Oak Park Conservancy District
Stormwater Best Management Practices (BMPs)
Stormwater Pollution treatment Practices (STPs)

STP-07

Activity: Oil/Water Separation

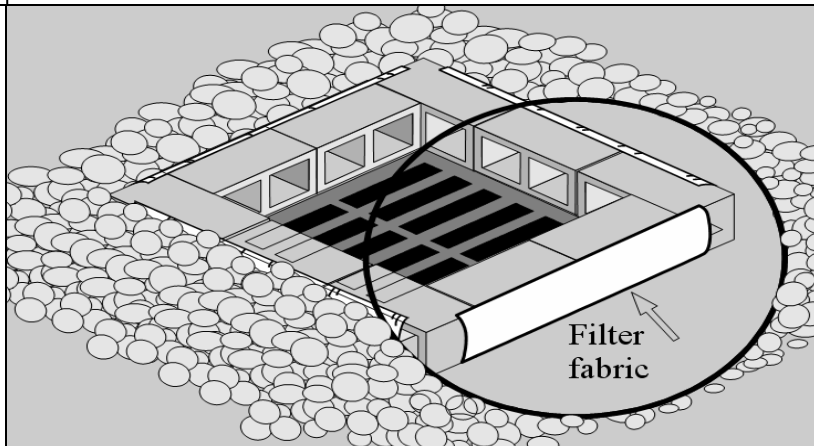
PLANNING CONSIDERATIONS:

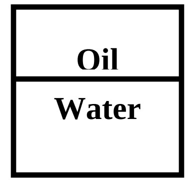
Design Life:
1 yr

Acreage Needed:
Minimal

Estimated Unit Cost:
N/A

Monthly Maintenance:
N/A





Target Pollutants		
Significant ♦	Partial ◈	Low or Unknown ◊

Sediment ♦ Heavy Metals ◊ Nutrients ◊ Oxygen Demanding Substances ◊ Toxic Materials ◊
Oil& Grease ♦ Bacteria & Viruses ◊ Floatable Materials ♦ Construction Waste ◊

Description

Oil/water separators are designed to remove one specific group of contaminants: petroleum compounds and grease. However, separators will also remove floatable debris and settleable solids. Two general types of oil/water separators are used: conventional gravity separator and the coalescing plate interceptor (CPI). This management practice is likely to create a significant reduction in the impacts of floatable materials and oil and grease as well as partial reductions in the impacts of sediment, nutrients, heavy metals, toxic materials, and oxygen demanding substances.

This BMP fact sheet discusses oil/water separators. Other systems can be used in conjunction with or as a simpler alternative to the complex design, inspection, operation and maintenance requirements of oil/water separators. STP-06: Media Filtration/Media Filters and Water Quality Inlets should also be reviewed.

Suitable Applications

- The various systems discussed in this fact sheet should be selected based on the targeted constituents, site area constraints, cost and frequency of maintenance and inspection requirements. Many of the systems are readily available in a variety of layouts through commercial vendors.
- One of the most important selection criteria that must be evaluated is the ability to bypass or convey large storm events without damaging the system, exceeding design flow capacity or resuspending collected pollutants.

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Suitable Applications (Continued)

- Another very important selection criteria is consideration of long-term inspection and maintenance resources. If there is not a plan to regularly inspect and maintain the selected system on a long-term basis, and a fiscal guarantor that the required maintenance resources will be available for the life of the system, then the system should not be installed. If these types of systems are not periodically inspected, cleaned and otherwise maintained, they will fail and could result in more intense impacts to stormwater quality than if they were not installed at all.

- Applicable to situations where the concentration of oil and grease related compounds will be abnormally high and source control cannot provide effective control.

- The general types of businesses where this situation is likely are truck, car, and equipment maintenance and washing businesses, as well as a business that performs maintenance on its own equipment and vehicles. Public facilities where separators may be required include marine ports, airfields, fleet vehicle maintenance and washing facilities, and mass transit park-and-ride lots.
- Conventional separators are capable of removing oil droplets with diameters equal to or greater than 150 microns. A CPI separator should be used if smaller droplets must be removed.

- Oil/water separators will be needed for a few types of industrial sites where activities result in abnormal amounts of petroleum products lost to exposed pavement, either by accidental small spills or normal dripping from the vehicle undercarriage (gas stations, auto shops, etc.)

- Separators may also be advisable where an area is heavily used by mobile equipment such as loading wharfs at marine ports. Limited data indicates oil/water separators can reduce the oil/grease concentration below 10 mg/l.

- The sizing of separators is based upon the rise rate velocity of oil droplets and rate of runoff. However, with the exception of stormwater from oil refineries there are no data describing the characteristics of petroleum products in urban stormwater that are relevant to design: either oil density and droplet size to calculate rise rate or direct measurement of rise rates.

Design and Sizing Conditions

- These systems should be designed by a licensed professional civil engineer.

- Sizing related to anticipated influent oil concentration, water temperature and velocity, and the effluent goal. To maintain reasonable separator size, it should be designed to bypass flows in excess of “first flush”. The bypass mechanism should be designed to minimize potential for captured pollutants from being “washed out” or resuspended under flows in excess of the “first flush”.

Design and Sizing Conditions (Continued)

- It is known that a significant percentage of the petroleum products are attached to the fine suspended solids and therefore are removed by settling not flotation. Consequently, the performance of oil/water separators is uncertain.

- The basic configurations of the two types of separators are illustrated in Figure STP-07-1. With small installations, a conventional gravity separator has the general appearance of a septic tank, but is much longer in relationship to its width. Larger facilities have the appearance of a municipal wastewater primary sedimentation tank. The CPI separator contains closely spaced plates which enhance the removal efficiency. In effect, to obtain the same effluent quality a CPI separator requires considerably less space than a conventional separator. The angle of the plates to the horizontal ranges from 0° (horizontal) to 60°, although 45° to 60° is the most common. The perpendicular distance between the plates typically ranges from 0.75 to 1 inch (1.9 to 2.5 cm). The stormwater will either flow across or down through the plates, depending on the plate configuration.

Design of Conventional Separators

The sizing of a separator is based upon the calculation of the rise rate of the oil droplets using the following equation:

$$V_p = 1.79(d_p - d_c)d^2 \times 10^{-8}/n \qquad (1)$$

where: V_p = rise rate (ft/second)
n = absolute viscosity of the water (poises)
d_p = density of the oil (gm/cc)
d_c = density of the water (gm/cc)
d = diameter of the droplet to be removed (microns)

A water temperature must be used to select the appropriate values for water density and viscosity from Table STP-07-1. The engineer should use the expected temperature of the stormwater during the December-January period. There are no data on the density of petroleum products in urban stormwater but it can be expected to lie between 0.85 and 0.95. To select the droplet diameter the engineer must identify an efficiency goal based on an understanding of the distribution of droplet sizes in stormwater. However, there is no information on the size distribution of oil droplets in urban stormwater. Figure STP-07-2 is a size and volume distribution for stormwater from a petroleum products' storage facility. The engineer must also select a design influent concentration, which carries considerable uncertainty because it will vary widely within and between storms.

To illustrate Equation 1: if the effluent goal is 10 mg/l and the design influent concentration is 50 mg/l, a removal efficiency of 80% is required. From Figure STP-07-2: this efficiency can be achieved by removing all droplets with diameters 90 microns or larger. Using a water temperature of 10°C gives a water density of 0.998. Using an oil density of 0.898, the rise rate for a 90 micron droplet is 0.0011 feet per second.

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Design and Sizing Conditions (Continued)

It is generally believed that conventional separators are not effective at removing droplets smaller than 150 microns. Theoretically, a conventional separator can be sized to remove a smaller droplet but the facility may be so large as to make the CPI separator more cost effective:

Sizing conventional Separator

$D = (Q/2V)^{0.5}$

Where: D = depth, which should be between 3 and 8 feet.
Q = design flow rate (cfs)
V = allowable horizontal velocity which is equal to 15 times the design oil rise rate but not greater than 0.05 ft/s (0.2 m/s)

<u>Application of the Conventional Oil/Water Separator</u>
Assume that a conventional oil/water separator is to be used to treat runoff from a 1/2 acre parking lot. Assume further it is to be sized to treat runoff from a rainfall rate of 0.50 inches/hr (which translates to a runoff rate of 0.50 cfs/acre when the area is 100 percent impervious).

Using the example above, the computed Vp is 0.0011 ft/sec (3.4 x 10^{-4} m/s). Using Equation 2, V = 15 x 0.0011 = 0.0165 ft/sec (5.0 x 10^{-3} m/s) which is less than 0.05 ft/sec (1.5 x 10^{-2} m/s); thus,

D = (Q/2V)0.05 = (1/2 x 0.05/(2 x 0.0165)) x 0.05
D = 3.8 ft (1.16 m)

L = VD/Vp = 0.0165 x 3.8/0.0011
L = 57 ft (17.4 m)

W = Q/(VD) = 0.25/(0.0165 x 3.8)
W = 4.0 ft (1.22 m), since W is less than 2 x D, increase width to W = 3.8 x 2 = 7.6 ft (2.32 m).

Thus, a conventional oil/water separator sized to capture runoff from a 0.5 in/hr (1.3 cm/hr) rainfall on a 1/2 acre parking lot would be:

D = 3.8 ft (1.16 m)
W = 7.6 ft (2.32 m)
L = 57 ft (17.4 m)

<u>Sizing CPI separator</u>
Manufacturers can provide packaged separator units for flows up to several cubic feet per second. For larger flows, the engineer must size the plate pack and design the vault. Given the great variability of separator technology among manufacturers with respect to plate size, spacing, and inclination, it is recommended that the design engineer consult vendors for a plate package that will meet the engineer's criteria. Manufacturers typically identify the capacity of various standard units.

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Design and Sizing Conditions (Continued)

The engineer can size the facility using the following procedure. First identify the expected plate angle, H (as degrees), and calculate the total plate area required,

$$A(ft^2).\ A = Q/V_p \cos(H) \qquad (3)$$

However, the engineer's design criteria must be comparable to that used by the manufacturer in rating its units. CPI separators are not 100% hydraulically efficient; ranging from 0.35 to 0.95 depending on the plate design (Aquatrend, undated). If the engineer wishes to incorporate this factor, divide the result from Equation 3 by the selected efficiency.

- Select spacing, S, between the plates, usually 0.75 to 1.5 inch (1.91 to 3.81 cm).
- Identify reasonable plate width, W, and length, L.
- Number of plates, N = A/WL.
- Calculate plate volume, $P_v(ft^3)$.

$$P_V = (\underline{NS} / 12 + L \cos(H))(WL \sin(H)) \qquad (4)$$

- Add a foot (0.3 m) beneath the plates for sediment storage.
- Add 6" to 12" (15.2 to 30.5 cm) above the plates for water clearance so that the oil accumulates above the plates.
- Add one foot (0.3 m) for freeboard.
- Add a forebay for floatables and distribution of flow if more than one plate unit is needed.
- Add after bay for collection of the effluent from the plate pack area.
- For larger units include device to remove and store oil from the water surface.
- Horizontal plates require the least plate volume to achieve a particular removal efficiency. However, settleable solids will accumulate on the plates complicating maintenance procedures. The plates may be damaged by the weight when removed for cleaning. The plates should be placed at an angle of 45° to 60° so that settleable solids slide to the facility bottom. Experience shows that even with slanted plates some solids will "stick" to the plates because of the oil and grease. Placing the plates closer together reduces the plate volume. However, if debris is expected such as twigs, plastics, and paper, select a larger plate separation distance. Or install ahead of the plates a trash rack and/or screens with a diameter somewhat smaller than the plate spacing.

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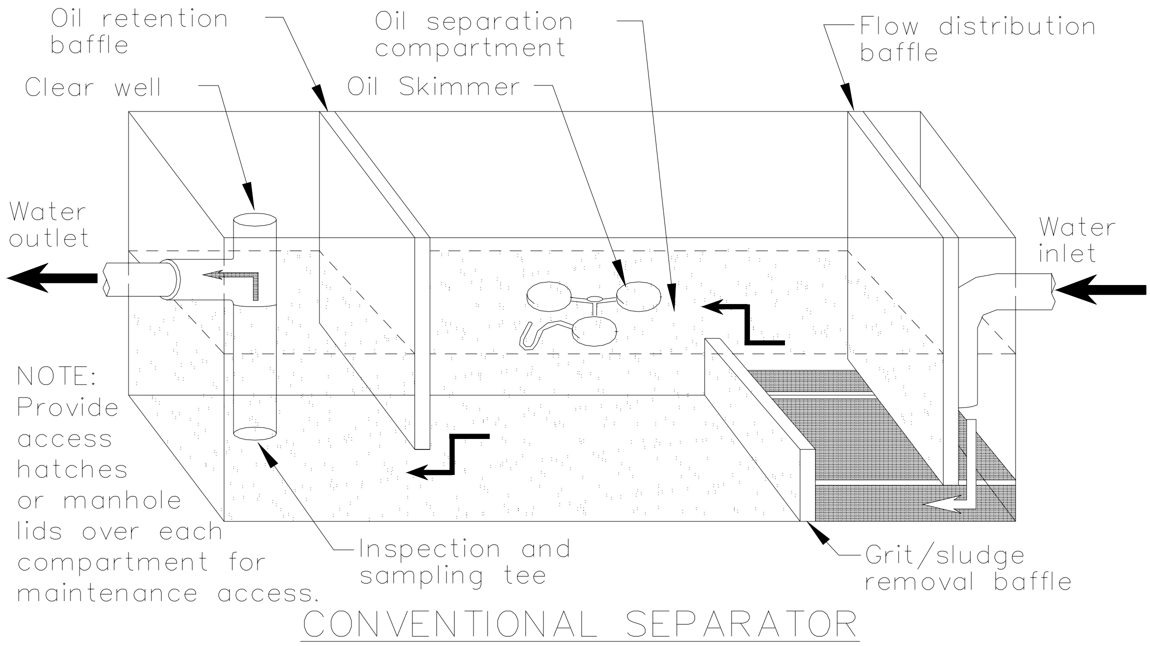
Inspection Checklist

- It is known that a significant percentage of the petroleum products are attached to the fine suspended solids and therefore are removed by settling not flotation. Consequently, the performance of oil/water separators is uncertain.
- The design loading rate for oil/water separators is low, therefore, they can only be cost-effectively sized to detain and treat nuisance and low flows (small storm or first flush events). Sizing to accommodate an average to large storm results in a large sized facility and is not economical and often not feasible.
- Undersizing or conveying flows in excess of the first flush for small catchments can result in poor performance or resuspension of collected pollutants.
- Oil/water separators require frequent periodic maintenance for the life of the structure.

Table STP-07-1
Water Viscosities & Densities

Temperature		Absolute Viscosity		Density of pure water in air	
°C	°F	(Poises)	(slugs/ft.sec)	(gm/cc)	(lbs/ft^3)
0	32.0	0.017921	0.00120424	0.999	62.351
1	33.8	0.017343	0.00116338	0.999	62.355
2	35.6	0.016728	0.00112407	0.999	62.358
3	37.4	0.016191	0.00108799	0.999	62.360
4	39.2	0.015674	0.00105324	1.000	62.360
5	41.0	0.015188	0.00102059	0.999	62.360
6	42.8	0.014728	0.00098968	0.999	62.359
7	44.6	0.014284	0.00095984	0.999	62.357
8	46.4	0.013860	0.00093135	0.999	62.354
9	48.2	0.013462	0.00090460	0.999	62.350
10	50.0	0.013077	0.00087873	0.999	62.345
11	51.8	0.012713	0.00085427	0.999	62.339
12	53.6	0.012363	0.00084870	0.999	62.333
13	55.4	0.012028	0.00080824	0.999	62.326
14	57.2	0.011709	0.00078681	0.999	62.317
15	59.0	0.011404	0.00076631	0.999	62.309
16	60.8	0.011111	0.00074662	0.999	62.299
17	62.6	0.010828	0.00072761	0.999	62.289
18	64.4	0.010559	0.00070953	0.999	62.278
19	66.2	0.010299	0.00069206	0.999	62.266
20	68.0	0.010050	0.00067533	0.998	62.254



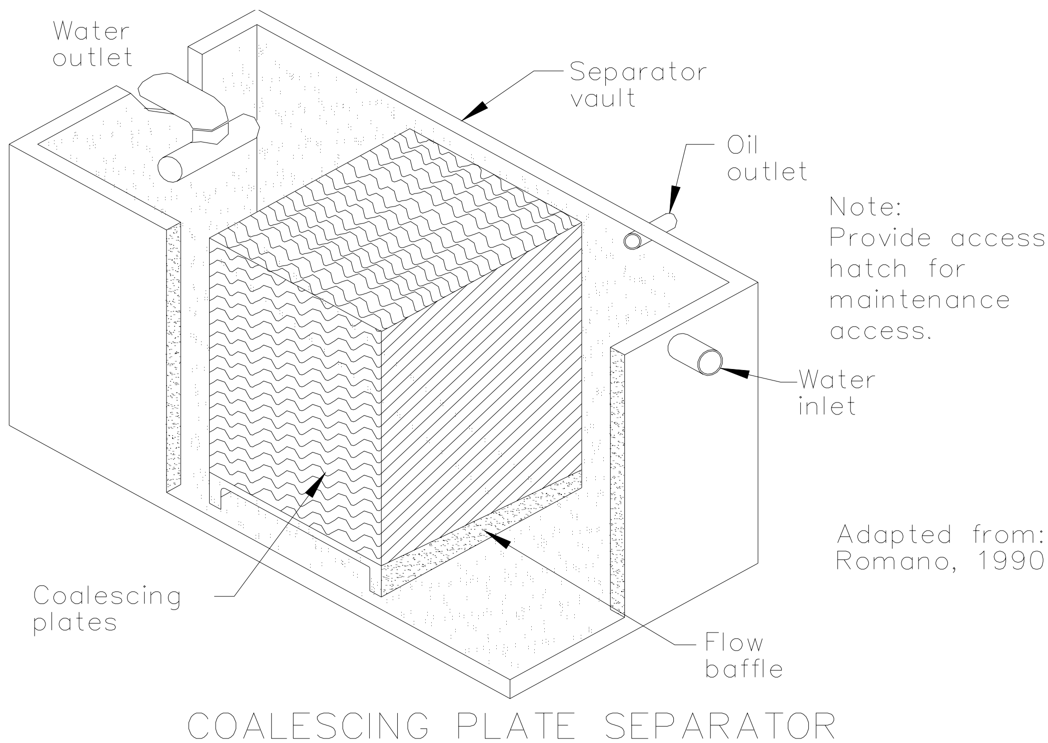


Figure STP-07-1
Oil/Water Separator Types

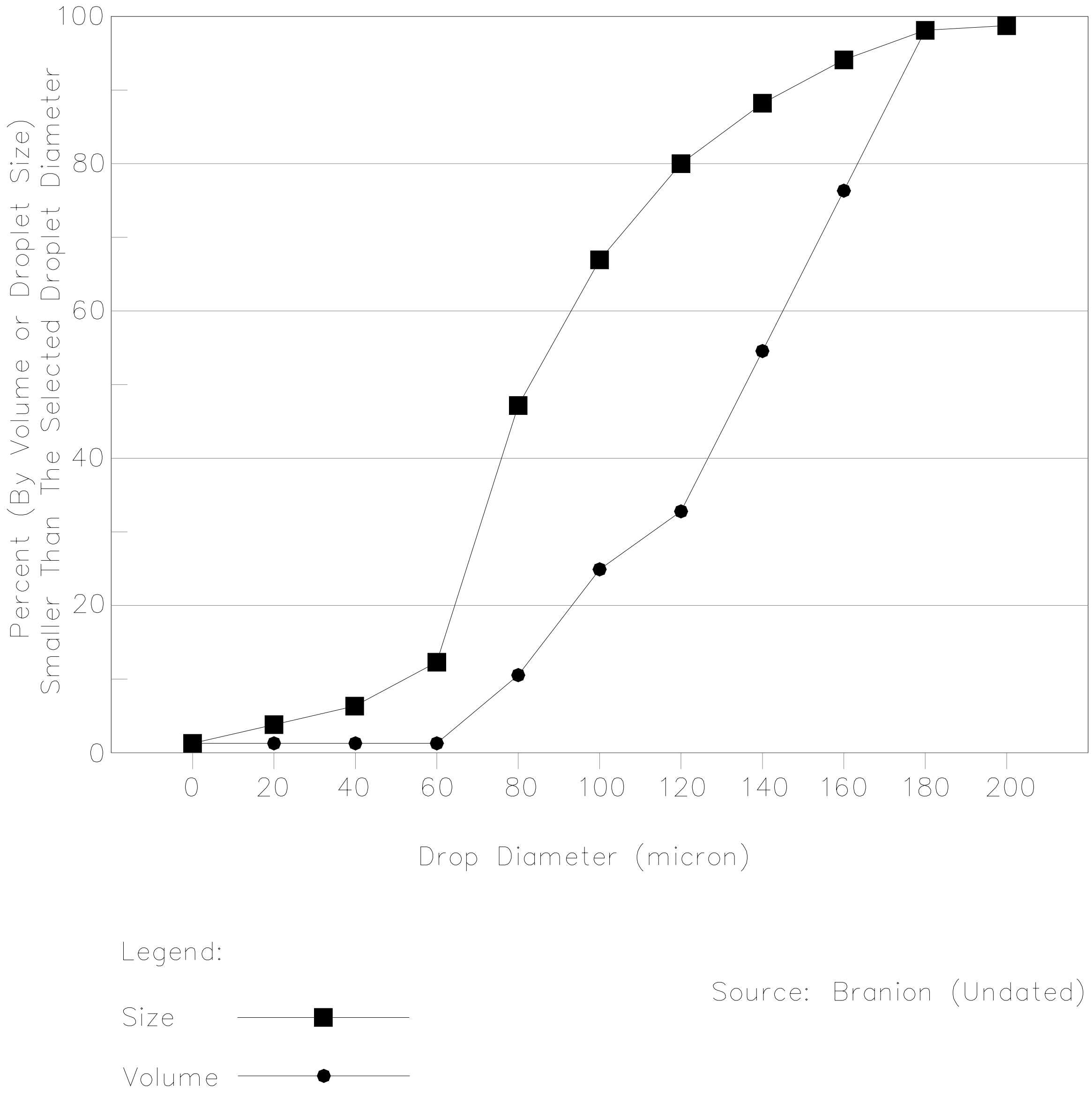


Figure STP-07-2

Particle Size, Capture, Distribution and Volume