

Oil removal is a function of the sum of the horizontal projection of all the plates in the pack (total plan area of the plates). Design of a coalescing plate separator is based on determining the total plan area of the plate pack needed to remove oil of a specified droplet size for a specific design flow. Because plate packs are manufactured items, vault sizing depends on the specific design features of the plate pack.

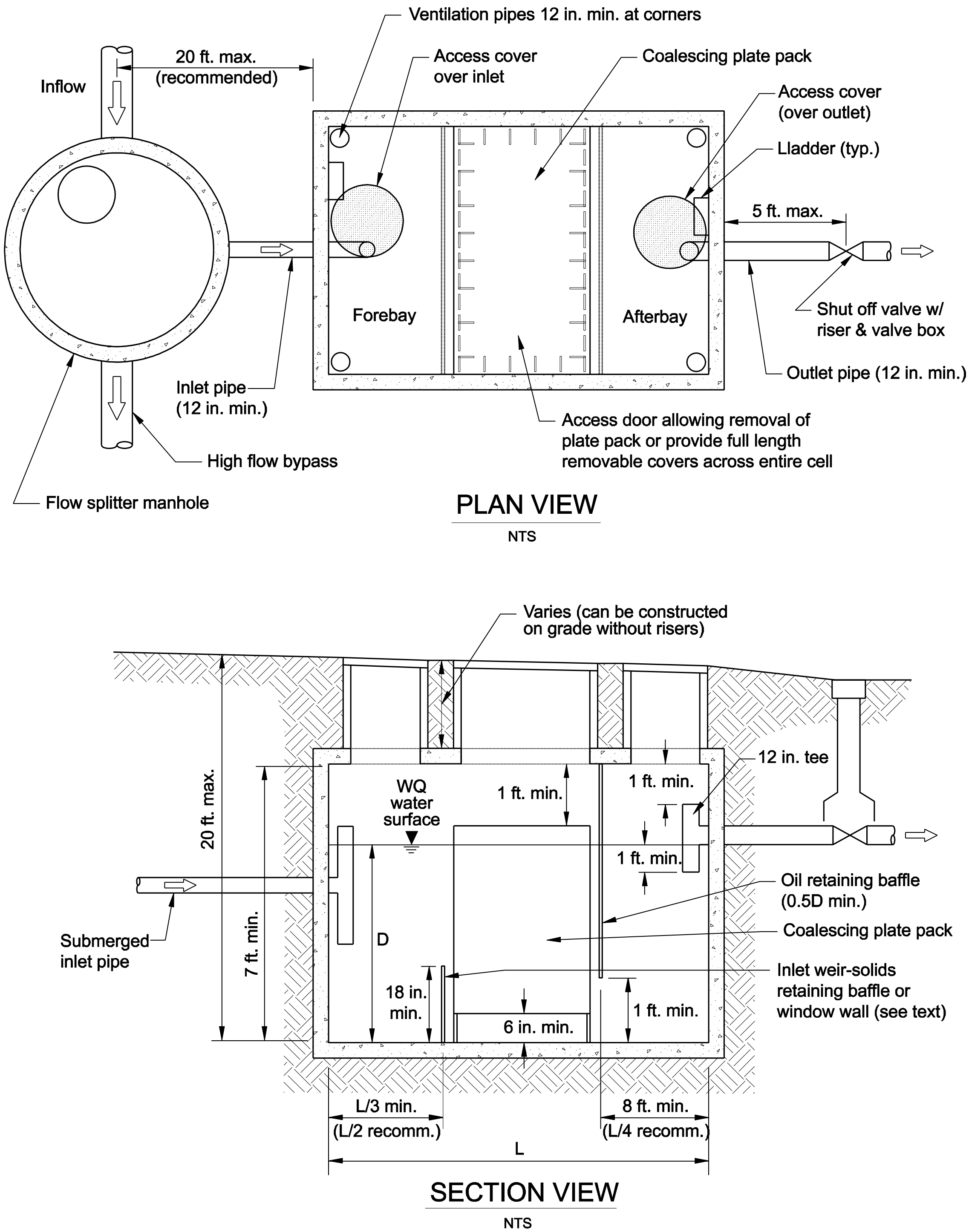

Figure 2 Coalescing Plate Oil/Water Separator

Pollutant Removal Capabilities

Typically, oil/water separators can meet a performance goal of 10 to 15 milligrams per liter in the treated runoff if designed to remove oil droplets 60 microns and larger.

Design Criteria for Coalescing Type Oil/Water Separators

This subsection describes the features of coalescing type oil/water separators and the design criteria that apply specifically to these installations.

1. Vaults must meet the following criteria:

    a) Forebay length (L_f) = 1/3 to 1/2 of vault length
    b) Forebay horizontal area must be greater than 20 square feet per 10,000 square feet of impervious drainage area
    c) The geometry and dimensions of the plate pack will depend on manufacturer's specifications.
    d) Afterbay length (L_a) = 8 feet minimum

Vault features

1. **Plate pack** shall be made of fiberglass, stainless steel or polypropylene. The spacing between the plate pack and vault sidewalls must be packed with a light weight removable material such as plastic or polyethylene foam to minimize short circuiting. Rubber flaps are not acceptable.

2. **Ventilation pipes** (minimum 12-inches in diameter or equivalent) must be provided in all four corners of vaults to allow for ventilation for maintenance personnel. Ventilation must also be provided to assure that pressure or vacuum does not occur within the vault due to fluctuations in the water surface elevation. Often this ventilation is provided by the holes in a standard manhole cover or the openings in a grate cover.

3. **Absorbent booms and/or skimmers** must be installed in the afterbay when needed

4. **Shut-off valve** must be included along the outlet pipe.

Design Procedure for Coalescing Type Oil/Water Separators

Basic steps are as follows:

Step 1 – Determine water quality design recurrence interval. Runoff collected by the upstream storm drain system needs to address the most stringent standards or reference ODOT's requirements summarized in Section 14.10.2.

Step 2 - Determine contributing area.

Step 2a – Determine hydrology. The water quality peak flow is needed to design an oil/water separator. Use hydrology guidance in Chapter 7 and the design recurrence interval from step 1.

Step 3 – Coordinate the plate pack geometry and dimensions with the various manufacturers of this feature.

Step 4 – Determine the length of the forebay and afterbay.

The length of the forebay can be calculated using:

$$L_f = \frac{L}{3} \text{ to } \frac{L}{2}$$

Where:

L_f = length of forebay in feet

L = length of vault in feet

The length of the afterbay can be calculated using:

$$L_a = \frac{L}{4}$$

Where:

L_a = length of the afterbay in feet

The minimum afterbay length (L_a) is 8 feet.

Step 5 – Calculate the horizontal surface area (WL_f) of the vault forebay.

The forebay horizontal area must be greater than 20 square feet per 10,000 square feet of impervious drainage area. The length of the forebay may be increased without having to increase the overall length of the vault.