ENVIRONMENT CANADA
CONSERVATION AND PROTECTION
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PACIFIC AND YUKON REGION

A REVIEW OF STORMWATER MANAGEMENT PRACTICES AT PETROLEUM PRODUCT BULK TERMINALS

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Prepared by:

Marie-Nelie Elien

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Manager
Petroleum, Chemical, Air & Hazardous Wastes Program
Environmental Protection
Conservation and Protection
Environment Canada
Kapilano 100 - Park Royal South Mall
West Vancouver, British Columbia
V7T 1A2

RESUME

Les eaux d'écoulement d'averse sont la principale source de déversement d'effluent des terminaux de produits pétroliers en vrac. Les principaux polluants associés avec ces opérations sont les hydrocarbures et les graisses, et quelques fois les solides en suspension. Ce rapport adresse plusieurs aspects de la gestion des eaux d'écoulement à ces facilités incluant les technologies de traitement, les procédures d'opération, les procédures d'échantillonnage et d'analyses, et les instruments de mesure. Ce rapport est basé sur une revue de la littérature, ainsi que plusieurs visites sur le terrain conduites pour documenter les pratiques courantes. Des recommendations sont aussi présentées.

ABSTRACT

Stormwater runoff is the major source of effluent discharge from petroleum bulk terminals. The major pollutants associated with these operations are oil and grease and sometimes suspended solids. This report addresses several aspects of stormwater management at these facilities including treatment technologies, operating procedures, sampling and analytical procedures, and monitoring devices. It is based on a literature review, and several site visits conducted to document current practices. Recommendations are presented.

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1.0 INTRODUCTION

Bulk terminals are used as marketing facilities for petroleum products. There are a number of these facilities in British Columbia whose normal operations include the receipt, storage and distribution of various petroleum products such as gasoline, diesel, furnace oils and aviation fuels. Due to the nature of these operations, petroleum products can be released in the stormwater runoff.

Environment Canada is concerned about the environmental impacts of discharges from these facilities on fish and fish habitat. Potential deleterious effects include acute and/or chronic toxicity, coating of the bottom of the water body and the consequent destruction of benthal organisms, and tainting of fish flesh.

This report provides information on several aspects of stormwater management at petroleum bulk terminals that have not yet been addressed recently in a single document, including treatment technologies, operating procedures, sampling and analysis, and monitoring.

2.0 APPROACH

This report is primarily based on information collected from Environmental Protection (EP), a literature review, and site visits.

Existing facilities in British Columbia were identified and inventoried from EP files and database. The site visits were limited to bulk terminals in The Lower Mainland which provided a representative cross section of operations that may be encountered elsewhere in B.C. A questionnaire was devised to facilitate data collection during the site visits which also included stormwater sampling.

Stormwater treatment technologies and sampling and analytical procedures are reviewed, and the effectiveness of pollution control measures assessed. Recommendations are presented for appropriate stormwater management.

3.0 BACKGROUND

3.1 Legislative Overview

Effluent discharges from this industry are regulated mainly through the federal Fisheries Act and the British Columbia Waste Management Act.

The Fisheries Act provides for the protection of fish and fish habitat. Environment Canada and the Department of Fisheries and Oceans (DFO) co-administer Section 36(3) of the Fisheries Act which makes it illegal to deposit "a deleterious substance" into fishery waters. A number of effluent guidelines and regulations have been developed under the Act for various industries to ensure that minimum national standards are met for these effluents. Although none has been developed specifically for petroleum product storage and distribution operations, the Petroleum Refinery Effluent Regulations and Guidelines, established in 1973, have been the basis for regulatory control of effluent discharges from these facilities.

The provincial Ministry of Environment (MOE) issues effluent permits pursuant to the Waste Management Act. Permits regulate discharges to the environment (air, land or water) by specifying contaminant limits. The ministry has established a series of pollution control objectives which are used in setting permit limits. During the application process, permits are also referred to Environmental Protection (Environment Canada). EP coordinates the federal response which includes comments from DFO and, in some cases, other federal agencies. Applicable provincial control objectives (Department of Lands, Forests, and Water Resources, 1974) and federal guidelines (Environment Canada, 1974) are summarized in Table 1.

Table 1: Provincial Objectives and Federal Guidelines Applicable to Effluent Discharges from Bulk Terminals (Oil and Grease).

	Discharges To Marine Waters	To Fresh Waters
	(mg/L)	
Provincial Objectives (Level A)	10	5
Federal Guidelines	10	10

3.2 Petroleum Marketing Industry Fundamentals

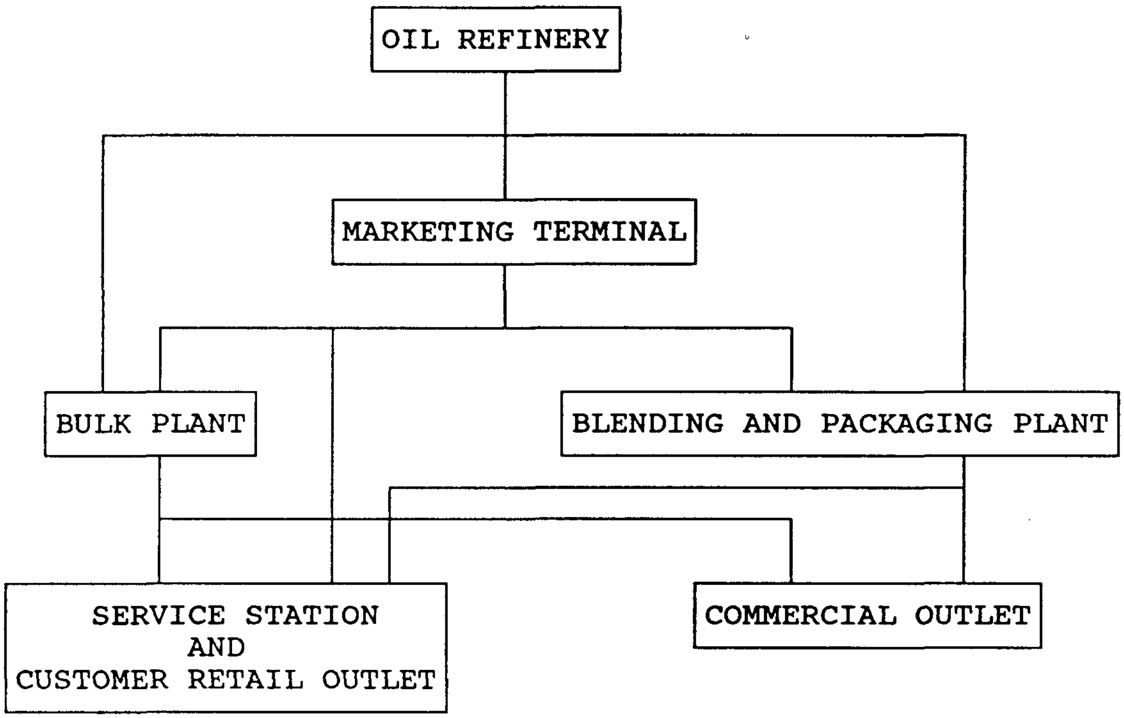
The petroleum marketing network consists of a number of storage facilities or transfer points that are used for the distribution of petroleum products to consumers. As illustrated in Figure 1, it typically includes various agencies designated as bulk terminals, bulk plants, blending and packaging plants, service stations and other customer retail outlets, and commercial outlets (PACE, 1987).

These operations are briefly described as follows:

Bulk Terminals

Bulk terminals, also referred to as marketing terminals, are the largest of the distribution centers and are usually owned and operated by major oil companies. Products

Figure 1: Typical Petroleum Marketing Distribution Network



are generally received by pipeline or barge from the parent refinery and may be delivered by either pipeline, tank car, tank truck or barge. These centers serve bulk plants, service stations and large customer accounts. The most common products handled are diesel, fuel oil, gasoline and aviation fuels.

Bulk Plants

Bulk plants are much smaller than bulk terminals in terms of size and storage capacity. Their basic function is local distribution. They generally receive products by tank car or by tank truck and deliver by tank truck.

Blending and packaging plants

Blending and packaging plants receive petroleum base stocks usually from the refinery, and these are stored along with chemical additives in small storage tanks. The stocks are then blended to produce formulations of the desired characteristics. These commodities and other specialty products such as solvents and lighter fluids are packaged in containers and distributed to retail markets.

Service stations and other customer retail outlets

Service stations and other customer retail outlets, such as convenience stores, are the main and final distribution point for the general motoring public. Service stations are usually equipped with underground storage tanks for gasoline and diesel fuels and might sell other products such as natural gas, propane, lubricating oils and specialty automotive products.

Commercial outlets

Commercial outlets are dispensing facilities consisting of one or more underground or above ground tanks that are owned by independent users. These facilities are usually owned and operated by organizations that have a fleet of vehicles.

The term "bulk terminals" is used throughout the report. However, it should be noted that the material presented applies to various types of operations including those that may be designated as bulk terminals, bulk plants, tank farms, keylock and cardlock facilities. Any of the following facilities may be encountered at these operations:

-A tank farm which consists of a number of large steel above ground storage tanks in a dyked area, as well as related facilities such as pipelines and pumps.

-Loading and unloading facilities for receiving and distributing the products. They consist of loading or unloading racks for tank trucks and possibly tank cars, and/or dock facilities for barges.

-A cardlock or keylock facility for dispensing fuel directly to customers.

-A warehouse facility for the storage and handling of drummed and packaged products such as lube oils, grease, brake fluids and transmission oils.

-Other auxiliary facilities such as an office and truck maintenance and/or truck washing facilities.

3.3 Inventory of Operations

An inventory of bulk facilities in British Columbia along with MOE permit stormwater discharge requirements is in Appendix A. It is primarily based on information acquired from Environmental Protection's database, and files which include copies of permits and related correspondance.

Most of the 29 operations identified are owned by major oil companies. Stormwater is usually discharged intermittently, depending on rainfall conditions. Simple gravity and API oil-water separators are the most popular methods of stormwater treatment used. Other treatment methods employed include ponds or lagoons, infiltration basins or rock pits, air flotation, and coalescing plate separators. All permits include a requirement for oil and grease or total hydrocarbons which varies from 5 to 20 mg/L, based on the site specific assessment by the Waste Management Branch. The permit may also include a requirement for other parameters such as solids and toxicity in cases where these are of concern.

4.0 STORMWATER MANAGEMENT

4.1 Stormwater Characteristics

Along with the stormwater quality requirements, the characteristics of the stormwater determine the degree of treatment required and hence, the level of complexity of the system. This section provides a review of stormwater characteristics at petroleum bulk terminals.

Sources of Effluent Discharge

For these facilities, effluent discharge is the result of stormwater runoff at the site, which may be contaminated to varying degrees with petroleum products depending on whether it originates from operating or non-operating areas. Other possible sources of effluent discharge include water which accumulates at the bottom of the storage tanks due to condensation (tank water bottoms), washwater from tank truck washing and loading/unloading rack cleaning, ballast water, and accidental product spills; these discharges are infrequent and usually of low volume. Ballast water is normally handled at refineries and therefore not a primary concern. Product spills should be rare occurences and their impact can be minimized by following certain spill containment procedures. Recommendations for spill prevention and containment are covered in a number of documents (BCPA 1984, EPS 1986, and PACE 1979 and 1980).

Quality of the Discharge

Some variation in runoff quality is to be expected due to differences in type and complexity of operation. Runoff quality is affected by a number of factors which are summarized in IEC (1978):

-Type of products handled at the facility,
-Loading/unloading rack activity frequency,
-Antecedent dry period,
-Effectiveness of housekeeping operations,
-Frequency, duration and intensity of precipitation,
-Type of ground surface and area of influence, and
-Degree of segragation of flows.

Table 2 summarizes reported concentrations for various parameters based on an API survey (1974) of 12 terminals and a PACE survey (1978) of 16 terminals. Additional information on the API (1974) survey is available in the IEC (1978) study.

Table 2: Reported Concentrations of Various Parameters in Bulk Terminal Stormwater

Parameter	Percentile*	Source		
		API (1974)	PACE (1978)	
		Before Treatment	Before Treatment	After Treatment
pH	50	6.5	7.1	6.9
	75	6.7	7.6	7.4
Oil & Grease (mg/L)	50	51	14	2
	75	-	32	7
Suspended Solids (mg/L)	50	52	147	53
	75	75	334	140
Phenols (mg/L)	50	-	0.015	0.024
	75	-	0.045	0.061

* The percentile value gives the probability that the observed value will be below that indicated here. Eg. there is a 75% probability that the pH value observed at a terminal will be below 6.7

The data indicates that oil and grease and suspended solids are the main pollutants of concern. PACE (1978) also analyzed samples from two terminals for ammonia-nitrogen and sulphide. The reported concentrations were very low (1.06 mg/L and 0.526 mg/L for ammonia-nitrogen and less than 0.1 [illegible]

Sources of Contamination

The principal areas where the runoff may pick up small quantities of oil and grease are the tank farm area and the loading/unloading facilities. Table 3 gives the oil and grease contribution of various sources of untreated stormwater. The data which is based on the API (1974) and PACE (1978) studies, was presented in graphical form in IEC (1978) and obtained by interpolation. It indicates that loading areas contribute the highest concentrations of oil and grease.

Table 3: Oil and Grease Contribution from Various Sources of Untreated Stormwater (IEC 1978) - mg/L

Stormwater Source	Percentile		
	50	75	90
Loading Rack Only	80	1000	3500
Loading Rack, Driveways and/or Parking Areas, Pump Areas	16	35	130
Loading Rack, Tank Farm, Driveways and/or Parking Areas, Pump Areas	5	15	40

Suspended solids contamination is mostly due to the input of sand and dust from truck traffic, and occasionally to the input of absorbents and sand used to clean up major spills.

Phenol contamination normally occurs from contact with gasoline. PACE (1978) found particularly high phenol concentrations in gasoline tank water bottoms. Average phenol concentrations of 76.4 mg/L and 81 mg/L were reported for two different grades of gasoline. Phenol concentrations of less than 15 mg/L were found for other products such as stove oil, turbo jet B fuel, diesel oil and furnace oil. Very high concentrations of suspended solids (8 to 1 200 mg/L) were also reported for the tank water bottom samples regardless of the product stored. Tank water bottoms may contain other toxic components such as organic lead compounds, heavy metals, benzo(a)pyrene and other aromatics (PACE, 1987).

Characteristics of Oil in Wastewater

The condition of the oil-water mixture also needs consideration when selecting a treatment system. Oil may be present as free oil, dispersed oil, emulsified oil or dissolved oil. Figure 2 shows the classification and size range of oil droplets found in oil-water mixtures. Free oil and dispersed oil rise to the surface of quiescent water in a reasonable period of time, with a rising rate that is mostly a function of the oil droplet size. Emulsified oil is formed either mechanically due to the action of centrifugal pumps, flow restricting orifices or other devices which break up the oil droplets into smaller ones, or chemically due to the action of chemical agents such as detergents. Mechanically or chemically emulsified oil is in such a finely divided state that the droplets do not rise in water even after a long detention time. Dissolved or soluble oil primarily consists of compounds such as phenolics, short chain carboxylics, naphthenic acids and other compounds that are known to be biodegradable (Sun et al., 1987). Some, or all, of these conditions may occur simultaneously.

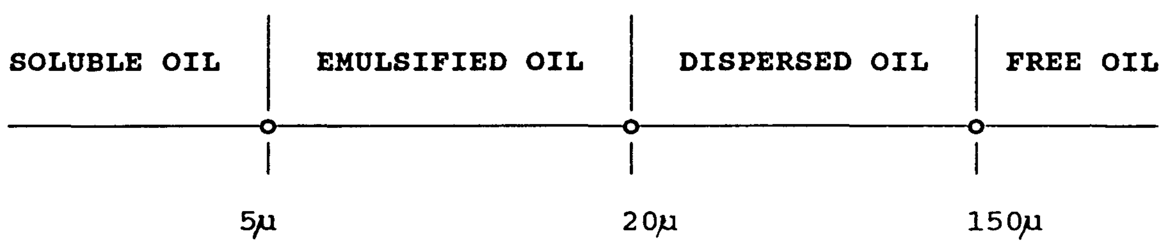


Figure 2. Classification and Size Range of Oil Droplets Found in Oil-Water Mixtures (Rhee et al., 1987)

4.2 Review of Treatment Technologies

Reviews of treatment technologies for oil-water separation are found in PACE (1978), IEC (1978) and Cheremisinoff (1987). The treatment technologies vary in complexity but most take advantage of the difference in specific gravities between oil and water to achieve separation. This section is a summary of the technologies available.

4.2.1 Gravity Separators

Simple Gravity Separators

A gravity separator may be just a simple one compartment tank, which allows free oils and solids to separate from the water. Simple gravity separators come in different shapes and dimensions and are designed to be used at facilities that generate low volumes of stormwater. The design basis for these separators varies considerably from one facility to another. Figure 3 illustrates a small circular gravity separator.

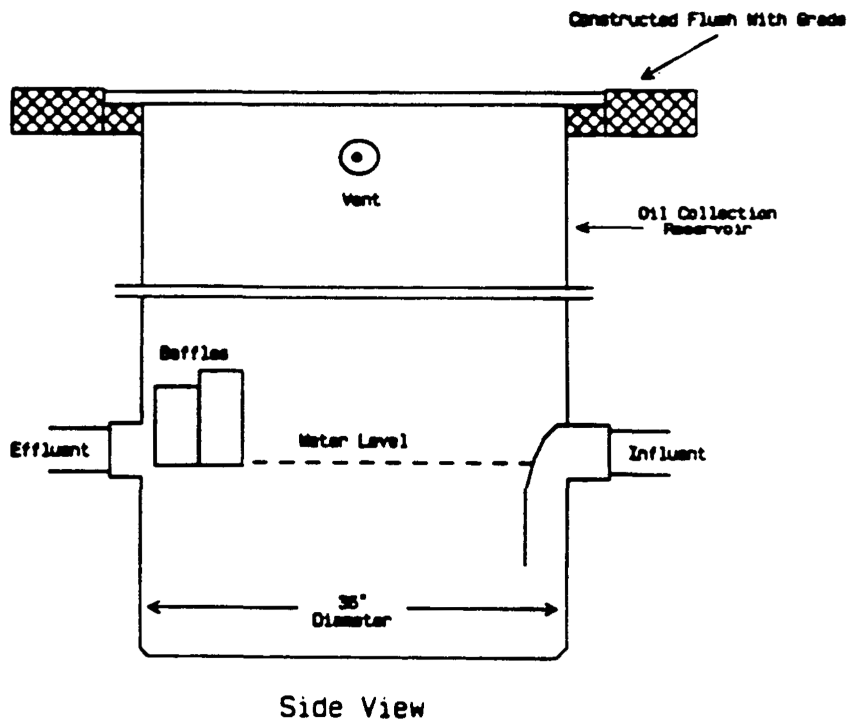


Figure 3: Simple Gravity Separator (Kilroy, 1986)

<u>API Separators</u>

API separators are large units that are designed in accordance with a specific procedure developed by the American

Petroleum Institute (API, Manual on Disposal of Refinery Wastes, 1969). Such separators are typically multichanneled and rectangular, made of reinforced concrete or steel, and designed for a specific minimum residence time and a maximum flow rate. A quiescent zone allows oil to rise to the surface. Suspended solids will coincidentally settle. API separators do not separate oil droplets smaller than the size of free oil nor do they break emulsions. The main components of an API separator include inlet and outlet chambers, a pretreatment stage, separating stages, baffles, and skimming devices. Other options include flight scrapers, covers or floating roofs, submersible sludge pumps and thermal heaters. Figure 4 illustrates an API separator with adjustable oil skimmer.

Parallel Plate Separators

Parallel plate separators are improvements over the API separators which are able to separate oil of smaller particle size. These systems utilize packs of parallel plates made of a corrosion resistant plastic material, spaced a few centimeters apart and normally inclined. Figure 5 illustrates the Corrugated Plate Interceptor (CPI) which was originally developed by Royal Dutch Shell and Pielkenrood-Vinitex of the Netherlands. As the oily water flows between the plates, the oil globules tend to coalesce into larger globules on the underside of the plates and then rise to the surface. Settled solids collect on the top surface of the plates and slide down to the bottom of the separator. Due to the design, parallel plate separators are more efficient, less subject to turbulence caused by high velocities, and require less space than API separators. Parallel plate packs can also be purchased separately and installed in existing separators to improve treatment efficiency.

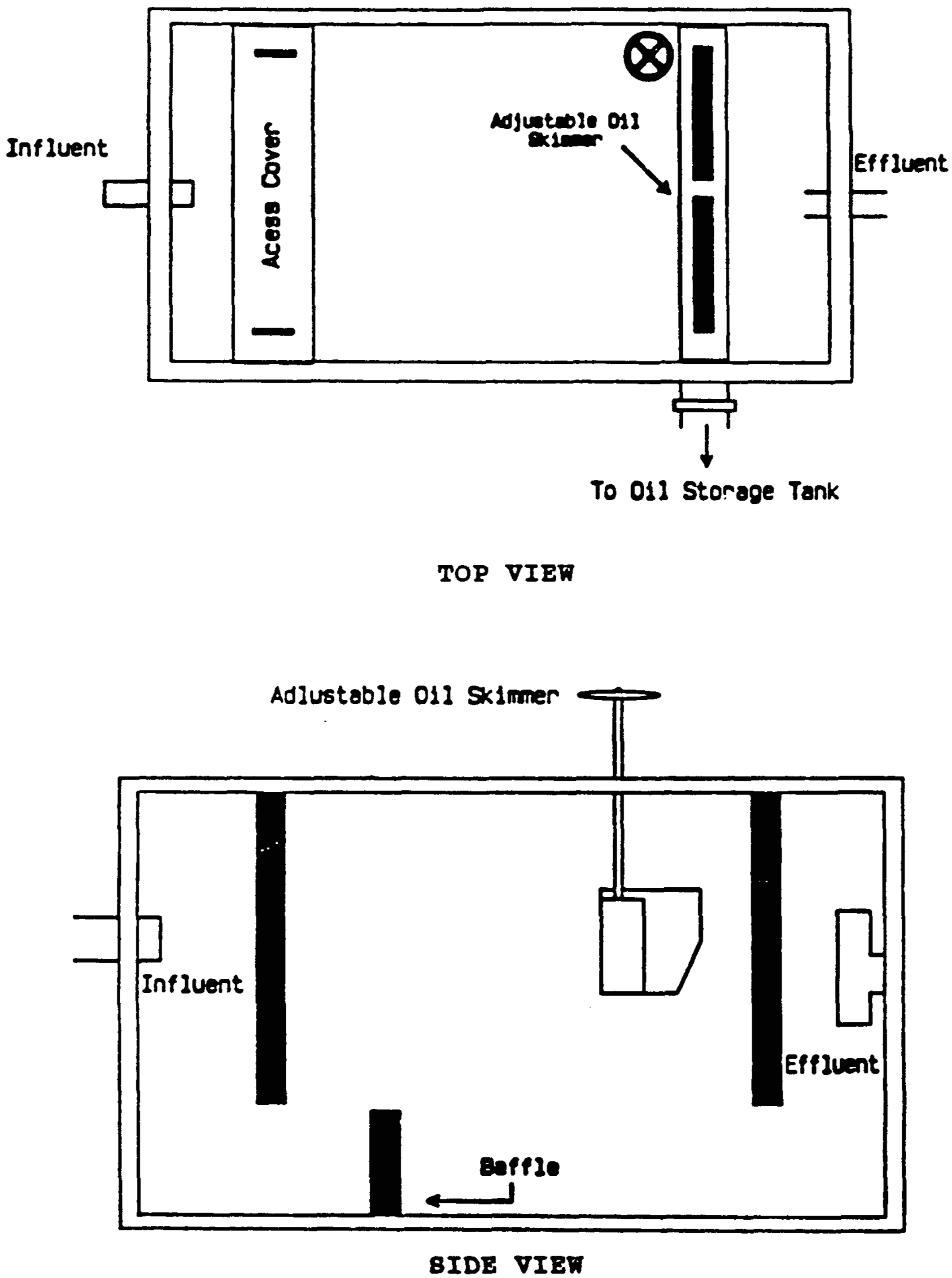


Figure 4: API Separator with Adjustable Oil Skimmer (Kilroy, 1986)

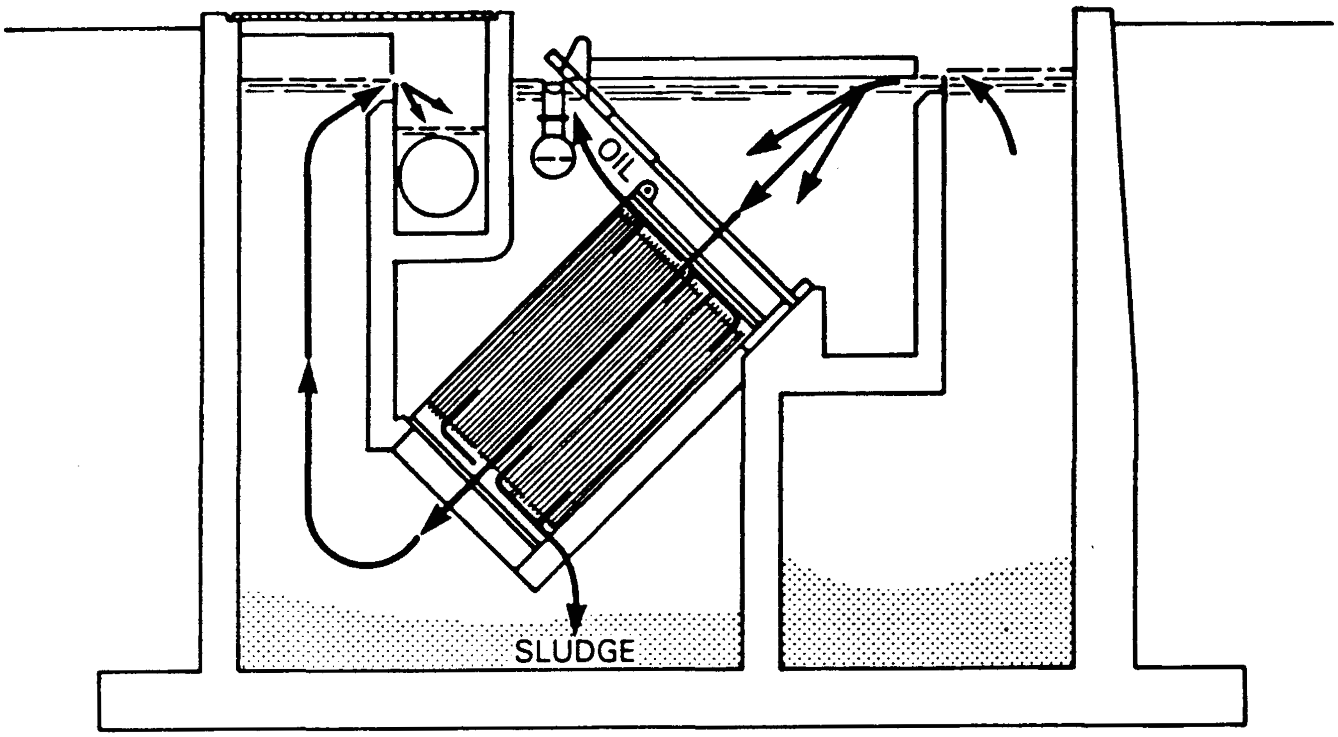


Figure 5: CPI Separator (API, 1979)

Ponds and lagoons

If sufficient land area is available, a pond or lagoon can be considered. The treatment consists of gravity separation of suspended solids and oil and grease and a slow reduction of oil and grease through biological oxidation. Ponds can be part of a system which includes other treatment works or serve as the only treatment system. PACE (1978) analyzed eight samples of bulk terminal stormwater which had been treated only by a lagoon, from the month of May to the month of September. The oil and grease effluent concentrations varied from 2 mg/L to 31 mg/L and averaged 12 mg/L. The influent levels were not reported. Ponds also provide spill containment. The water contained may also be allowed to seep into the ground (infiltration basins), where further treatment is presumably provided by the soil media. Ponds, however, can produce large amounts of algae depending on the climate, which may render a high suspended solids level in the effluent. Maintenance work to remove accumulated sludge and algae may be difficult.

4.2.2 Air Flotation Processes

Air flotation can be used for the separation of emulsified oil. Small air bubbles introduced into the wastewater float to the surface. While rising, the fine air bubbles attach themselves to oil globules or particles and carry them to the surface. Coagulant or flocculant aids may also be used to enhance efficiency. There are two methods of air flotation, dissolved and induced. The major differences in the two processes are the method by which air is introduced and the size of the air bubbles produced. The dissolved air flotation method is employed more frequently because of its reliability.

Dissolved Air Flotation

Dissolved air flotation processes include the following basic components:

- Pressurizing pump,
- Air injection facilities,
- Retention tank to provide air-liquid contact,
- Pressure-reducing valve, and
- Flotation tank

Bubbles averaging 10 to 100 microns diameter (Cheremisinoff, 1987) are produced by pressure reduction. The process may operate in either of three different modes: Full stream, split stream or recycle stream pressurization. The latter mode is more common since superior effluent quality and economy in power are achieved. Figure 6 illustrates the three modes of operation.

Induced Air Flotation

In the induced air flotation process, bubbles are generated by propellers or diffusion of air through a porous media. Bubbles are usually an order of magnitude larger than those generated in a dissolved air flotation system. Designs based on the induced air principle generally result in multi-cell units. Figure 7 illustrates the induced air process.

4.2.3 Other Treatment Methods

A number of other treatment processes can be applied to oily wastewaters. Their use for the treatment of bulk terminal runoff is often not justified because they are either impractical or too costly. Very limited data is available on their use and performance at bulk terminals. These methods include:

Biological Treatment

Biological treatment processes rely on organisms to break down waste organic compounds. The application of these processes to remove oil, however, is limited to dilute wastewaters contaminated only with dissolved oils. Free oil tends to coat the organisms and can cause system failure.

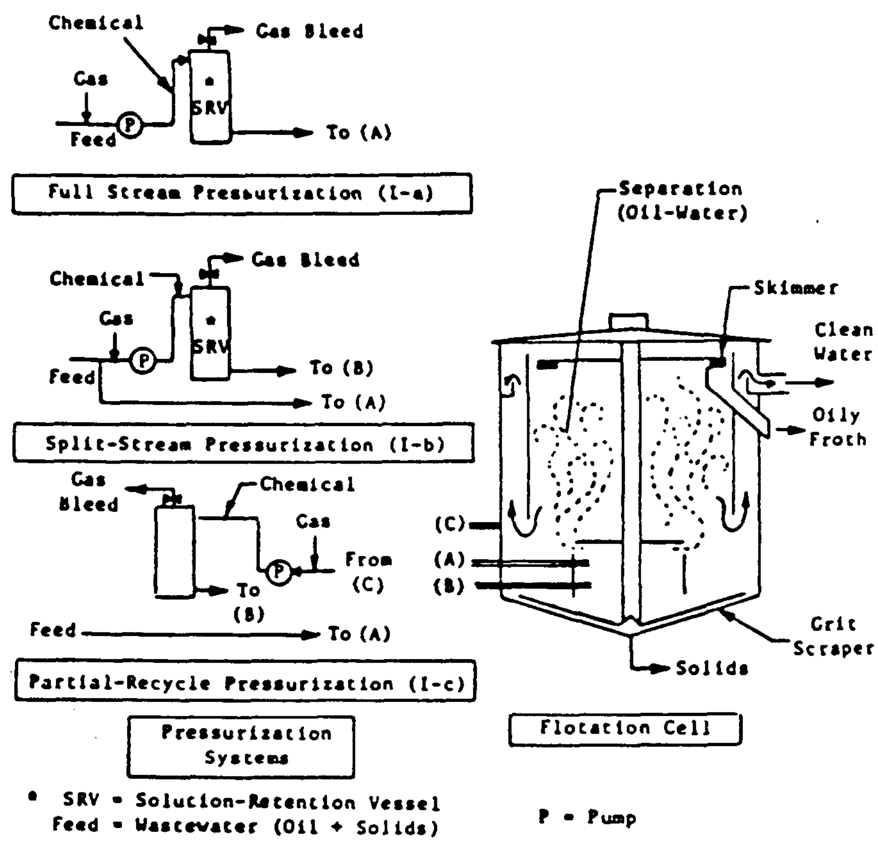


Figure 6: Dissolved Air Flotation Process (Cheremisinoff, 1987)

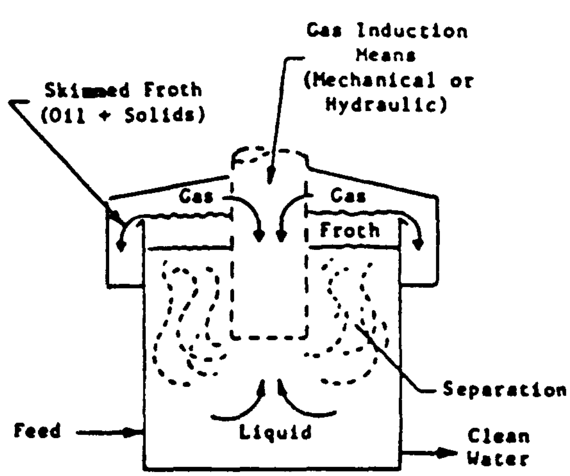


Figure 7: Induced Air Flotation Process (Cheremisinoff, 1987)

Filtration

Filtration through beds of porous media has been used in refinery operations generally to polish effluent from API separators. A wide variety of filter media can be used but conventional systems utilize beds of anthracite coal and sand.

Membrane Separation

Membrane separation methods such as reverse osmosis and ultrafiltration are pressure driven processes based on the sieving action of a membrane retaining molecules larger than the membrane pores. These methods can produce virtually oil-free water. Membrane fouling is likely to occur frequently when applied to oily wastewaters. Large capital and operating costs are associated with membrane separation processes.

Other Coalescence Techniques

Apart from parallel plates, filter packs made of a fibrous media or loose media can be used for the coalescence of small droplets into larger droplets. These units operate on the same principle as the corrugated plate separator but are more sensitive to build-up of particulate materials within the filter pack.

Sorbents

Sorbents such as activated carbon can be used as filters for the treatment of oily waters. However, they are generally used just for polishing as the capital and operating costs can be high.

Centrifugation

Although centrifugation is an efficient oil-water-solids separation technique, it is too expensive to be used at bulk terminals, where oil and solids concentrations are relatively low.

4.3 Commercially Available Treatment Systems

PACE (1978) carried out an analysis of commercially available oil-water separators. The investigation focused on gravity separators as they were identified as being the best practical and economical treatment alternatives for bulk terminal runoff. The following systems were included in the investigation:

API Separators

- AFL Gravity Differential Separator (by AFL Industries, Inc.)
- Hydro-Gard Oil-Water Separator (by Inland Environmental)
- Rex API Oil-Water Separator (by Rex Chainbelt Inc.)

Parallel Plate Separators

- Corrugated Plate Separator (CPS); (by Pilkenroad Separator Company)
- Corrugated Plate Separator (CPS); (by Heil Process Equipment Company)
- Claripack Multiple Phase Clarifier; (by Control and Metering)

Coalescing and Porous Media Separators

- G.E. Oil-Water Separator (by General Electric Company)
- AFL Polishing Pack Separator (by AFL Industries, Inc.)
- Hyde Oil-Water Separator (by Hyde Products, Inc.)

PACE observed that the CPS units offered more advantages in comparison to the API separators, including high performance, small space requirements and lower cost. However, the CPS units also had some disadvantages such as non-uniform tank configuration, deep excavation requirements and more demanding maintenance requirements. PACE also observed that the coalescing and porous media separators were very efficient but required considerably more maintenance than the other separators.

A review of commercially available treatment systems for oily wastewaters is presented in Appendix B. The survey is based on a more recent collection of vendor literature. The systems reviewed utilize a wide range of treatment methods including API, parallel plates and membrane separation, filtration, coalescence, centrifugation and air flotation. Skimmer devices are also included. The type of wastewaters treated, treatment method, available capacity, and effluent quality achieved are reported as claimed in the vendors' literature. It should be noted that influent concentrations are seldom reported.

5.0 MONITORING

5.1 Sampling Procedures

Due to the low solubility of oils and greases in water, a contaminated discharge will likely be a two-phase system. The distribution of oils and greases will not be uniform unless the mixture is completely emulsified or in a very fine stable dispersion, which makes the task of obtaining a representative sample very difficult. Certain precautions can be taken during sampling to obtain a representative sample:

-The sample should be collected in a clean, dry glass container with a plastic screw-type cap. If a stopper is used, it should be made of glass or of inert plastic (such as teflon). Cork or other absorbent materials must not be used unless covered with aluminum foil.

-The sample must be of adequate quantity for accurate analysis. In general, the larger the sample, the more likely it is to be representative but for practical reasons the usual sample size is one liter.

-An air space should be left above the liquid in the sampling container to facilitate handling during analysis.

-The sampling container should not be rinsed with the sample before it is drawn as oils and greases may adhere to the inside of the container and lead to a false high reading. For this same reason, the sample should be collected directly into the sample container and the entire sample should be analyzed. The collection of a composite sample, which requires that a series of small samples are combined into one large container, is therefore impractical. It is better to examine discreet samples collected at prescribed time intervals to obtain the average composition over an extended period.

-A sampling facility should be provided along with the treatment works. If none exists, good judgment is required when selecting the location and manner by which the sample is drawn. It is preferable to sample at a point where the water composition is reasonably homogeneous. This would be at a point where the flow is rapid or turbulent and the oil has had a chance to mix with the water, such as downstream of a pump or constriction (e.g. a weir). When sampling out of a basin where no such conditions exist, samples should be taken at different points or different depths or both.

-When drawing a sample from a pipeline, the liquid should be allowed to flow for two to three minutes before taking the sample.

-The sample should be sent to the laboratory for analysis as soon as possible after collection. If analysis is to be delayed for more than a few hours, the sample should be preserved by the addition of 5 mL HCl (hydrochloric acid) and kept cool at 4 ^{o}C.

5.2 Oil and Grease Analytical Procedures

5.2.1 Definition of the Term "Oil and Grease"

The term "oil and grease" is used to describe a wide variety of substances. Chemically, this includes hydrocarbons of mineral origin (and therefore most petroleum products) and glycerides of animal and vegetable origin that are liquid or solid at ordinary temperatures. Another significant feature implied is that the substance is insoluble in water.

The determination of "oil and grease" is commonly by solvent extraction. Therefore, analytically the term refers to any matter which is extractable by the solvent used. This includes the classes of materials mentioned above and also other solvent extractable substances which would not fit the conventional description of "oil and grease" because they are water soluble. These soluble substances are considered as interferences in oil and grease analyses despite their classification as "soluble oil and grease".

The term "oil and grease" is also often used interchangeably with terms such as "hydrocarbons" and "petroleum products" which are much more specific in their meaning. This often leads to confusion as it is not always known what is being referred to. For example, stormwater discharge permit conditions might include a limit for "oil and grease", "total hydrocarbons" or "petroleum products" and, in some cases there is a separate requirement for both "oil and grease" and "total hydrocarbons". The following sections, which include a discussion of analytical procedures and their limitations, will shed some light on the use of these terms and the appropriateness of certain oil and grease analytical procedures.

5.2.2 Description of Commonly Used Test Methods

The following is a summary of the procedures which are covered in more detail in the Standard Methods (American Public Health Association, 1985).

The Partition-Gravimetric Method

In this test method, 1 liter of sample is acidified to pH 2 or lower and transferred to a separatory funnel. The sample is extracted serially with three 30 mL volumes of trichlorotrifluoroethane (freon). The separated solvent extracts are combined and filtered into a distilling flask through a solvent moistened filter paper. The solvent is evaporated by immersing the flask in a 70 ^{o}C water bath. The flask is cooled and the residue is determined gravimetrically.

<u>The Partition-Infrared Method</u>

This method is based on the measurement of absorbance of the extract in the infrared region. The carbon-hydrogen bonds contained in hydrocarbons exhibit a very distinct energy band in the range of 3.4 to 3.5 microns. The sample is acidified and extracted as in the Partition-Gravimetric method. The extracts are combined and diluted with the solvent to a final volume of 100 mL. A series of standards are prepared with a reference oil. The infrared absorbance of the sample extract is measured and compared with that of the standards to obtain a quantification.

<u>The Soxhlet Extraction Method</u>

The sample is acidified and filtered through a filtering device precoated with diatomaceous earth. The material collected by the filter is then dried in a hot-air oven at 103^{o}C and is contacted with freon in a Soxhlet apparatus for 4 hours. The solvent containing the extracted materials is then evaporated in a water bath at 70^{o}C and the residue is determined gravimetrically.

<u>The Hydrocarbon Method</u>

This method involves the addition of silica gel to the solvent after the extraction procedure to remove polar components. These include lower molecular weight aromatics, acids, surfactants, hydrocarbon derivatives of chlorine, sulfur, and nitrogen, and other water soluble organic compounds. The substances that remain are designated hydrocarbons. This procedure can be introduced in any of the aforementioned methods before final measurement.

5.2.3 Limitations of the Methods

The test methods just described are occasionally used interchangeably under the assumption that the results are comparable. It is important to understand that "oil and grease" is defined by the method used. When interpreting oil and grease results, the method used and its limitations should be noted. Any procedural differences such as using a different solvent and different solvent to sample ratio, and extracting the sample at different pH values could affect the result (Sun et al., 1987). The following is a discussion of the limitations of the methods. The information presented is summarized in Table 4.

Partition-Gravimetric Method

Significant portions of low-boiling fractions that volatilize at temperatures below 70 ^{o}C are lost in the solvent removal operation, which makes this method unsuitable for samples that contain light petroleum distillates such as gasoline. Also, this method is generally used to measure relatively large oil contents and does not provide the needed precision to assess regulatory compliance since the detection limit is about 10 mg/L. Excessive concentrations of natural greases or synthetic or modified compounds and certain residue-type materials from heavy petroleum fractions are not well recovered due to insolubility in the solvent. Many non-hydrocarbons such as phenolics and carboxylic acids (Sun et al., 1987), and hydrocarbons of non-petrogenic origin are recovered by the procedure and therefore interfere with the determination. The method is very dependent on the analyst, which makes it difficult to reproduce results.

Partition-Infrared Method

The Partition-Infrared Method is preferred over the Gravimetric Method since it allows for the measurement of many relatively volatile hydrocarbons, is quicker and more precise. With adequate instrumentation, oil and grease concentration down to 0.2 mg/L can be measured. However, partial loss of volatile compounds does occur, and as in the gravimetric method, interfering compounds contribute to oil and grease measurements and certain compounds are not recovered due to their insolubility in the solvent. Moreover, all components do not absorb infrared radiation to the same extent, which introduces another small source of error.

The Soxhlet Extraction Method

The Soxhlet Extraction Method is used when the solvent forms an emulsion which cannot be broken in the Gravimetric procedures. Most of the limitations encountered in the Partition-Gravimetric method apply to the Soxhlet Extraction Method. However, due to the filtration step, fewer interfering compounds are recovered. For instance, phenolics and low molecular weight carboxylic acids which are soluble under acidic conditions, will pass through the filtering device and thus do not interfere (Sun et al., 1987). Duplicate results can only be obtained by strict adherence to all details, especially the rate and time of extraction.

The Hydrocarbon Method

As a result of the silica gel treatment, the Hydrocarbon Method eliminates most interferences from non-hydrocarbons and hydrocarbons of non-petrogenic origin. when combined with the infrared determination, partial evaporative losses are expected. It is considered that this method gives a better representation of the "true" oil and grease content of the sample.

Table 4: Summary of Commonly Used Analytical Techniques

	Method			
	Gravimetric	Infrared	Soxhlet	Hydrocarbon
Procedural Difference	Simple extraction	Simple extraction	Sample is first filtered & cake is extracted in Soxhlet device	Simple extraction & treatment of extract with silica gel
Detection Method	Gravimetric	Infrared	Gravimetric	Infrared
Detection Range	About 10 mg/L	About 0.2 mg/L	About 10 mg/L	About 0.2 mg/L
Loss of Volatile Hydrocarbons	Considerable	Partial	Considerable	Partial
Interferences	Considerable From non-hydrocarbons & hydrocarbons of non-petrogenic origin	Same as for the Gravimetric Method	Some From the larger interfering molecules which are retained on the filter	Less than the other methods Any interfering compounds which are not adsorbed by silica gel

5.3 Other Methods

Many other methods have been used for the measurement of oil and grease in water. These include turbidimetry, ultraviolet absorption and fluorescence, and gas-liquid chromatography. These methods are briefly described as follows:

Turbidimetry

In turbidimetry, the amount of ordinary white light transmitted through a finely divided suspension is compared with that transmitted by a standard suspension. This very simple principle can be applied to detect oil in water but presents many shortcomings. The method is not very accurate and does not distinguish between oil and other substances which cause turbidity. Turbidimetry is only suited for applications where the base turbidity of the water is known and does not fluctuate. Detection by this method is also dependent on oil droplet size.

Ultraviolet absorption and fluorescence

The ultraviolet absorption method is based on the measurement of absorbance in the ultraviolet region. The ultraviolet fluorescence method, on the other hand, is based on the ability of many organic and some inorganic compounds to absorb radiant energy from the ultraviolet region and then to emit the energy in the form of visible light. The sample is extracted with a solvent in both methods. Although these methods are very sensitive, they have major drawbacks. Fluorescence is not a property shared by all hydrocarbons, only aromatics. Ultraviolet absorption is only due to aromatic ring structures and other conjugated double bonds. As with turbidimetry, detection by absorption and fluorescence methods is dependent on oil droplet size. Furthermore, variations in absorption and fluorescence efficiencies between oils do occur.

Gas Chromatography-Mass Spectrometry

Gas chromatography-mass spectrometry is a technique which involves the vaporization of a liquid sample followed by the separation of the various gaseous components formed and their transportation by an inert carrier gas to a mass spectrometer, where they can be individually identified and quantitatively measured. Although this technique is very powerful for identification and measurement of hydrocarbons, it is too expensive to be used for routine analyses.

5.4 Oil-Water Monitors

Oil-water monitors are helpful tools that can be used to obtain a trend indication of the oil and grease content in discharges. These instruments have been based on a wide variety of measurement concepts but the most common are infrared absorption, ultraviolet light absorption, and fluorescence. Oil-water monitors are used extensively on ships as they are more convenient than laboratory methods and are the only means by which oil may be monitored in overside discharges.

In a bulk plant or terminal situation, these instruments can be installed with the treatment system to provide automatic and continuous monitoring of the discharge. A control system may also be integrated so that effluent is discharged only if it does not exceed a predetermined oil and grease concentration. The performance of the monitor has to be checked from time to time with laboratory techniques although some difficulty can be expected when trying to correlate the test results with those of the Standard Methods (Sun et al.,1987 and Cook et al., 1978).

Current commercial systems generally use a sample preparation scheme to reduce the effects of varying oil droplet size. Cormack (1983) presents a summary of available commercial oil-water monitors. Table C-1 in Appendix C, lists the commercial systems along with certain operational characteristics.

6.0 STORMWATER MANAGEMENT PRACTICES AT SELECTED FACILITIES

6.1 Site Visits

Appendix E includes the site visit reports for seven facilities visited in the Lower Mainland. The objective of the visits was to document current stormwater management practices and to collect stormwater samples to determine their oil and grease content. Much of the information is based on interviews with plant personnel. Appendix D contains a questionnaire which was developed to facilitate the collection of information during the site visits. Tables 5 and 6 present a summary of the operations visited and stormwater management practices.

Table 5: Summary of Operations Visited

Site	Year Built	Capacity (m^3)	Products Handled(1)	Methods of Receipt(2)	Methods of Delivery(2)
1	1957	23 848	A,B,C,D,F	I,J	K
2	1953	265 508	G	I	I
3	-	-	A,B,E,H	I,J,K	K,L
4	1985	12 000	D	I	I
5	1935	312	A,B,C	K	K
6	1955	14 000	A,D	I	K
7	1969	7 154	D	I	I

(1) Products Handled:
A-Gasoline D-Jet fuel G-Crude oil & semi-refined products
B-Diesel E-Propane H-Other oil products
C-Stove oil F-Methanol

(2) Methods of Receipt and Delivery:
I-Pipeline J-Tank car K-Tank truck L-Barge

Table 6: Summary of Stormwater Management Practices at Operations Visited

Site	Stormwater Treatment Facilities	Cleaning Frequency	Dyke Drainage	Tank Water Bottoms
1	Gravity separators	Every year	Manually activated pump Over-the-dyke	Slop tank
2	API separator & retention pond	3 times in the last 10 years for the separator	Manually operated valve	-
3	Gravity separators	-	Manually operated valve Through-the-dyke	Treatment facility
4	Parallel plate separator	Once in the last 5 years	Manually activated pump Over-the-dyke	Slop tank
5	Gravity separator	Every 4 months	Manually operated valve Through-the-dyke	Removed by vacuum truck
6	Gravity separators	Every year	Manually operated valve	Slop tank
7	Collection sump & pump well	Every year	Manually activated pump Over-the-dyke	Slop tank

Six out of the seven operations employ a simple gravity or API-type separator. One of these operations also includes a lagoon. One operation employs a parallel plate separator which is integrated with an oil-water monitoring device. Stormwater runoff which collects within the tank farm containment dyke is generally inspected prior to discharging via a manually activated drainage system which may go over or through the dyke. The schedule for maintenance of the separators varies between facilities. The separators are generally inspected regularly. Oil removal and cleaning of separators is usually done as needed. Tank water bottoms and oily wastes are commonly placed in a slop tank and are eventually taken to a refinery for reprocessing. The operations usually monitor their stormwater discharges on a monthly basis according to the requirements of the Waste Management Branch permit.

6.2 <u>Stormwater Quality</u>

6.2.1 Sampling and Analytical Methods

Duplicate grab samples were collected in an acid-washed glass bottle. The samples were held in a cooler and transported to the Environment Canada Laboratory. Analyses were made for freon extractable oil and grease, using both the Infrared and the Hydrocarbon procedures in order to compare results.

6.2.2 Results and Discussion

Table 7 presents the analytical results. In general, the oil and grease values were the same for both methods, which indicates that effluents from these operations contain very little interfering compounds. As indicated by some results, the Hydrocarbon Method may yield lower oil and grease values since it removes most interfering compounds, as discussed in Section 5.0. Effluent oil and grease concentrations were in the range of <0.2 to 7.1 mg/L, which suggests that the existing stormwater treatment systems can produce an acceptable effluent. However, the quality of the flow which enters the treatment systems will vary, depending on a number of factors which were discussed previously, and may challenge the performance of these systems.

Table 7: Analytical Results for Collected Stormwater Samples

Site	Date Sampled	Procedure		Sample Source
		Infrared (mg/L)	Hydrocarbon (mg/L)	
1	Nov. 7/1989	1.9, 1.9	1.9, 1.9	Separator effluent Truck loading area
2	Nov. 17/1989	<0.2	<0.2	Separator effluent Tank farm area
3	Nov. 23/1989	5.9, 7.1	5.9, 6.9	Separator effluent Tank farm and truck loading areas
3	Nov. 9/1989	2.2, 3.5	2.2, 3.0	Final discharge Yard, truck loading tank farm and lube oil blending areas
4	Jan. 3/1990	0.2, 0.2	0.2, 0.2	Final discharge Tank farm area
5	Jan. 3/1990	5.5, 5.2	5.3, 5.0	Separator effluent From the entire site
6	-	-	-	No sample taken
7	Jan. 3/1990	0.8, 0.8	0.6,0.6	Final discharge Tank farm area

7.0 SUMMARY AND RECOMMENDATIONS

Stormwater runoff from petroleum bulk terminal operations generally contains oil and grease and suspended solids in low concentrations. The environmental impacts of stormwater discharges can be minimized by adopting good practices. Based on the information collected during site visits and the literature review, the following observations and recommendations are made with respect to stormwater management.

7.1 Stormwater Handling

Contaminated and uncontaminated flows should be segragated if practical. For example, the loading/unloading facilities are more subject to spills than other areas and runoff from such areas may be handled separately from yard runoff which is relatively clean. Also, the terminal should be designed so that the area of potential contamination is minimized. Spills should be contained and cleaned up as soon as they occur to prevent the product from getting into the stormwater.

Tank water bottoms may contain phenols, high levels of suspended solids and other toxic components. Such waste should not be discharged into the stormwater treatment system as very small amounts can contaminate large amounts of stormwater. In addition, stormwater treatment systems are generally not designed to handle this type of waste. It is best to store tank water bottoms in a recovery (slop) tank for future removal and treatment off site.

Tank farm dykes are required to be completely impervious and sized so as to have the holding capacity of the largest tank plus 10% of the balance of the tanks, or 110% of the largest tank, whichever is greater (BCPA 1984, EPS 1986 and IEC 1978). Runoff which accumulates within the tank farm dykes should be contained for inspection prior to discharge to the treatment system. The dykes may then be drained by means of a manual start syphon or pump. Over-the-dyke drainage systems are desirable as they prevent any potential spills from seeping out of the dykes in an uncontrolled manner if the drain valve is inadvertently left open. Where piping passes through dykes, passages should be designed, constructed and maintained to prevent seepage from the dyked area.

Gravity collection systems are preferred over pumps because of their reliability and because pumping tends to create emulsions which may pass through the treatment system unaffected. If pumping is required upstream of the treatment system, positive displacement pumps are preferrable as they minimize the formation of emulsions.

7.2 Stormwater Treatment

Previous studies and the current investigation indicate that available stormwater treatment technologies are capable of producing an effluent which meets regulatory discharge standards. Among the many alternatives available, gravity separators which include simple separator tanks, API separators, parallel plate separators and lagoons are identified as best practical and economical treatment alternatives.

Most petroleum bulk terminal operations are equipped with simple gravity or API separators. Oil and grease results of samples collected at some operations suggest that a gravity separator generally provides adequate stormwater treatment. If the existing system fails to provide the desired level of treatment, the following alternatives should be considered:

-Upgrade the separator, if possible, by the addition of parallel plate packs.

-Add a retention basin for flow equalization.

-Add an oil skimmer to remove floating oil as it accumulates.

-If emulsion problems are created, provide a coagulation/flocculation facility or/and a dissolved air flotation unit.

-Install a more sophisticated treatment system.

The design basis for stormwater treatment systems varies from one operation to another. Underdesign is a major cause of poor performance. Based on the local conditions, the treatment system should be designed to handle a storm for the return frequency and duration negotiated with the Waste Management Branch. A return period of 10 years and a storm duration of 24 hours are common minimum design parameters.

7.3 Maintenance of Separators

In addition to underdesign, some of the factors that adversely affect separator performance are (PACE, 1980):

- Excessive turbulence at inlet and outlet
- Too high a feed rate
- Poor flow distribution
- Inefficient oil skimming
- Sludge buildup on the bottom.

Consequently, routine maintenance must be practiced if separators are to perform properly. Regular inspections should be carried out for buildup of oils and sludges, excessive turbulence, correct water levels in the separator, obstructions and for failure caused by defective parts of the separator.

Separators should be cleaned on a regular basis. Removal of oil by suction is desirable before it has accumulated to a depth of 4 inches. Sludge removal is recommended before a depth of 12 inches is reached (PACE, 1987). At cleaning, the separator should be refilled with clean water. This provides buoyancy for the adequate separation of floatables and minimizes the formation of an oil film on the walls of the empty separator and, its subsequent release in the effluent.

Emulsions must be excluded from the separator. In order to avoid emulsion generation in the stormwater, hot water-steam cleaning methods should be used instead of detergents, and agitation (e.g. pumping, turbulent flow) should be minimized.

7.4 Monitoring

A monitoring program should be designed to determine the adequacy of environmental protection measures. An effluent sampling facility should be provided.

Since oil and water coexist as a multiphase system, considerable judgment must be used to obtain representative samples. Appropriate sampling techniques are discussed in Section 5 and involve: the collection of an adequate quantity of the sample in an appropriate container; avoid rinsing the sampling container; sampling at a location where the water composition is reasonably homogeneous; and, if necessary, preservation of the sample before analysis.

The most commonly used procedures for oil and grease analysis include the Gravimetric Method, the Infrared Method, the Soxhlet Extraction Method and the Hydrocarbon Method. All of these procedures involve the extraction of the sample with a solvent which may extract other substances not considered to be "oil and grease". Fewer interferences are associated with the Hydrocarbon Method.

The differences in the various methods must be recognized and the method used should be specified when reporting analytical results. Oil and grease determination using both the Infrared Method and the Hydrocarbon Method for samples collected at the operations visited yielded very similar results. This suggests that bulk terminal stormwater effluents contain few interfering compounds.

Oil-water monitors are effective tools for spill detection and continuous monitoring of discharges. Larger operations should consider these devices as part of their operation.

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APPENDIX A:

INVENTORY OF BULK TERMINALS PERMITTED BY THE MINISTRY OF ENVIRONMENT UNDER THE WASTE MANAGEMENT ACT

TABLE A-1: LIST OF BRITISH COLUMBIA OPERATIONS
AND STORMWATER DISCHARGE PERMIT REQUIREMENTS

NAME	LOCATION	DISCHARGE Max. daily (m^3/day)	DISCHARGE Avg. daily (m^3/day)	TYPE OF TREATMENT	RECEIVING BODY	EFFLUENT QUALITY REQUIREMENTS	COMMENTS
Petro-Canada Inc.	Duncan	29	.75	API oil-water separator + infiltration basin	ground	Oil & grease; 20 mg/L (grab) 10 mg/L (a.q.a.)	Effluent application filed on May 3, 1989
Petro-Canada Inc.	Fort St. John	7.04	.63	API oil-water separator + infiltration basin	ground	Oil & grease; 20 mg/L (grab) 10 mg/L (a.q.a.)	Effluent application filed on May 5, 1989
Petro-Canada Inc.	Gold River, Vancouver Island	45	3	API oil-water separator + infiltration basin	ground	Oil & grease; 20 mg/L (grab) 10 mg/L (a.q.a.)	Effluent application filed on March 31, 1989
Petro-Canada Inc.	Colwood	69	-	Gravity separation	Mill Stream Creek	Oil & grease; 5 mg/L	Effluent permit issued on January 25, 1988
Petro-Canada Inc.	Williams Lake	variable	variable	Oil-water separation through the use of baffles	Ditch flowing into Williams Lake	5 mg/L of petroleum products	Effluent application filed on April 7, 1987
Petro-Canada Inc.	Pemberton	11.20	.63	API oil-water separator + infiltration basin	ground	Oil & grease; 20 mg/L (grab) 10 mg/L (a.q.a.)	Effluent application filed on June 22, 1989
Petro-Canada Inc.	Chilliwack	(1)100	3.50	Untreated (storm water runoff is uncontaminated)	Ditch leading to Kateseslie Creek	Oil & grease; 5 mg/L	Storm water runoff from the parking area
		115	4	Two gravity oil separators	Kateseslie Creek	Oil & grease; 5 mg/L	Storm water runoff from the filling and driveway area
		(2)45	1.70	Gravity oil separator	Kateseslie Creek	Oil & grease; 5 mg/L	Storm water runoff from the dyked tank storage area, truck discharge area & drum filling area Effluent permit issued on November 5, 1987 Application to combine discharge (1) with (2) and to amend the characteristics of the effluent to oil & grease 20 mg/l (grab) and 10 mg/l (a.q.a.) filed on January 31, 1989
Petro-Canada Inc.	Ganges, Saltspring Island	-	-	-	-	-	No effluent permit

							The Regional Waste Management Branch is to conduct some monitoring to determine if an effluent discharge permit is required
Petro-Canada Inc.	Port Moody	16	4 380 (3)	Cavitette sewage plant and oil separator	Burrard Inlet	Sanitary wastes: 45 mg/L BOD5 60 mg/L TSS Storm water: 5 mg/L Oil & grease	(3) 4 380 m^3/annum of combined sanitary wastes and storm water Effluent permit last amended on September 3, 1981 An application has been filed on June 30, 1988 to amend the effluent permit as in (4).
		(4)1 000	100	Additional new concrete twin bay oil separator	Burrard Inlet	Combined effluent: 45 mg/L BOD5, 60 mg/L TSS, 96 HrLC50=100% Oil & grease; 20 mg/L (grab) 10 mg/L (a.q.a.)	Sanitary wastes and storm water from the lower plant
		(4)1 000	100	Twin bay underground oil separators	Open ditch leading to Burrard inlet	Combined effluent: 96 HrLC50=100% Oil & grease; 20 mg/L (grab) 10 mg/L (a.q.a.)	Combined effluent from the upper plant
Petro-Canada Inc.	Terrace	36.20	1.06	API oil-water separator + infiltration basin	ground	Oil & grease; 20 mg/L (grab) 10 mg/L (a.q.a.)	Effluent permit application filed on October 15, 1989
Chevron Canada Ltd.	Richmond	60	7	Oil-water separator with baffles and oil skimmer	North arm of the Fraser River	Oil & grease; 5 mg/L Non-filterable residue; 20 mg/L Toxicity; 96 HrLC50=100%	Effluent permit issued on February 25, 1986
Chevron Canada Ltd.	Bear Cove, Port Hardy	27	10	Oil-water separator	Ground	5 mg/L of oil	Effluent permit issued on April 18, 1984
		-	-	Oil-water separator and a 1 140 m^3 reservoir equipped with an oil skimmer	Ground	5 mg/L of oil	
Chevron Canada Ltd.	Hatch Point	1 200	150	22 m^3 oil-water separator and a 6 000 m^3 reservoir equipped with an oil skimmer	Overland flows discharging into Satellite Channel	5 mg/L of oil	Effluent permit issued on July 5, 1983
Chevron Canada Ltd.	Kamloops	750	10	API oil-water separator	A lined evaporation pond and landscape irrigation	Better than petroleum bulk storage plant yard runoff water	Effluent permit issued on August 10, 1981
Chevron Canada Ltd.	Houston	(5)340 (6)15	- -	Oil separator tank + rock pit	ground	Oil & grease; 15 mg/L	(5) Wet weather discharge of storm runoff (6) Dry weather discharge of truck wash effluent Effluent permit issued on May 6, 1981
Chevron Canada Ltd.	North Burnaby	19 550	-	Two API gravity separators in parallel, air flotation unit and final settling basin	Burrard Inlet	pH; 6.0-8.5 Oil & grease; 8 mg/L Non-filterable residue; 20 mg/L Phenols; 0.5 mg/L Toxicity: 96 HrLC50=75%	Effluent permit amended on May 16, 1986

Chevron Canada Ltd.	Vanderhoof	7	-	Oil-water separator + rock pit	ground	Oil & grease; 15 mg/L	Petroleum fuel cardlock facility Effluent permit amended on December 22, 1986
Esso Petroleum	New Hazelton	23	.70	Oil-water separator tank	Waterfall Creek	Oil & grease; 5 mg/L	Effluent permit issued on March 24, 1987
Esso Petroleum (Imperial Oil Ltd.)	Kamloops	126	-	API oil-water separator + holding pond	ground	Non-filterable residue; 10 mg/L Petroleum distillates; 5 mg/L	Effluent permit issued on September 13, 1988 Application to amend the characteristics of the effluent to oil & grease 15 mg/l and non-filterable residue "report only" filed on January 31, 1989
Esso Petroleum (Imperial Oil Ltd.)	North Burnaby	90	-	Petroleum interceptor	Ditch leading to Silver Creek	Oil & grease; 5 mg/L	Storm water from the tank farm area
		160	-	Petroleum interceptor	Ditch leading to Silver Creek	Oil & grease; 5 mg/L	Storm water from the tank truck loading area
		10	-	Petroleum interceptor	Ditch leading to Silver Creek	Oil & grease; 5 mg/L	Storm water from the pumping area Effluent permit amended on December 9, 1986
Esso Petroleum (Imperial Oil Ltd.)	Chilliwack	70	-	Oil-water separator and temporary pond	Ditch leading to Atchelitz Creek	Oil & grease; 5 mg/L Total hydrocarbons; 5 mg/L	Petroleum fuel cardlock facility Effluent permit issued on August 11, 1988
Texaco Canada Ltd.	Burnaby	831	35	Oil-water separator	Burrard Inlet	Oil & grease; 5 mg/L Total suspended solids; 20 mg/L	Effluent permit issued on October 8, 1974
Shell Canada Ltd.	Burnaby	-	300	Storm water retention ponds	Eagle Creek	Oil & grease; 5 mg/L Non-filterable residue; 20 mg/L	Effluent permit amended on August 8, 1986
Shell Canada Ltd.	Chilliwack	500	-	2 oil-water separators and temporary pond	Ditch leading to Atchelitz Creek	Oil & grease; 5 mg/L Total hydrocarbons; 5 mg/L	Petroleum fuel cardlock facility Effluent permit issued on August 11, 1988
Shell Canada Ltd.	Burnaby			Oil-water separators	Sewer		
Vancouver Island Tank Farm (Pay Less Gas Co.)	Chemainus	68	-	Oil-water separator	Stuart Channel	Oil & grease; 5 mg/L	Storm water from the tank truck loading area
		477	-	Oil-water separator	Stuart Channel	Oil & grease; 5 mg/L	Storm water from the tank farm area Effluent permit issued on January 7, 1987
Trans Mountain Pipe Line	Burnaby	10 500	-	API separator and containment lagoon	Eagle Creek	Oil & grease; 5 mg/L Toxicity; 96 HrLC50=100%	Effluent from dyked tank area of crude oil tank farm. Effluent permit amended on January 31, 1985
Trans Mountain Enterprise	Richmond	212	-	Collection and discharge sumps	Ditch leading to north arm of Fraser River	Oil & grease; 5 mg/L	Aviation fuel tank farm. Effluent permit amended on May 16, 1985
PLH Aviation Systems	Richmond	-	-	Coalescing plate separator	Ditch leading to north arm of Fraser River	Oil & grease; 5 mg/L	Aviation fuel tank farm. Effluent permit issued on January 31, 1985

APPENDIX B:

REVIEW OF COMMERCIALLY AVAILABLE TREATMENT SYSTEMS

TABLE B-1: REVIEW OF COMMERCIALLY AVAILABLE TREATMENT SYSTEMS

MANUFACTURER/SUPPLIER	MODEL	WASTEWATERS TREATED	TREATMENT METHOD	CAPACITY	CLAIMED EFFLUENT QUALITY	COMMENTS
McTighe Industries Inc. 118 W 4th Ave/PO Box 928 Mitchell, SD 57301-0928 Tel.: (605) 996-1162	POWS and PCO	Wastewater contaminated with oils and/or other volatile liquids and solids. pH range from 2 to 12. Temperatures: up to 100 oC.	Gravity separation combined with corrugated parallel plates.	12 to 4 500 gpm (65 to 24 530 m3/day)	Below 10 ppm	
Fast Systems Inc. 1717 Sublette Ave St Louis, MO 63110 Tel.: (314) 781-3278	PACE S-Series and SM-Series	Any combination of fresh water, salt water, petroleum based oil, mechanical and chemical emulsions. Specific gravity: up to 0.94 Viscosity: any which will flow through the piping. Temperatures: between 10 and 70 oC.	Primary gravity separation combined with membrane separation.	S-Series: 670 gal/day (3 m3/day) to 52 000 gal/day (236 m3/day) SM-Series: 670 gal/day (3 m3/day) to 13 000 gal/day (61 m3/day)	Treating heavy fuel oil: ND (max.) ND (avg.) Treating light fuel oil: ND (max.) ND (avg.) Treating chemical emulsion: 6.5 ppm (max.) 1.0 ppm (avg.)	Oil, active cleaning agents and water are recovered for reuse SM-Series: Marine separator capable of treating emulsified bilge slops
Aquanetics Inc. 111 Milbar Blvd Farmingdale, NY 11735 Tel.: (516) 454-7600	Portable Handtruck Model PMORS40A	Any industrial oil with the exception of motor oils and invert-emulsion water-oil cutting fluids. Viscosity: 50 to 2 000 SSU. Maximum water content of 20%	Filtration combined with a low-temperature vacuum distillation process.	16 m3/day	0.001% (10 ppm) water content Particulate contamination level reduced to 70 particles larger than 10 μ per milliliter	On-site oil reclamation system.
RGF Environmental Systems 4803 N.E. 12th Ave Fort Lauderdale, Florida 33334 Tel.: 1-(800) 345-3303	Ultrasorb Series I and II	Oil contaminated water. Temperatures: between 32 and 200 oF (0 and 93 oC).	Series I: Combination of settling tank, coalescing baffles, metallic attraction oil removal wheel and absorption filter. Series II: Combination of coalescing centrifugal separator and absorption filter.	1 to 15 gpm (5 to 82 m3/day)	Below 10 ppm of oil if Series I is followed by Series II.	Series II processes the effluent from Series I. Water is recovered for reuse
American Colloid Company 1500 W Shure Drive Arlington Heights, Illinois 60004 Tel.: (312) 392-4600	-	Wastewater containing emulsified oils and petrochemicals or dissolved metals in concentrations as high as 2% by volume.	Adsorption, flocculation and encapsulation process with a clay-based powder.	100 to 2 400 gph (9 to 218 m3/day)	Water that can be recycled or discharged to a sewer.	Produces a non-leachable sludge cake
Engineered Equipment Products, Inc. (Enquip) 3319 N Lewis P.O. Box 589 Tulsa, Oklahoma 74101 Tel.: (918) 599-8111	TSI	Oil-water mixtures	Gravity separation with a baffle and: - Coalescing option (a series of flat steel plates set parallel at 45o slope. - Heating coil option for releases of heavier oils. - Oil-stop valve option at the end of the effluent discharge pipe.	1 to 4 500 gpm (5 to 24 520 m3/day)	Below 3-5 ppm under normal operating conditions and 10 ppm when subjected to the maximum flows which the units were designed to handle	

Megator Corporation 562 Alpha Drive Pittsburgh, PA 15238 Tel.: 1-(800) 245-6211	Alpha S/S Skimmer	Oil-water mixtures, sewage scum, wastewater with floating debris. pH range from 2 to 12.	Suction	5.5, 11 and 22 gpm (30, 60 and 120 m3/day)		Oil recovery units consist of three fixed stainless steel spun wound floats, self-priming pump, suction hose and gasoline engine
Monroe Environmental Corporation 11 Port Avenue Monroe, Michigan 48161 Tel.: 1-(800) 992-7707	Max-E-Clene	Wastewater with floating oils.	Adherence of oil to a motor driven belt.	2 to 180 gph (0.2 to 17 m3/day) of recovered oil.		Oil skimmer
Bird Machine Company of Canada, Ltd. 2600 Wentz Avenue Saskatoon, Saskatchewan Canada S7K 2L1 Tel.: (306) 931-0801	Decanter and Disc models	Oil-water slurries.	Centrifugal separators.		Suitable for discharge to a wastewater treatment system	Purified oil stream can be reused
Quantek (Fram Industrial) P.O. Box 50096 Tulsa, OK 74150 Tel.: (918) 834-2929	CPS	Oil-water mixtures. Temperatures: between 40 to to 160oF (4 to 71oC). pH range of 2 to 12.	Gravity separation with coalescing plate packs.	2 to 1 000 gpm (11 to 5 451 m3/day)	Contamination reduced from the 100 ppm range to below 15 ppm	The recovered oil contains a maximum of 0.03% water in normal operation
National Fluid Separators, Inc. 829 Hanley Industrial Court St. Louis, MO 63144 Tel.: (314) 968-2838	Oilmaster	Oil-water mixtures.	Gravity separation with coalescer.	2, 5 and 10 gpm (11, 27 and 55 m3/day)	Below 15 ppm	The recovered oil may be burned as fuel or reprocessed
Highland Tank & Mfg. Co. Box 338 Stoystown, PA 15563 Tel.: (814) 893-5701	Sti-P3	Non-emulsified oil-water mixtures. Temperatures: between 40 to to 180oF (4 to 82oC).	Gravity separation with parallel corrugated plate coalescer.	28 to 5 000 gpm (153 to 27 255 m3/day)	Free petroleum hydrocarbon concentration below 15 ppm.	
World Water Systems Inc. P.O. Box 3427 Tustin, CA 92681 Tel.: (714) 641-2968	Industro-Sep	Chemically or mechanically emulsified oil-water mixtures.	Combination of gravity separation, water extraction (with spir-o-lators)		Water that is clean enough to be legally disposed of or recycled	The recovered oil supports combustion. Reclaims the cleaning agent and removes colour
AFL Industries, Inc. 3661 W Blue Heron Blvd. Riviera Beach, FL 33404 Tel.: (305) 844-5200	EGS	Wastewater contaminated with free oils.	Enhanced gravity separation.	25 to 700 gpm (136 to 3 816 m3/day)	Reduction down to 10 ppm.	
	VTC	Wastewater contaminated with mechanically emulsified oils.	Gravity separation with coalescing medium.	10 to 3 600 gpm (55 to 19 624 m3/day)	Reduction down to 10 ppm.	
		Wastewater contaminated with mechanically emulsified oils.	Pressure filtration with coalescing medium.	25 to 1 200 gpm (136 to 6 541 m3/day)	Reduction down to 0-5 ppm.	Polishing pack
Great Lakes Environmental Inc. 463 Vista Addison, IL 60101	SRC	Wastewater contaminated with free and dispersed oils.	Gravity separation with diffuser and slant rib coalescing medium.	5 to 2 000 gpm (27 to 10 902 m3/day)	Below 10 ppm.	
	API	Wastewater contaminated with free	Gravity separation.			

Tel.: (312) 543-9444		oils.				
	CGD	Wastewater contaminated with free oils.	Gravity separation with diffuser.	25 to 1000 gpm (136 to 5 451 m3/day)		Coalescing packs can be added to improve separation efficiency
	DAF	'Wastewater contaminated with emulsified oils and suspended solids.	Dissolved air flotation system.			
ACG Technology Ltd. 2175 Dunwin Drive, Unit 5 Mississauga, Ontario Canada L5L 1X2 Tel.: (416) 828-7450		Wastewater with floating oils.	Adherence of oil to a beltless rotating wheel.			Oil skimmer
Pielkenroad Separator Company P.O. Box 53563 Houston, Texas 77052 Tel.: (713) 524-3078		Wastewater contaminated with free oils.	Gravity separation with cross flow corrugated plate pack.		10 to 15 ppm.	
		Wastewater contaminated with mechanically emulsified oils.	Gravity cross flow corrugated plate separation with dissolved air flotation system.		10 to 15 ppm.	
		Wastewater contaminated with chemically emulsified oils.	Flocculator-dissolved air flotation system.		5 to 15 ppm.	
		Wastewater contaminated with dissolved oils.	Biological treatment system or activated carbon absorption system.			
Pollution Control Engineering, Inc. 10751 Lakewood Blvd. Downey, CA 90241 Tel.: (213) 861-1297	PCE Belt skimmer	Wastewater with floating oils.	Adherence of oil to a motor driven belt.	up to 1 200 gpd (up to 4.5 m3/day oil removed)		Oil skimmer
Tenco Hydro Inc. 5220 East Avenue Countryside, Illinois 60525 Tel.: (312) 482-7200	Skim-Kleen	Wastewater with floating oils.	Adherence of oil to a motor driven belt.	up to 120 gph oil removal. (up to 27.3 m3/day)		
	Clari-float	Wastewater contaminated with emulsified oils.	Chemical coagulation and flocculation in combination with dissolved air flotation.	5 to 1 500 gpm (27 to 8 176 m3/day)	Typical performance data for a vegetable and mineral oil processing plant shows a 99% removal of the emulsified oil	
WEMCO Canada 5155 Creekbank Road Mississauga, Ontario Canada L4W 1X2 Tel.: (416) 625-1637	1+1 and nozzle-air oil-water separators	Wastewater contaminated with emulsified oils.	Induced gas flotation cells.	50 to 5 000 gpm (273 to 27 255 m3/day)	Below 10 ppm	Equipment is to follow gravity oil separation
	Pacesetter		Gravity separation with coalescing and plate packs.		Dirty water reduced from 30 000 ppm to 15 ppm	

APPENDIX C:

COMMERCIALLY AVAILABLE OIL-WATER MONITORS

Table C1: Commercial Oil-Water Monitors (Cormack, 1983)

Monitor	*Detection principle*	*Range (mg litre⁻¹ oil)*	*Accuracy*	*Sensitivity*	*Response time*
AEG/Slo (Finland), 'Oili'	Infrared (IR) absorption at 3.4 μm wavelength with no solvent extraction	0–10 000	±10 mg litre^{-1} or ±20%		<10 s
Anacon (USA), Arcas Model 705 'COW'	Gas chromatography	0–2 500		0–5 mg litre^{-1}	Cycle time 5 min
APV-Bowser Filtration (UK), Model 861-ST Mk V	Turbidimetry: ratio of visible light absorbed and scattered measured	Calibration conversion from turbidity units to mg litre^{-1} oil required to determine range (nominally 0–500)	±0.02% turbidity	<1 mg litre^{-1}	Instantaneous
Bailey (UK), Model OT3	Ultraviolet (UV) fluorescence	0–100	±5–15%	0.5 mg litre^{-1}	Instantaneous upon sample entry into measurement cell
Biospherics (USA), 'Clam'	Turbidimetry: measurement of optical density of oil–water dispersion	1–1 000		1 mg litre^{-1}	Cycle time 15 s
Clarke Chapman International Combustion Div. (UK), Model 4979	Sample sprayed on to PTFE drum and UV fluorescence measured	No further information available at this time			
Fram (USA), 'Fluid Analyzer'	Absorption in near IR at 700 nm with no solvent extraction	0–100			
Horiba (Japan), Model OCMA-32	IR absorption at 3.4–3.5 μm with CCl_4 solvent extraction, solvent recycled and used as reference. 1:1 solvent/sample ratio	Variety of scales: 0–1, 0–5, 0–20, 0–50, 0–100, 0–200, 0–1 000	±2% scale		22 s to 90% full-scale deflection
GST Regeltechnik (W. Germany), 'Mex 2'	Turbidimetry using near IR at 900 nm. Two modes of operation, scattering or absorption, both using intermittent dual beam	Scattering mode: 1–10; Absorption mode: 1 mg litre^{-1} to 10 g litre^{-1}	±1% calibrated scan		1–2 s
Salen & Wicander (Sweden), 'SOP', 'SOC' and 'BOM'	Integration of quantity of volatiles with colorimetric measurement of sample sprayed on to polypropylene tape	0–200; 0–1 000	±20%; ±5% for one oil only	2 mg litre^{-1} to 10% at full-scale deflection	30 s

Table C1: Contd.

Monitor	Detection principle	Range (mg litre^{-1} oil)	Accuracy	Sensitivity	Response time
SERES (France) 'DRUR Oleometer'	Turbidimetry: simple measurement of optical density of emulsified sample in visible range	0–100 0–250 0–1 000	±12.5%	Min. 1 mg litre^{-1}, 1% scale	Total system response time 8 s
Teledyne (USA), '660 Series'	UV absorption utilising dual-beam technique, one as reference. Measurement at 254 nm and 400 nm reference	0–10 0–50 0–100	±2%	±1 mg litre^{-1} but ±1% for 0–10 mg litre^{-1} scale	30 s

APPENDIX D

QUESTIONNAIRE USED FOR SITE VISITS

PETROLEUM BULK TERMINAL QUESTIONNAIRE

Date..............................
Facility name.....................
....
Contact...........................

1. TYPE OF OPERATION

A. Location of Plant
General description...
....
....
....
Proximity to water course.....................................

B. Method of receipt
(Marine, pipeline, rail, truck)
....

C. Method of delivery
(Marine, pipeline, rail, truck)
....

D. Products handled
....
....

E. Where are the products distributed to?
....

F. Storage capacity (include number of tanks)
....

G. Personnel size
....

H. Age of facility
(has it been modified or upgraded, when)
....

I. Facility complexity
Truck washing...
Maintenance garage..
Handling of ballast water.....................................
Drum reconditioning...

2. SPILL PREVENTION/CONTAINMENT MEASURES

A. Containment diking around storage tanks
Is it impervious?..................................
Holding capacity...................................
Capacity of largest tank...........................
Collection sump within the dyked area..............
Impervious floor...................................
Dike drainage
(over or through dike, where is it disposed off)
....

B. Loading and unloading areas
Containment facility (curbs, drainage trenches, interceptor drains, catchment basins, sumps, concrete slabs, etc.)
....
....
....
Grade..

3. STORMWATER COLLECTION AND TREATMENT

A. How is runoff collected and where is it routed?
From tank farm area................................
....
From loading and unloading areas...................
....
From yard..

B. Type of treatment...................................
....
Size...
Installation (under/above ground)..................
Is it equipped with an oil skimmer?................
Other auxiliary devices............................
....
How often is oil removed?..........................
Estimated annual volume of oil.....................
How is removed oil disposed off?...................
....
How often is sludge removed?.......................
Estimated annual quantity of sludge produced.......
How is sludge disposed off?........................

4. OTHER LIQUID WASTES

A. Any truck washing.effluent?........................
Are detergents used?...............................

B. Washing of facility
....

C. Truck flushings..

D. Tank water bottoms
How often are they drained?...............................
Where is drainage routed?.................................

E. Ballast water
How is it treated?..

5. IDENTIFICATION OF STORMWATER SAMPLES

....
....

COMMENTS

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PLANT LAYOUT

Total area:

APPENDIX E

SITE VISIT REPORTS

SITE 1

Site 1 is a large operation situated about 1 km from Burnaby Lake. It is manned by a staff of about 55 persons and the property occupies an area of approximately 17 acres. Built in 1957, the facility includes a tank truck loading area, a tank farm area, a warehouse, and a maintenance garage. Products are received by pipeline and tank car and are distributed by tank truck. Products handled are gasoline, diesel, stove oil, jet fuel and methanol and total storage capacity is approximately 150 000 barrels (23 848 m3). Stormwater management practices are as follows (refer to Figure E1):

Tank Farm Area:

All product storage tanks are contained in a clay-sealed earth dyke which is drained via a large ditch followed by a concrete gravity separator with underflow baffles and skimmer. The separator effluent is discharged with a manually activated pump and over-the-dyke drainage system into a ditch that runs south along the east boundary of the property. Tank water bottoms flow to a slop tank located within the dyked area.

A portion of the pump area is paved and drains into a buried 3-compartment concrete gravity separator with underflow baffles. The separator effluent is discharged via a small open ditch into the east boundary ditch.

Truck Loading Area:

Stormwater runoff from the truck loading area is collected via strip drains and routed to a separator which is similar to the one installed in the pump area. The separator effluent is discharged into a small open ditch and routed to another gravity separator which is located at the west boundary of the property.

Warehouse

Stormwater runoff is collected via a catch basin and proceeds to the west boundary separator.

Garage

Stormwater runoff is discharged to the sewer. Truck flushings are stored in the slop tank.

Every week, the separators are checked for oil accumulation. When the floating layer of oil accumulates to a few centimeters, it is removed and placed in the slop tank. Wastes accumulated in the slop tank are removed by truck and sent to the parent refinery for reprocessing. The separators are cleaned approximately once a year.

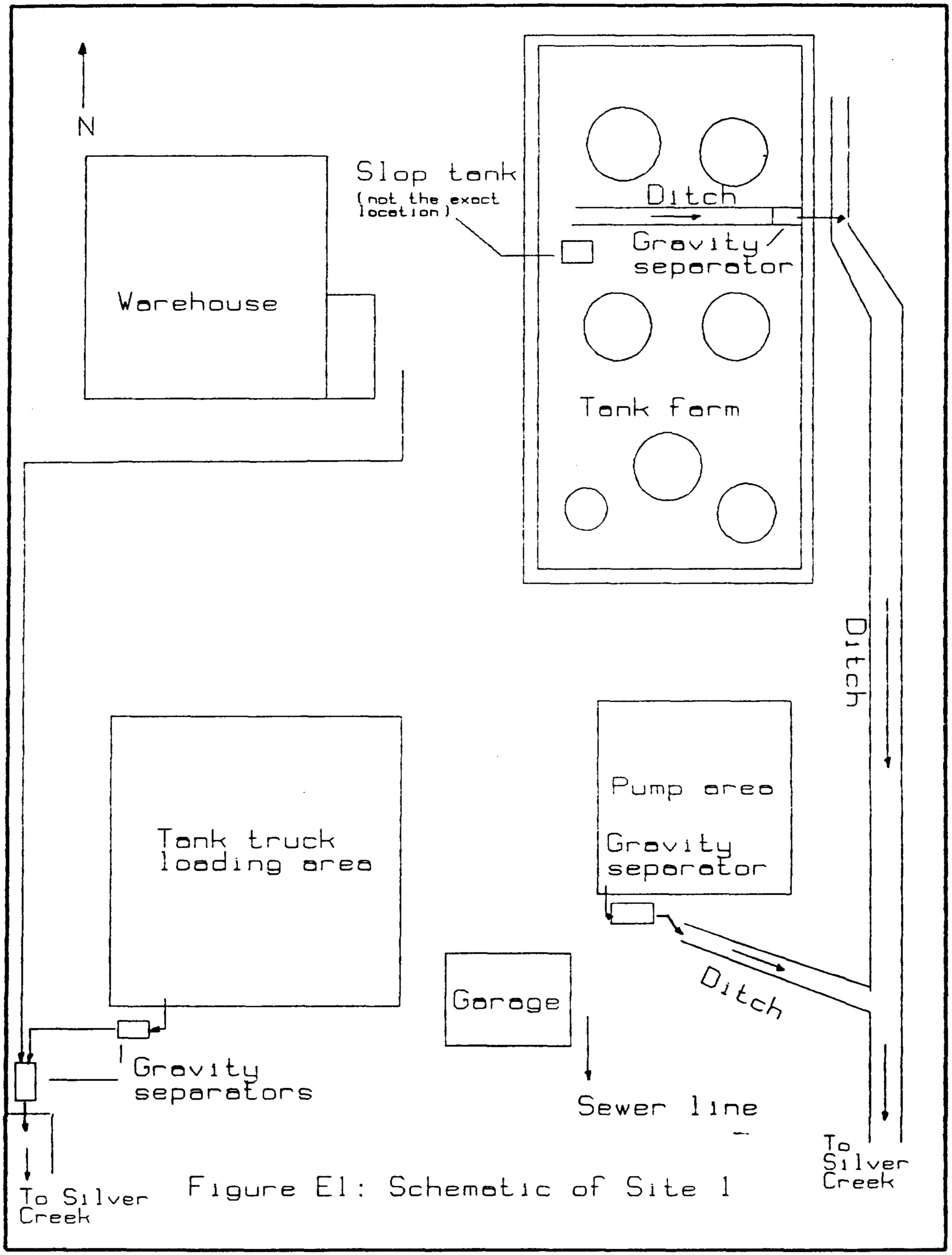

Figure E1: Schematic of Site 1

SITE 2

This facility, which is located about 1 km away from Burnaby Lake, was built in 1953 and consists of a tank farm and associated auxiliary facilities. It is a fairly large operation which is manned by a staff of about 35 persons. Crude oil and semi-refined products are received by pipeline and distributed in the same manner to a number of refineries. Three new tanks are being added to the site, which will result in a total tankage capacity of about 1 670 000 barrels (265 508 m^3). Stormwater management practices are as follows (refer to Figure E2):

The site slopes to the south-west. The tanks, which are located in the upper area of the site, are contained within a clay-lined earth dyke. The outside of the dyke walls is presently covered with a plastic material to minimize erosion but will eventually be covered with vegetation.

Stormwater which has accumulated within the dyked area is drained via a manually operated valve to an API separator. This is an uncovered concrete basin with distribution, separation and effluent chambers, rotary pipe skimmer and oil sump. The conductivity of the effluent is monitored daily. Steam cleaning of the separator was necessary only 3 times in the last 10 years. An additional separator will be added with the installation of the three tanks.

A large retention pond is located at the south end of the property. It provides additional treatment for the separator effluent and for any runoff from the rest of the property that naturally drains into it. The pond also provides containment for spills.

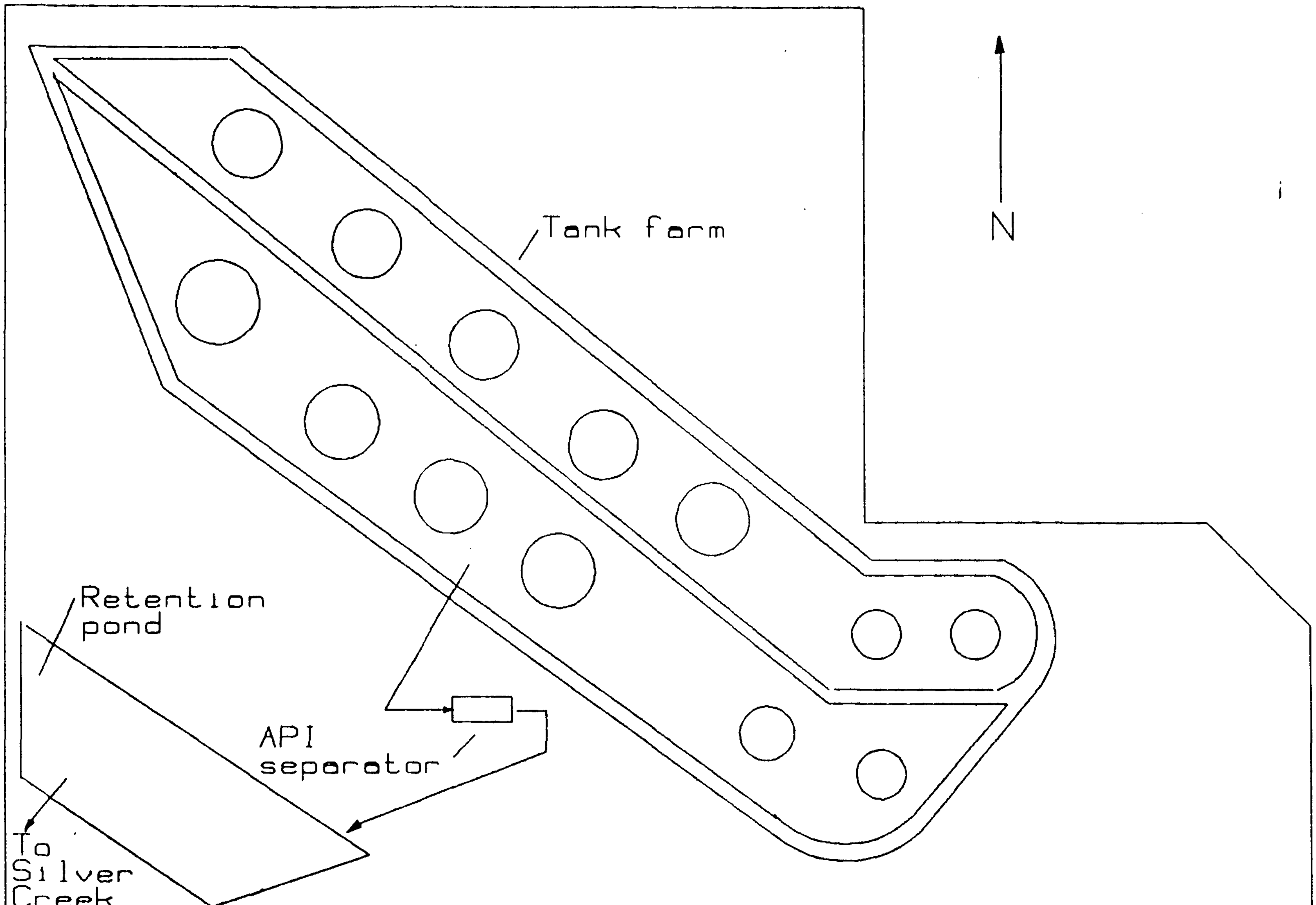

Figure E2: Schematic of Site 2

SITE 3

This large facility is located near Burrard Inlet and is divided into two main sections. One section consists of a tank farm with truck loading facilities and garage. Gasoline, diesel fuel and propane are the main products handled. These products are received by pipeline and distributed by tank truck. Oil products are handled in the other section which includes a warehouse, two dock facilities, a tank car unloading area, a truck loading rack and a lube oil tank farm. Products are received by tank car or truck and distributed by barge and tank truck. Lube oil blending and packaging accounts for a small part of the operation. Stormwater management practices are as follows (refer to Figure E3):

Section I

Most of the stormwater runoff collected in this section is directed to a concrete retention tank measuring 6.0m L X 1.3m D X 2.0m W and which is followed by an above ground concrete API separator having a capacity of 20 cfm. The retention tank is in fact an old above ground gravity separator. The retention tank and the separator both have removable timber covers. The separator effluent and runoff from yard area are routed to a ditch running along the boundary of the property and are eventually discharged into the Burrard Inlet. Skimmed oil proceeds to two slop tanks located in the tank farm.

Tank Farm Area

The product storage tanks are contained within three separate impervious dyked areas. Tank water bottoms and stormwater from within the dyked enclosures are discharged to the retention tank with a manually operated through-the-dyke drainage system.

Truck Loading Areas and Garage

The west truck loading area drains into the retention tank. Another small separator is buried at the east loading rack. It handles runoff from that loading rack and also from the garage. The separator effluent discharges into the boundary ditch.

Section II

Warehouse and Lube Oil Tank Farm Areas

The lube oil storage tanks are enclosed within a concrete rectangular dyke. Stormwater collected within the dyke is routed to a 50 cfm concrete underground twin bay separator which measures 10.7m L X 2.76 m D X 5.05 m W. The paved yard area near the warehouse also drains into the same twin bay separator. The effluent discharges into the Inlet.

Lube Oil Truck Loading Rack

A concrete separator is buried in this area. It handles stormwater runoff from the truck loading rack and from the blending operation. The separator effluent proceeds to the twin bay separator. An oil sump is also provided underneath the loading rack area for spill containment.

Tank Car Unloading Area

As this area is seldom in operation, any runoff produced is essentially oil-free. A cement pad area with curbs is provided. A slop tank is buried underneath the cement pad area. Stormwater runoff from the cement pad area is piped to two open collection tanks which are emptied when full.

Dock facilities

Each dock contains drip pans which drain to a holding tank. Oily wastes are stored in the cement pad area slop tank. A stormwater collection facility and a boom are provided at the west dock.

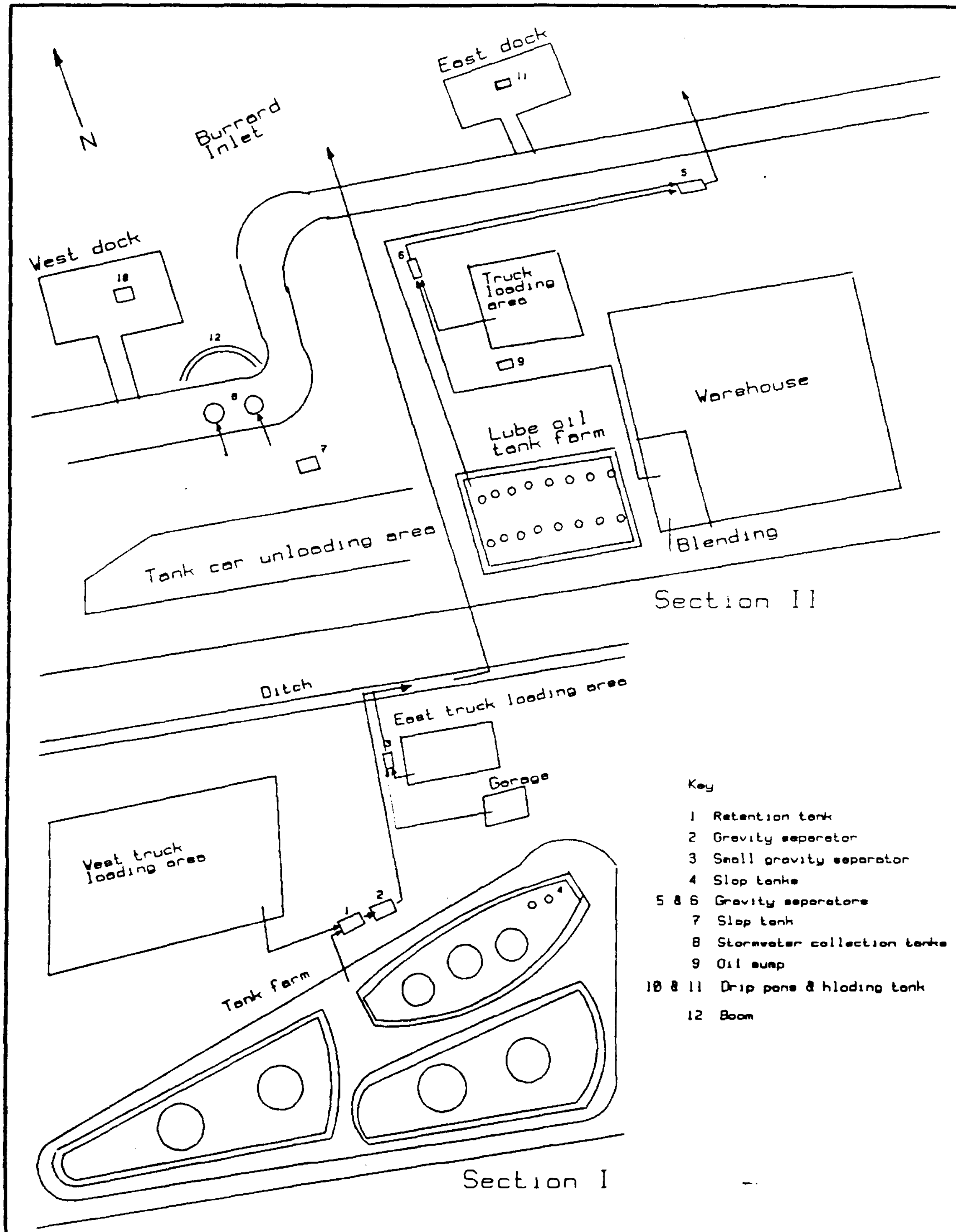

Figure E3: Schematic of Site 3

SITE 4

This relatively small and new operation was built in 1985. It consists of a jet fuel tank farm and related facilities and is located a few meters south of the north arm of Fraser River. Four jet fuel storage tanks provide an overall tankage capacity of 12 000 m3 and are contained within an earth dyke which is lined with an impervious material. Fuel receipt and delivery is by pipeline. Stormwater management practices are as follows (refer to Figure E4):

Stormwater collected within the dyked area is discharged with a manually activated pump and over-the-dyke drainage system to a coalescing plate separator manufactured by "Fram Industrial". It consists of a coated steel tank equipped with 6 packs of corrugated parallel plates, skimming device and oil sump. The system is also equipped with a "Biospherics" oil-water monitor. If the effluent oil content is greater than 3 ppm, the effluent exit valves are automatically closed and the system shut down. The effluent is recirculated to the inlet of the separator but the system has to be reset in operation manually.

Approximately 20 gallons of tank water bottoms are collected every day and directed to the oil sump which has a capacity of 200 gallons. The oil sump is also equipped with a float that triggers a red light when enough oil has accumulated in the sump. The oil is then pumped to a slop tank.

The system is apparently subject to very little maintenance. Corrugated plate packs cleaning has been necessary only once since the system was installed.

The separator effluent discharges into a ditch and passes through two oil booms before its eventual discharge to the north arm of the Fraser River.

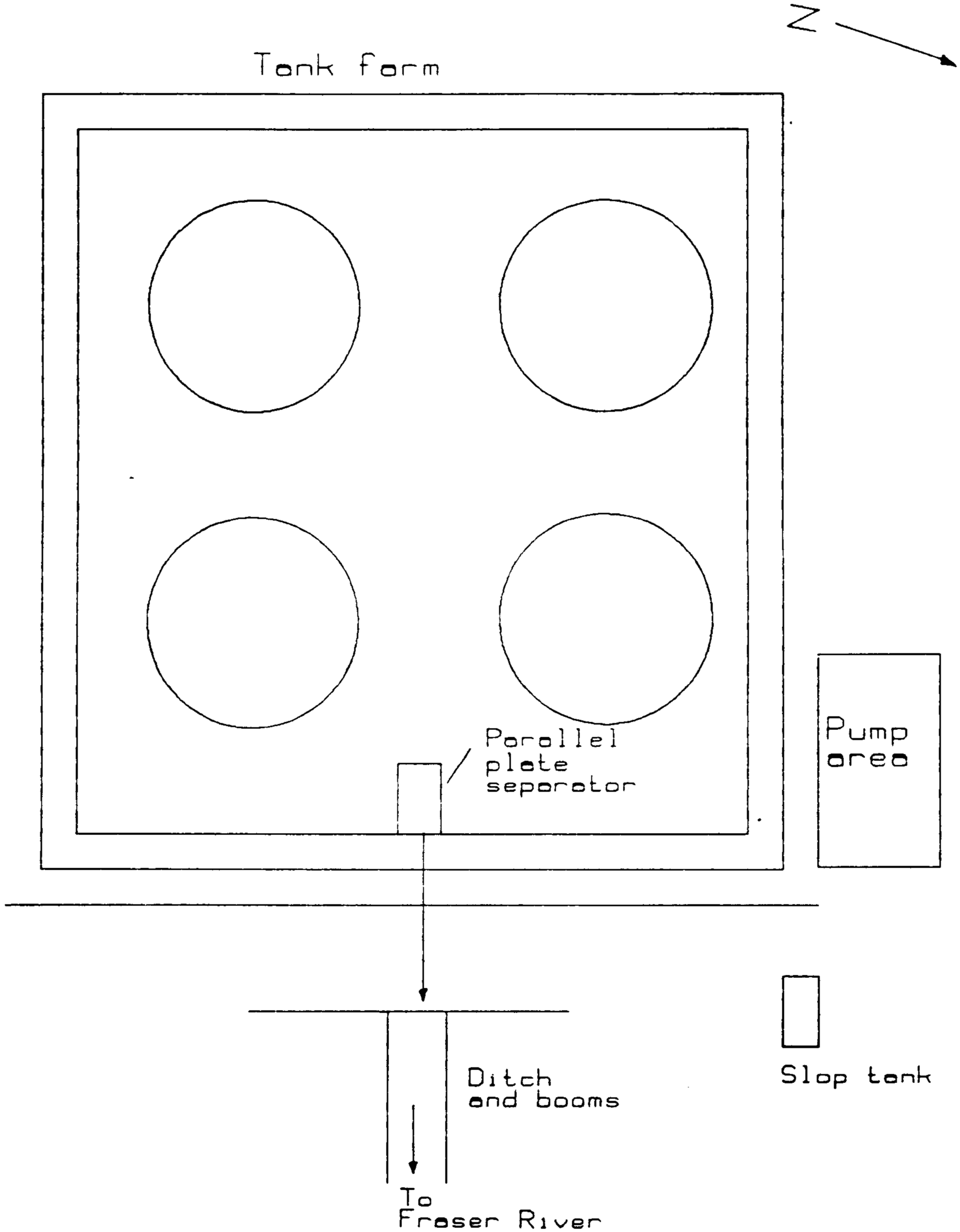

Figure E4: Schematic of Site 4

SITE 5

This small operation was built in 1935. It is located in an industrial area, adjacent to the north arm of the Fraser River. It includes a tank farm, a truck loading rack, a keylock facility, a warehouse and a float fueling facility for boats. Total tankage capacity is approximately 68 500 gallons (312 m^3). Products handled are gasoline, diesel and stove oil. The method of receipt and delivery is by tank truck. The operation is manned by two persons and serviced by two trucks. Stormwater management practices are as follows (refer to Figure E5):

Tank Farm Area

The product storage tanks are contained within a concrete rectangular enclosure where a slope is provided. Stormwater which collects at the south end of the tank farm is routed to a 6 000 gallons underground concrete gravity separator via a manually operated valve and through-the-dyke drainage system.

Other Operating areas

Stormwater runoff from the rest of the site is collected and routed to the same 6 000 gallons separator, whose effluent discharges directly to the north arm of the Fraser River. Every four months, the separator is emptied and cleaned with a vacuum truck. The waste is hauled away from the site and taken to the associated refinery.

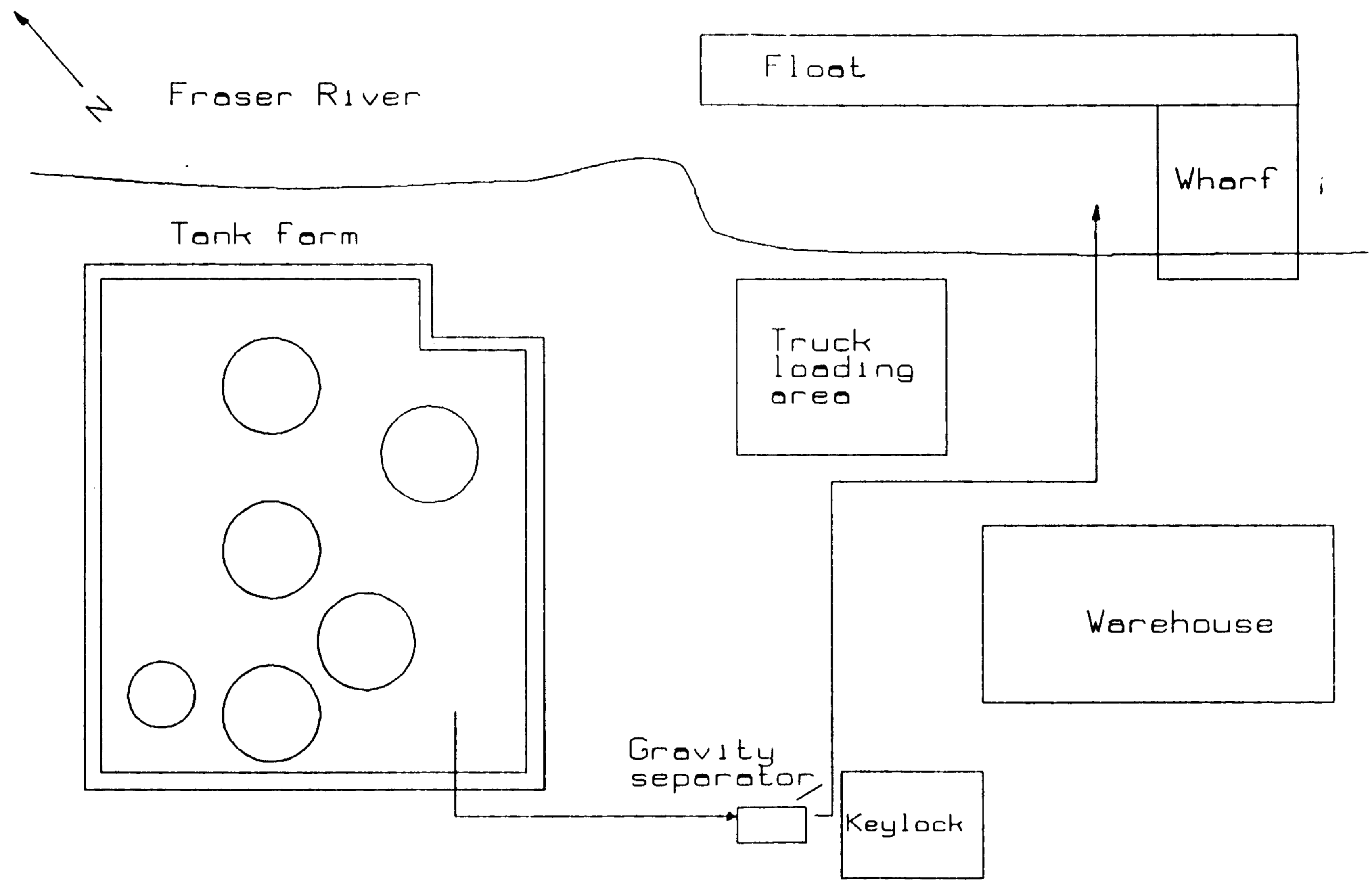

Figure E5: Schematic of Site 5

SITE 6

This medium size operation was built in 1955 and is located in Burnaby. It includes a tank farm, a warehouse, and a tank truck loading area. Products handled are gasoline and jet fuel. These are received by pipeline and delivered by tank truck. The total tankage capacity is approximately 14 000 m^3. Stormwater management practices are as follows (refer to Figure E6):

Tank Farm Area

The six storage tanks are contained within a concrete enclosure. Stormwater runoff which accumulates in the tank farm is discharged via a manually operated valve to an underground concrete gravity separator. A 22 700 litres fiberglass slop tank is also buried just outside of the enclosure. Tank water bottoms are stored in the slop tank. Oily wastes from the slop tank are taken to the parent refinery.

Tank Truck Loading Area

The tank truck loading area drains into an underground concrete separator having a capacity of 22 700 L.

Warehouse

The warehouse is seldom used. Stormwater runoff from this area is routed to a nearby underground concrete separator.

Yard Area

Three concrete underground separators having each a capacity of 45 000 L are placed to collect stormwater runoff from the yard area.

The main separator is located at the entrance of the property. It receives the effluent from the other separators and runoff from the yard area holding tanks. Effluent from this separator is discharged to the sewer. The separator is cleaned approximately once a year with a vacuum pump.

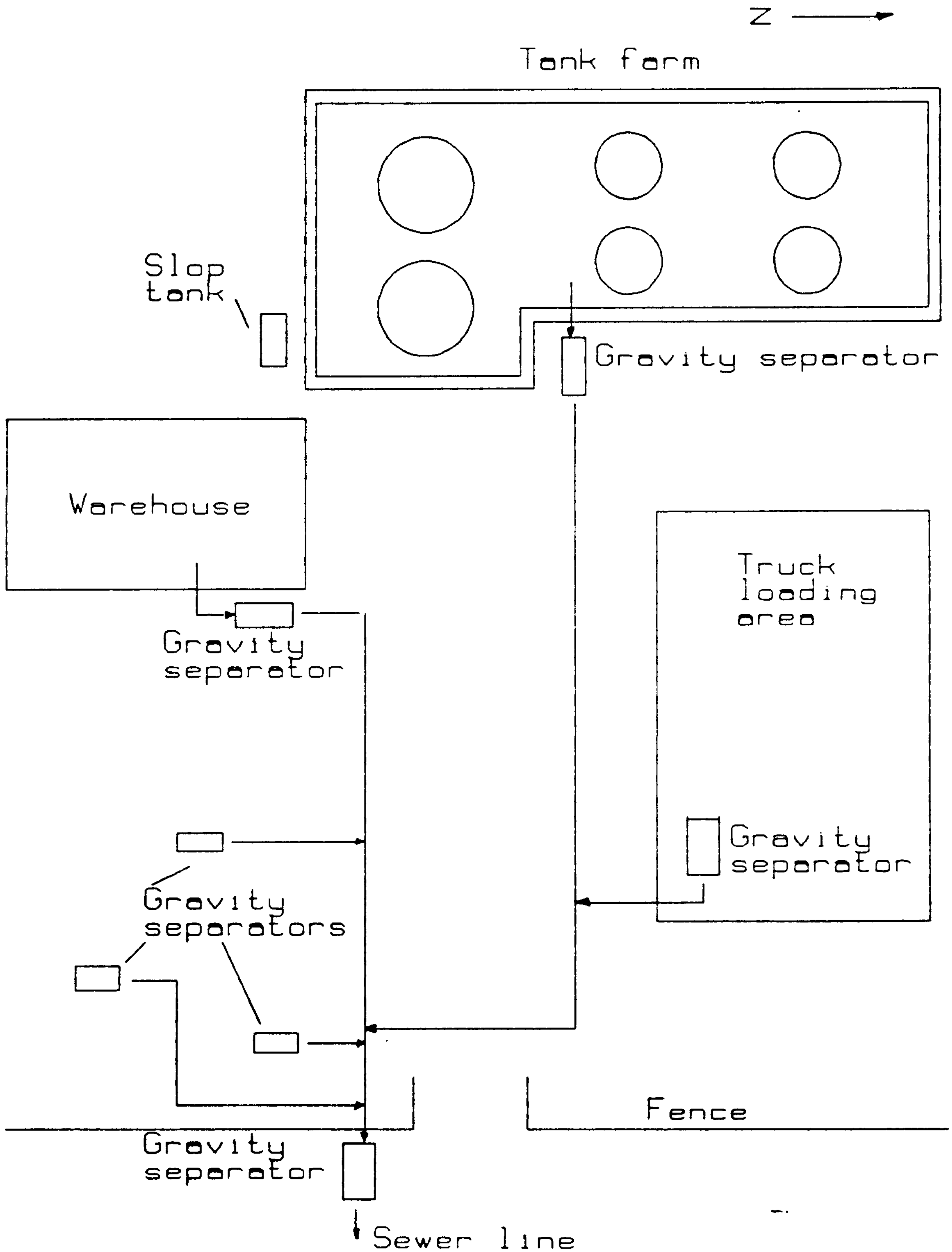

Figure E6: Schematic of Site 6

SITE 7

This facility is located near the north arm of Fraser River. It is a small jet fuel tank farm operation which was built in 1969. It includes five tanks which provide a total storage capacity of about 45 000 barrels (7 154 m^3). Fuel transfer in and out of the facility is by pipeline. The five tanks are enclosed within an earth containment dyke. The dyke walls are lined with an impervious material which does not connect to the clay base of the floor. Stormwater management practices are as follows (refer to Figure E7):

Stormwater runoff collects at the north east corner of the tank farm and flows to a buried collection sump followed by a manually operated pump well, in which a minimum water level is maintained such that it is never pumped dry. The stormwater is discharged with an over-the dyke drainage system into a ditch running along the east side of the tank farm.

Tank water bottoms are discharged to a slop tank. Oily wastes are transported to another facility for reprocessing.

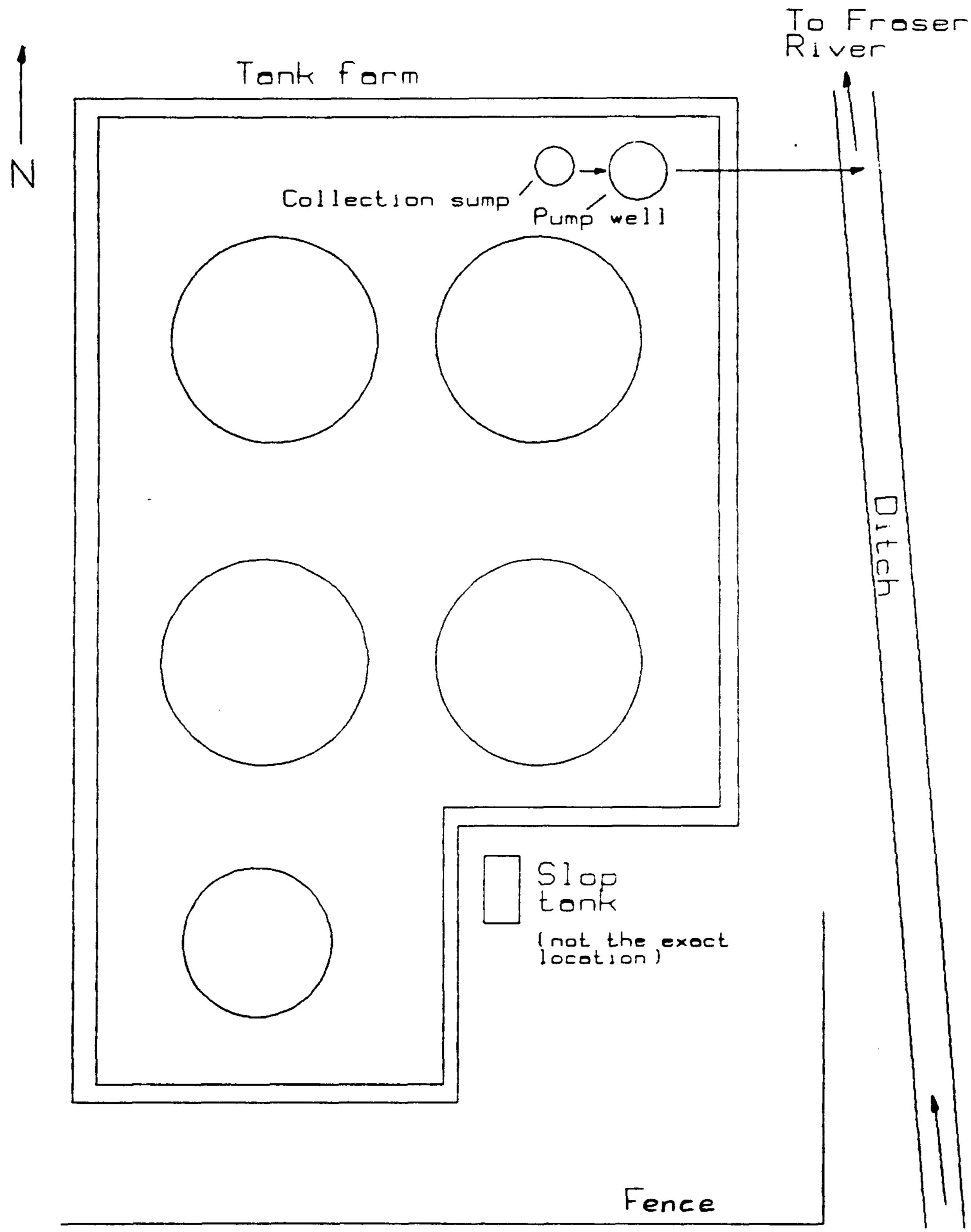

Figure E7: Schematic of Site 7