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Stormwater on the Horizon

How NPDES Phase II Regulations Will Affect Industrial Facilities

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Significant progress has been made in controlling water pollution since the 1972 passage of the Clean Water Act. Most progress to date has come from controlling industrial and municipal wastewater discharges. However, pollution from diffuse sources such as runoff from agriculture, urban areas, and construction sites still impairs water quality.

To address this problem, the U.S. Environmental Protection Agency (EPA) is regulating stormwater discharges through the National Pollutant Discharge Elimination System (NPDES) program in two phases. The most recent set of regulations, Phase II, was published in the *Federal Register* Dec. 8, 1999, and builds on Phase I requirements for construction and industrial activities in the following ways:

- A facility may be able to seek the new "conditional no-exposure exclusion" that exempts it from having to obtain a permit.
- A facility may be affected by another entity's permit if it conducts or participates in construction activity affecting 1 ac (0.4 ha) or more, as opposed to the previous 5 ac (2 ha) or more under Phase I regulations.
- A facility may be affected by another entity's permit if located in a municipality, county, or other regulated entity subject to the Phase II Small Municipal Separate Storm Sewer System (MS4) program.

Each local permitting authority will apply these requirements in different ways. Therefore, it is important for the industrial community to understand what these regulations are trying to accomplish and how they will be locally specific. To provide a local government perspective, this article will discuss how the State of Indiana will implement Phase II regulations and how an industrial facility in Indianapolis met new requirements using a stormwater detention system.

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Common Chemicals Promote Estrogen Production in Fish

Commonly used industrial, household, and agricultural chemicals that wind up in streams could be causing more harm to the sexual development and reproduction of fish than previously thought, according to researchers at the University of Maryland Biotechnology Institute (UMBI; Baltimore).

Historically, scientists have suspected that gender changes observed in various fish species were caused by estrogens or estrogen-like molecules, such as polychlorinated biphenyls and petroleum products. Such chemicals dock onto an estrogen receptor in the cells of the liver, ovaries, fat, breast, brain, bone, and many other target tissues, according to John Trant, an associate professor at UMBI's Center of Marine Biotechnology. The activated receptor then initiates a series of changes related to sexual physiology.

Such occurrences first were observed in the 1980s, when environmental estrogen mimics were causing male fish to produce yolk proteins — an estrogen-mediated response — in rivers downstream of London, Trant said. "Normally this occurs only in females, but they were seeing it in immature animals and in male fish," he noted.

Until now, most research on endocrine disruptors has focused

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Achieving "No Sheen" in Airport Stormwater Runoff

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As environmental regulations regarding oil in stormwater discharges have become more stringent in recent years, more sophisticated best management practices have been implemented in an effort to comply. For example, as part of modifications made in 1997 to the Ventura County Camarillo Airport (Camarillo, Calif.), a high-efficiency oil–water separator was installed to treat stormwater runoff from the area where fuel trucks are filled. Testing

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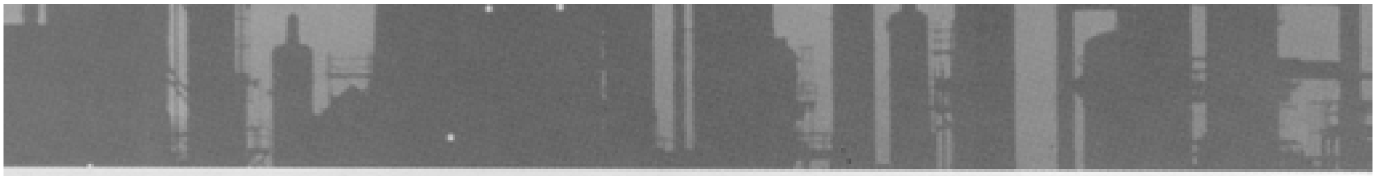
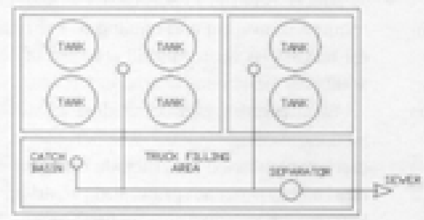


Figure 1: Tank Farm Berm and Drains



Airport Stormwater

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was conducted to demonstrate that the technology would perform as required and, after 5 years of operation, the stormwater separator has required little maintenance.

The airport's fueling area is approximately 60 x 100 ft (18 x 30 m) and has three sections separated by berms (see Figure 1, above). Two of the sections contain fuel tanks and the third comprises the location where the fueling trucks are filled before they transport the fuel to aircraft. Each bermed area includes catch basins with drains leading to a precast concrete separator vessel outfitted with several multiple-angle enhanced gravity separator plates.

Spaced 0.2 to 0.4 in. (5.1 to 10.2 mm) apart, the double-corrugated plastic plates are stacked in modules and immersed in the water flow. As water entering the system flows through the plate stacks, the oil droplets rise by their natural buoyancy to meet the undersides of the plates. The droplets are captured and separated from the water stream at the plate surface, where the oil accumulates as a film. The accumulated oil film eventually grows thick enough to separate from the plates and rise as large globules to the upper surface of the water, where it is removed periodically by a vacuum truck.

Designed by airport authority staff, the aboveground fuel farm had to be located in an area that would contain a spill of an entire storage tank, or approximately 12 000 gal (45 m^3); the rainfall from a 10-year storm, which was calculated to be a 4-in. (102-mm) rain event; and the spill of a fuel delivery truck, which can carry as much as 8000 gal (30 m^3) of fuel.

The separator installed at the airport is a vertical, cylindrical precast concrete tank with a 48-in. (1219-mm) inside diameter. Its design includes a 4-in.-diameter (100-mm-diameter) inlet pipe, inlet chamber for grit collection, concrete baffles, separating chamber containing 10 ft^3 (0.28 m^3) of multiple-angle polypropylene coalescing media, 6-in. (150-mm) outlet pipe, and cast-iron access cover (see Figure 2, below).

Stormwater or any accidental fuel spills collected by the fueling apron's berms enter drains that direct the flows to the oil–water separator. The system is a permanent structural best management practice designed to process up to 50 gal/min (190 L/min) of stormwater from the fueling area. Rainfall calculations indicated that this flow would be suitable for this application. Effluent discharged from the system must have hydrocarbon levels of 10 mg/L or less. This function is necessary to meet the Clean Water Act's requirement for "no sheen" on stormwater leaving a treatment unit.

Designing the separator to meet the 10 mg/L standard required taking into account the nature of the hydrocarbons present — in this case, jet fuel — and their configuration. Hydrocarbons in stormwater can exist in one or more of the following conditions:

Free oil. These large droplets or sheets rise freely to the surface and are removed easily in simple gravity separators.

Mechanically dispersed oil. These fine droplets range in size from a few microns up to a few millimeters. The oil found in these droplets usually results from some mechanical mixing of oil and water, such as is found in pumping or turbulent flow through a pipe. The sizes of the oil droplets practically can be plotted on a "bell curve," with some small, some large, and a predominance of average-size droplets. Average size varies depending on the amount of mixing the two liquids have undergone and the presence or absence of emulsion-causing surfactant chemicals. These dispersions may be removed using an enhanced gravity system. Most of the oil present at the airport site is expected to be in this form.

Chemically stabilized emulsions. These droplet dispersions are similar to mechanically dispersed oil, but the droplets have been stabilized by surfactants. More surfactants or more mixing will cause a smaller average droplet size. The average droplet size is important because many separation devices are designed to capture droplets by gravity or enhanced gravity separation. The larger the average droplet size, the smaller — and consequently less expensive — the separator will be.

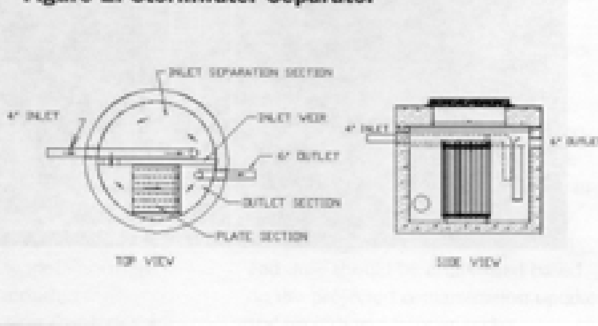
Oil adhering to solid particles. These particles can be removed by filtration or enhanced gravity separation if the combined specific gravity is different from that of the water. If the net specific gravity of the oil-coated particle is the same as that of the water, the oil will not have any gravitational incentive to rise and therefore will not be removed by any system that depends on gravity to work.

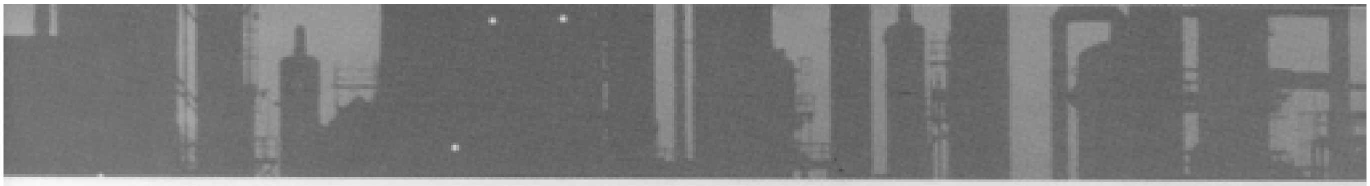
Dissolved oil. This configuration consists of truly dissolved oil or finely dispersed droplets so small — less than 5 μm — that removal by normal physical means is impossible. Dissolved oil must be removed by biological treatment, absorbents, distillation, or other nongravity means.

In a stormwater stream, the majority of the oil will be present as either free oil or mechanical dispersions of oil and may be treated readily using enhanced gravity systems. Therefore, most hydrocarbon removal systems depend on gravity or enhanced gravity separation, taking advantage of the buoyancy of the droplets.

The rising of hydrocarbon droplets in a separator is governed by Stokes' Law, which gives the rate of fall for a small sphere in a viscous liquid. When a small sphere falls under the action of gravity through a viscous medium, it ultimately acquires a constant velocity that is defined as follows:

Figure 2: Stormwater Separator





$$V_p = \frac{G}{(18 \times \mu)} \times (d_p - d_c) \times D^2 \qquad (1)$$

where

V_p = droplet settling velocity, cm/s,

G = gravitational constant, 980 cm/s^2,

μ = absolute viscosity of continuous fluid (water), poise,

d_p = density of particle (droplet), gm/cm^3,

d_c = density of continuous fluid, gm/cm^3, and

D = diameter of particle, cm.

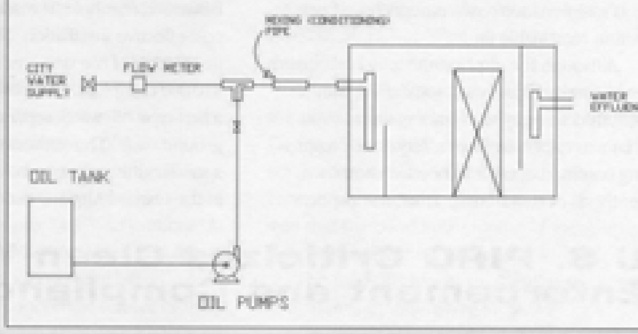
As Equation 1 shows, the important variables are the viscosity of the water, the difference in the specific gravity of the water and hydrocarbons, and the hydrocarbon droplet size. Because the oil droplets rise instead of fall, the velocity is a negative number. After these variables are known, the droplet rise velocity and, therefore, the required separator size may be calculated. Stokes' Law is only valid for spherical particles or droplets — the small oil droplets treated by the airport's separator are essentially spherical — and only in a laminar flow range. (Laminar flow proceeds slowly and in layers in the main flow direction, as opposed to turbulent flow, which moves in many directions while generally moving in the main flow direction.)

As part of the process of designing the separator for Camarillo Airport, an estimate of oil droplet sizes was made. This estimate, along with an assumption of the expected operating temperature, was used with Stokes' Law to estimate the rate at which droplets in the stormwater would rise during separation. This information was used to determine the size of the separator that would be needed to adequately treat the stormwater runoff from the airport's fueling apron.

The contract for supplying and installing the separator required testing the device under simulated operating conditions. The test was conducted using potable water under pressure from a local fire hydrant. The oil was injected under controlled conditions and the water–oil mixture was directed through a conditioning tube designed to produce a specific amount of turbulence to thoroughly mix the two liquids before the combination entered the separator inlet pipe at a sewer inlet grating (see Figure 3, above).

Although the test was designed to simulate system operations, corn oil was used for the test instead of jet fuel for environmental and safety reasons. However, because corn oil has a somewhat higher specific gravity than jet fuel, its use made the test somewhat more rigorous. Injecting the oil at a set rate and using a conditioning tube of known turbulence — as measured by the Reynolds number in the tube — parallels specifications developed by the U.S. Coast Guard and the International Maritime Organization (IMO; London) for testing shipboard bilge water separators.

Figure 3: Schematic of Flows During Test



Municipally treated water with a pH of 6.5 was obtained from a convenient fire hydrant. The normal fire hydrant valve was used to regulate the water flow rate. For the test, an oil-injection system was created using polyvinyl chloride (PVC) pipe and a 1-in. (25-mm) turbine-type flowmeter with digital readout. The flowmeter, which had been previously calibreated, measured the water flow upstream of the oil-injection point for accuracy and included a digital electronic readout of flow at any given point in time, as well as total flow. The oil was injected into the conditioning pipe through an injection tee. The injection pumps consisted of two small electrically powered bellows-type pumps operated in parallel to provide the appropriate flow rate. The pump stroke was adjusted to regulate the flow of oil to the injection tee. The conditioning pipe consisted of 2.5-in. (65-mm) schedule 80 PVC. The Reynolds number and velocity in the conditioning pipe were calculated, indicating a Reynolds number of approximately 19 000.

During the testing, samples were taken and instantaneous flow measurements were made approximately every 30 minutes (see Table 1, below). Water flows ranged from 50.0 to 47.3 gal/min (189.2 to 179.0 L/min) and the water temperature remained relatively steady, increasing from 72°F (22C°) at the start to 74°F (23°C) by the end of the test. The oil flow was measured again at the end of the test and found to be 78 mL/min. When combined with water at a flow rate of 50 gal/min (189 L/min), this oil flow is equivalent to 412 mg/L. An independent laboratory took samples and provided the results.

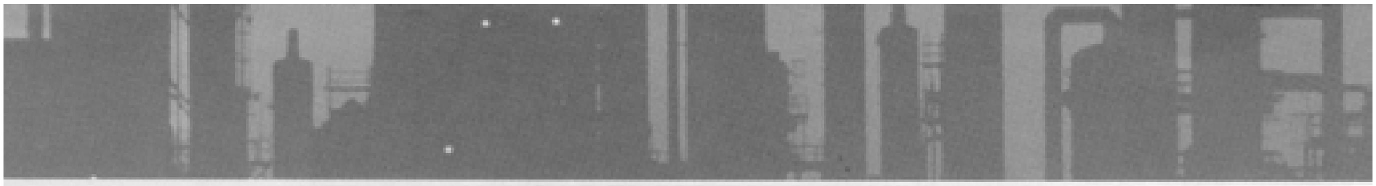
While tested under simulated design conditions, the separator showed consistent results and performed better than predicted. Whereas the system had been predicted to achieve a treatment level of 10 mg/L, it instead produced effluent with an oil content either at or below the detection limit of 3 mg/L. No sheen was seen in the outlet of the separator, confirming the results of the analysis.

Since the separator was installed in late 1997, maintenance mostly has consisted of yearly cleanings to remove accumulated oil and sludge. However, minimal amounts of oil have been captured, presumably because the fueling system is relatively new and well-maintained, keeping leakage to a minimum. Operators have been trained to take precautions to avoid spilling even small amounts of

Table 1. Results of the Ventura Camarillo Airport Fuel Apron Separator Test

Sample number	Time	Water flow, gal/min (L/min)	Effluent oil content, mg/L
1	10:00 p.m.	50.0 (189.2)	Undetectable
2	10:32 p.m.	48.0 (181.7)	3
3	11:26 p.m.	48.0 (181.7)	Undetectable
4	12:01 a.m.	47.3 (179.0)	Undetectable
5	12:30 a.m.	47.9 (181.3)	Undetectable

Note: The detection limit was considered to be < 3 mg/L.



hydrocarbons during fueling operations. Overall, the system is working as designed, and maintenance requirements have been within reasonable limits.

Although the airport authority had considered several "box-type" separators, they all required some type of underground vault that was expensive, had safety issues regarding confined entry, and needed their own methods of dewatering. Thus, the airport authority was glad to find an oil/water separator that could be installed in a standard prefabricated manhole. It made for a simple and cost-effective installation. The purchase and installation of the unit cost approximately $10 000 compared to an estimated $25 000 for a box-type oil–water separator in an underground vault. The authority has since installed a similar unit at a new underground fuel farm at the Oxnard Airport, also managed by the County of Ventura Department of Airports.

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