Design of An Oil/Grit Separator Under Dry and Wet Weather Conditions

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Highlights

- Industrial oil spills to a storm drainage system must be intercepted and treated to remove oil under all conditions.
- A triangular intercepting channel is designed to convey dry weather flow in a storm tunnel.
- An offline oil/water interceptor is designed to trap the intercepted oil under dry and wet weather conditions.

Introduction

Industrial oil spills have been identified to be a severe problem at the Humber Creek in the Etobicoke district of the City of Toronto. Unless spills are adequately controlled at the creek, the downstream wetland may be threatened. Part of the middle section of the creek was enclosed in a concrete storm tunnel. An offline oil/grit separator (OGS) with a standard circular inlet was previously constructed on the sidewall of the storm tunnel to capture spilled oil in the creek. It was found most spilled oil bypassed the OGS due to low capture capacity and inlet clogging. A new OGS with an interceptor channel was designed to improve the spill capture. Based on a physical model study, the new OGS can capture the target oil spill volume inside the OGS under dry and wet weather conditions. The following sections describe the design of the new OGS and the physical model testing.

Methodology

Design oil spill volume and conditions

Based on the spill records from the Ministry of the Environment's Spill Action Centre, the most frequent oil spills at the Humber Creek were located at parking areas and gas stations of the upstream industrial part of the subwatershed. An analysis of spill event volumes indicated that the design oil storage capacity of the oil spill control system should be at least 1000 L. It was also determined that most spills occurred during dry weather. Thus, the design flow condition was the baseflow of the creek, which was measured to be 120 L/s.

Design of OGS and inlet diversion channel

Figs 1 and 2 show the design of the tilted plate OGS and the triangular inlet diversion channel. The inlet diversion was designed as a 45° triangular lateral drop channel with a longitudinal slope of 5% that could carry 120 L/s and push sediment into the OGS. The rising and falling ramps of the channel were also designed to be horizontal so the full length of the drop channel can be used to convey the flow. As a result, the downstream cross-section has larger dimensions than those at the upstream end. The falling ramp of the drop channel also serves as an overflow spillway for wet weather flow. The tilted-plate OGS (with tilted plate settlers) was designed to trap oil droplets with a much smaller area compared to the traditional OGS (API, 1990; Iggleden, 1973). The standard tilted-plate separator (TPS) pack consists of 47 corrugated plates in a unit of 1750 mm long by 1000 mm wide by 1000 mm high. The plates are held at a spacing of 20 mm by supporting combs at each end of the pack. There are 46 compartments for bulk flow and oil globule separation, with a total plate surface area of 69 m^2. However, the total plate surface area is not fully utilized due to hydraulic turbulence. The effective surface area available for separation is therefore 43.5 m^2.

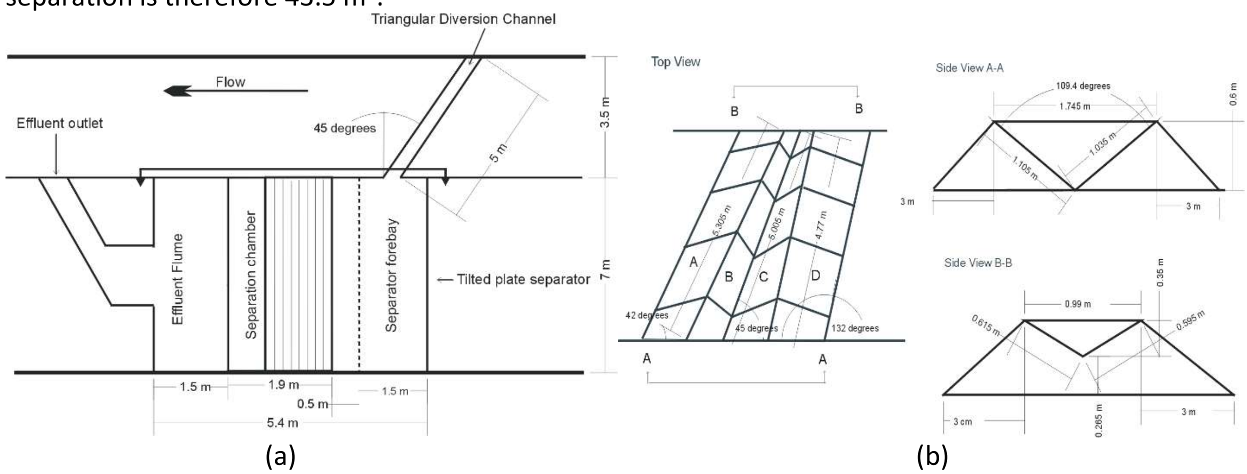

Figure 1. The tilted plate OGS and the lateral intercepting channel.

Physical model analysis

Using a length scale of 1:5, the physical model was constructed, as illustrated in Fig. 2. Styrofoam and the fishing tank solids were used to simulate floating oil and sediments. The tested flowrate at the physical model ranged from 2 to 70 L/s.

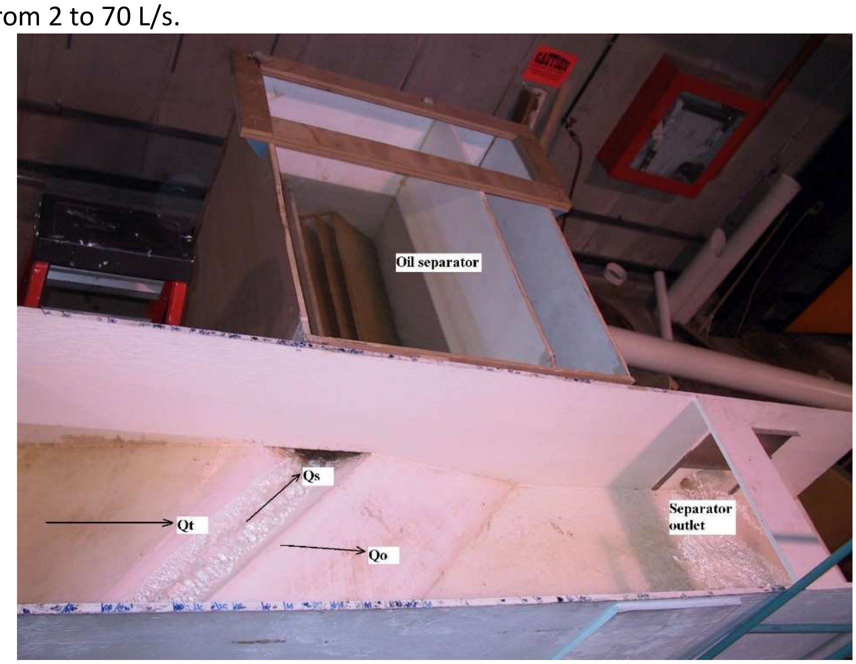

Figure 2. The Physical model of OGS and intercepting channel.

Results and discussion

The first experiment was to determine the maximum flow that could be conveyed by the diversion channel without any overflow (i.e., baseflow). The measured flow was 2.34 L/s. The projected flow was about 131 L/s which is close to the design baseflow of Humber Creek. As the total flow (Q_t) increased, the flow through the OGS (Q_s) also increased until Q_t reached about 70 L/s. Beyond a total flow (Q_t) of 70 L/s, the flow through the OGS (Q_s) began to decrease. Thus, the maximum flow through the OGS was about 21 L/s at the model or 1170 L/s in an actual situation using the discharge scale.

The 45° diversion channel allowed water to enter the OGS at an angle. As a result, a vortex was observed inside the OGS. Both the Styrofoam and the fishing tank solids were trapped inside the separator at higher flows without any sign of being flushed out. It was observed that the overflow (Q_o) from the diversion channel might have some impact on the flow through the separator (Q_s). When the total flow of the storm tunnel (Q_t) was low, the outflow from the OGS (Q_s) was not backup by the overflow (Q_o) from the diversion channel. At higher total flows, the backwater effect of the overflow limited the treated effluent from the OGS and prevented any trapped oil from being flushed out.

Conclusions and future work

The preliminary design procedure of oil spill control systems for the storm tunnel is different from that recommended by American Petroleum Institute (API, 1990) for wastewater treatment. The highly variable flow at the storm tunnel can significantly affect the treatment performance of the OGS. Thus, a flow diversion structure should always be designed to control the flow entering the OGS. An angled drop diversion channel can convey not only flow but also floatables and sediments to the OGS, where regular maintenance can be performed easily. The OGS should be designed to prevent any inlet clogging that may trigger overflow at the diversion channel and facilitate maintenance activities such as the removal of trapped oil, floatables, and sediments.

Results of the physical model study confirmed the designed conveyance capacity of the proposed diversion channel. However, the angled diversion channel also caused a vortex action inside the first and second chambers of the OGS. The physical model study also identified the maximum flow at the proposed OGS under high flow conditions. The maximum flow through the oil/water separator first increased and subsequently decreased due to backwater at the OGS outlet at high flow conditions. Although the proposed OGS might experience flows more significant than the designed treatment rate, laboratory observations indicated that light and heavy materials trapped insider the OGS might not be flushed out.

The final detailed design of the spill control system at the Humber Creek should address the vortex problem created by the angled diversion channel. Installation of baffles at the 2nd chamber may be one of the potential solutions for the vortex problem. A monitoring program should also be designed to assess the performance and maintenance requirements of the spill control system.

References

American Petroleum Institute (API). (1990). Monographs on Refinery Environmental Control – Management of Water Discharges, Design and Operation of oil/water separators Refining Department, API Publication 241.

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