Ministry for the
Environment
Manatu Mo Te Taiao

Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand

Prepared by a Joint Working Group of the Ministry for the Environment, local authorities and petroleum marketing companies

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EXECUTIVE SUMMARY

The *Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand* offer guidance on specific measures which can be taken by the owners and managers of such sites to ensure that water discharges will not cause significant adverse effects on the environment. The Guidelines have been prepared by an Oil Industry Environmental Working Group with members from central and regional government and industry.

The Guidelines are in three parts. Part A - Objectives of the Guidelines discusses the purpose and scope of the Guidelines and sets out the legislative requirements for water discharges. Part B - Best Management Practices sets out the means by which facility owners and operators may comply with these requirements. Appendices contain supporting technical information.

Part A. Objectives

Chapter 1 sets out the purpose and scope of the Guidelines and lists some other guidelines relating to the oil industry. The purpose of the Guidelines is to assist in the sustainable management of water resources by ensuring that water discharges from petroleum industry sites meet the quality objectives laid down in regional policy statements and plans.

Chapter 2 describes the regulatory background for the management of water quality. Section 2.2 explains the different roles and responsibilities of regional councils and territorial local authorities and describes how the planning process operates under the framework of the Resource Management Act 1991. Section 2.3 lists those provisions of the Act which relate specifically to water quality. Sections 2.4 and 2.5 discuss some other important publications dealing with water quality management.

Part B. Best Management Practices

Chapters 3-6 discusses the drainage systems needed for dealing with water discharges from different types of site. Each of these chapters has three sections: a chapter summary; a section which specifies basic system design requirements; and a section which discusses the different types of drainage systems that are needed. Chapter 3 deals with retail service stations, Chapter 4 with truck stops, Chapter 5 with terminals and depots, and Chapter 6 with manufacturing plant sites.

Chapter 7 deals with the design of water treatment systems. Section 7.1 contains a summary of the chapter. Section 7.2 discusses how to estimate the total capacity needed in such systems, which depends on flow conditions. Sections 7.3 and 7.4 deal with containment systems, and section 7.5 discusses different types of treatment devices.

Chapter 8 deals with the day-to-day management of water treatment systems. Section 8.1 contains a summary of the chapter. Section 8.2 sets out the goals of such systems. Section 8.3 deals with the impact of site cleaning on the water treatment systems. Section 8.4 deals with risk mitigation. Sections 8.5 and 8.6 discuss maintenance and inspection of water treatment systems, and Section 8.7 deals with operating procedures. Section 8.8 briefly discusses other potential contaminants.

Chapter 9 deals with the monitoring of the performance of water treatment systems. Section 9.1 contains a summary of the chapter. Section 9.2 refers to earlier work on monitoring oil industry sites. Section 9.3 describes self-monitoring, and Section 9.4 deals with monitoring by regional councils. Section 9.5 describes appropriate sampling protocols.

Appendices

Appendix 1 contains some results of risk assessment studies. Appendix 1.1 gives estimates of the risks posed by spillages of fuel, especially at service stations and truck stops. Appendix 1.2 deals with the environmental effects of other, general automotive products sold and used at service stations and recommends best management practices. Appendix 1.3 summarises the results of a modelling study of the potential effects of stormwater discharges from oil interceptors on four different types of aquatic environment. These effects were found to be relatively minor under most conditions.

Appendix 2 contains some results from monitoring studies. Appendix 2.1 gives the results of two monitoring projects undertaken by NIWA Ltd for the oil industry and for the Auckland Regional Council. The oil industry project dealt with suspended solids and hydrocarbons, and the ARC project dealt only with suspended solids. Appendix 2.2 gives the results of a spill trial undertaken using an API interceptor. Appendix 2.3 shows the notified spill records of the petroleum marketing companies in New Zealand for the period 1992-95 in both graphical and tabular form. Appendix 2.4 shows the size distribution of oil particles in the discharges from different types of pumps run at various speeds. Appendix 2.5 shows the results of trials of the effect of a degreaser on the effectiveness of separators.

Appendix 3 provides more detail for service station owners and operators. It is in two parts. Appendix 3.1 sets out best management practices, and Appendix 3.2 is a generic surface spillage mitigation plan for service stations.

Appendix 4 contains selected national rainfall data. Appendix 4.1 gives rainfall data for sites throughout New Zealand, presented in terms of the annual amount of rainfall which falls during storms of a range of intensities. Appendix 4.2 comprises isohyet maps for storms with a 10% annual probability of occurrence. Appendix 4.3 interprets this data in terms of flow device configurations.

Appendix 5 deals with the design of oil-water separators. Appendix 5.1 gives the design calculations for API separators; Appendix 5.2 deals with parallel plate separators; and Appendix 5.3 presents the basic equations for separator design.

Appendix 6 contains worked examples of how to specify the oil-water separator needed on a typical site. Appendix 6.1 gives the calculations for an API interceptor and Appendix 6.2, for a corrugated plate interceptor.

Appendix 7 contains information on changeover valves supplied by Christchurch City Council.

Appendix 8 gives idealised site layouts for a service station, truck stop, storage depot, and manufacturing site.

DEFINITIONS

AGCS - Above-ground containment system: an above-ground (or partially depressed) bulk tank compound (i.e., one or more tanks in a group). Also referred to as a dike or bund.

ANZECC - The Australian and New Zealand Environment and Conservation Council.

Approved waste management contractor - A contractor registered by a local authority for the collection and disposal of refuse under the Offensive Trade provision of the Health Act 1956.

BTEX - Benzene, toluene, ethylbenzene, and xylenes.

BOD - Biochemical oxygen demand, also known as BOD_5 (in this document BOD refers to carbonaceous BOD unless noted otherwise)

Compound - Bunded area surrounding storage facilities.

Contaminant - Any liquid or solid that: (a) when discharged into water changes or is likely to change the physical, chemical, or biological condition of water; or (b) when discharged onto or into land or into air changes or is likely to change the physical, chemical, or biological condition of the medium.

Depot - Primary storage facility from where products are distributed to customers.

Detergent - A surface-active compound, either natural or synthetic, which acts as a cleansing agent by emulsifying the oils and greases (occurring on hardstanding surfaces) as a result of its ability to reduce interfacial tension between dissimilar liquids.

Diesel stop - Also known as a truck stop (see below).

DOL - Department of Labour (often the Occupational Safety and Health Service in these Guidelines).

Hydrotest (water) - Water which has been reticulated into a storage tank or pipeline for hydrostatic pressure testing of the structures.

Installation - Alternative name for a depot.

Oil(s) - Petroleum-based contaminants which have the potential to contaminate water.

Operational water - Water such as fire-fighting water, wash-down water, mains water (used for testing of equipment such as tanks or pipelines), sea water, or water which settles out of stored product.

PAH - Polycyclic aromatic hydrocarbons.

Petroleum marketing companies - Divisions of companies responsible for the handling and storage of refined petroleum products.

Receiving waters - Natural waters such as streams, ponds, lakes, rivers, groundwater, harbours, or the sea. Receiving waters do not include pipelines, which act only as a conduit between sites and receiving waters, but discharges to pipelines are as sensitive as the receiving waters downstream of them.

Retail sites - Sites such as service stations established for the purpose of dispensing fuels to the community.

RMA - The Resource Management Act 1991.

Terminal - Alternative name for depot.

Trade waste - Liquid waste from industrial or trade premises discharged to a territorial local authority sewerage system.

Truck stop - A staffed or unstaffed facility dispensing diesel (and sometimes gasoline and lubricating oil) to commercial customers.

UST - Underground storage tank.

PART A

OBJECTIVES

1. INTRODUCTION

1.1 The Purpose of these Guidelines

The *Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand* offer guidance on specific measures which can be taken by the owners and managers of such sites to ensure that water discharges will not cause significant adverse effects on the environment.

The purpose of the Guidelines is to assist in the sustainable management of water resources by ensuring that water discharges from petroleum industry sites meet the quality objectives laid down in regional policy statements and plans. This is achieved by ensuring that such water discharges are not contaminated by petroleum products but that these are intercepted and managed by control systems which provide appropriate levels of protection for people, property, and the environment.

The Guidelines are intended to complement the Dangerous Goods Act 1974, the Dangerous Goods Regulations, the Hazardous Substances and New Organisms Regulations (or subsequent legislation), and the Resource Management Act 1991. They do not replace or supersede the requirements of these Acts and Regulations but provide guidance on how their requirements can be met, and how at the same time the environment can be protected from the potential hazards of petroleum product releases. Adoption of the provisions of the Guidelines, supported as necessary by detailed technical documentation, will enable site owners and managers to comply with national and local law.

1.2 The Scope of the Guidelines

The Guidelines are intended to assist in the management of the impacts of emissions and wastes on water discharges from petroleum industry sites, as shown in Figure 1.1. They deal with sites at which the principal products stored are gasoline, kerosene, diesel, lubricating oil and fuel oil. Four general types of site are discussed, as follows:

- retail service stations
- truck stops
- terminals and depots
- lubricating oil blending and grease manufacturing plants

The Guidelines do not deal with petroleum refineries or oil recycling sites, but do address the issue of waste oil collected at service stations.

In New Zealand, refinery-supplied storage facilities are located close to deep-water ports, except for the Wiri Oil Terminal which is adjacent to an estuarine environment. Other facilities are located adjacent to a wide variety of environments which may:

(a) support aquatic ecosystems and/or other wildlife,

(b) be used as recreational waters, or

(c) be used for drinking purposes.

In designing systems to protect the external receiving water environments adjacent to petroleum industry sites, the aim is to separate catchment areas on the site which are not likely to be contaminated by oil from those which are potentially contaminated by oil (for example, around fill points) and to make separate provision for the handling of industrial effluents such as those from vehicle washes.

The Guidelines give detailed advice on the design of new facilities and facilities which are being substantially upgraded, i.e., those sites where major site engineering works are being undertaken so as to allow all catchments to be segregated and engineering controls to be installed. However, following the procedures within the Guidelines will assist all sites, irrespective of whether they are new, redeveloped, or unchanged, in meeting their obligations under the Resource Management Act.

1.3 The Structure of the Guidelines

The remainder of Part A - Objectives of the Guidelines discusses the legislative requirements in more detail (Chapter 2). Part B - Best Management Practices sets out the means by which facility owners and operators may comply with these requirements. This is achieved by good design, diligent management of sites, and periodic performance monitoring, both by owners and operators and by authorities. Compliance with the conditions in Part B is considered to be a useful basis for a resource consent.

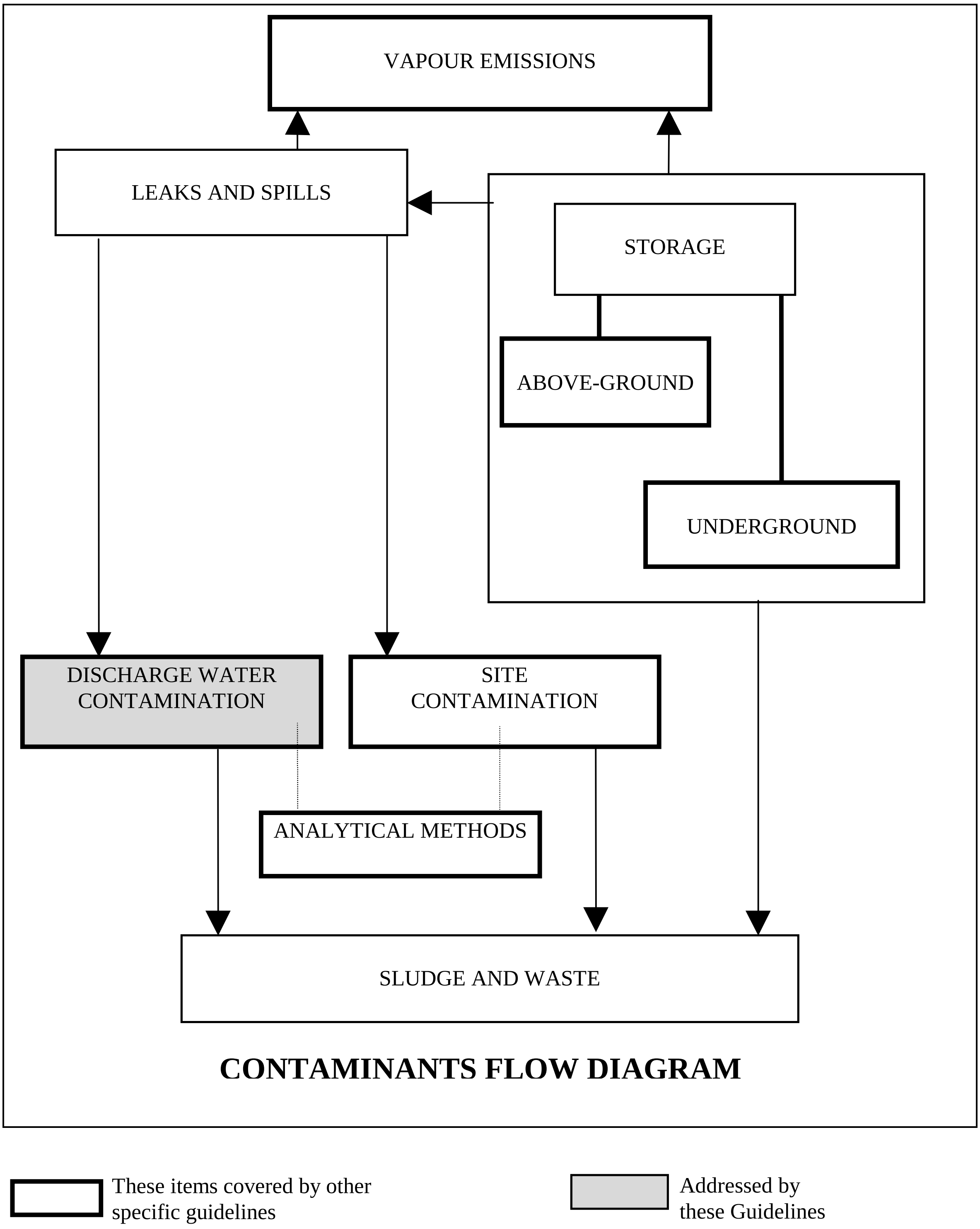
Chapters 3-6 discuss the four types of site mentioned above. They describe how the different types of activity on the sites affect the water discharges and show how the sites should be designed to allow effective separation and treatment of water which may be exposed to contamination. Chapters 7-9 deal with the management and monitoring of systems.

Appendices 1-8 provide supplementary information for those readers who need more technical detail than is given in the main text. They include, for example, detailed methodologies for designing specific treatment devices.

1.4 Relationship with Other Guidelines

This guideline is one of a suite of inter-related guidelines developed for the New Zealand Petroleum Industry as shown on the following pages. In some instances there is a close relationship between this and “Assessment and Management of Petroleum Hydrocarbon Contaminated Sites” because discharges sometimes contaminate sites while, conversely, contaminated sites occasionally discharge contaminants to stormwater systems and surface water bodies. Also, both guidelines are linked to “Analytical Methods for Determining Petroleum Products in Soil and Water” as shown in the diagram which follows.

Figure 1.1. The scope of these Guidelines and of other petroleum industry guidelines.



1.5 Other Guidelines

Other environmental management codes of practice or guidelines which deal with the oil industry and which have been published or are being developed by the Ministry for the Environment, the Department of Labour, local authorities, and the petroleum marketing companies include:

Design, Installation and Operation of Underground Petroleum Storage Systems. Occupational Safety and Health Service, Department of Labour. 1992. (due to be revised)

Management of Existing Underground Petroleum Systems. Occupational Safety and Health Service, Department of Labour. May 1995. (due to be incorporated with the above in a revised publication)

Transportation and Disposal of Petroleum Storage Tanks and Related Wastes. Occupational Safety and Health Service, Department of Labour. May 1995.

Above-ground Bulk Tank Containment Systems. Ministry for the Environment. June 1995.

Assessment and Management of Petroleum Hydrocarbons Contaminated Sites (currently being finalised).

Analytical Methods for Determining Petroleum Products in Soil and Water (currently being finalised).

Facility Vapour Emissions and Air Quality (currently in early stages of development).

Petroleum Storage and Handling at Farms and Small Commercial Sites (to be developed in the future).

Other publications on water quality are listed in Sections 2.4 and 2.5.

2. THE REGULATORY BACKGROUND FOR WATER QUALITY MANAGEMENT

2.1 Chapter Summary

This chapter describes the regulatory background for the management of water quality. Section 2.2 explains the different roles and responsibilities of regional councils and territorial local authorities and describes how the planning process operates under the framework of the Resource Management Act 1991. Section 2.3 lists those provisions of the RM Act which relate specifically to water quality. Sections 2.4 and 2.5 discuss some other important publications dealing with water quality management.

2.2 Plans and Resource Consents

Discharges of water from a site may be:

- to a stream, lake, or other freshwater body;
- to a stormwater system (and, in exceptional circumstances, to sewers);
- to the coastal marine area (harbour, estuary, coast);
- to land (soakage field); or
- to groundwater.

Under the Resource Management Act 1991 (the RM Act), the responsibility for controlling such discharges rests with regional councils, and unitary authorities where they operate as regional councils (Gisborne, Marlborough, and Tasman District Councils, and Nelson City Council). It is essential that the relevant council is consulted as early as possible in planning a new operation, or an extension or upgrade of an existing facility.

The relevant territorial local authority may be responsible for managing discharge permits for stormwater systems under delegated authority from the regional council. Where the territorial local authority manages a sewerage system, connections will need to be authorised by way of a permit from the local authority.

In addition to the RM Act, regional councils generally are in the process of preparing regional resource management plans. Most, if not all, regional councils have prepared transitional regional plans to cover the transition from previous legislation to the RM Act. The regional council should be consulted for proper interpretation of these plans.

It is often advisable to utilise the services of an experienced person or consultant to prepare an application for a resource consent and the supporting "assessment of environmental effects", where required. Sometimes the consultant or contractor who is responsible for the project has the expertise to do this. The regional council can advise the best course of action. This depends essentially on the complexity of the activity for which a consent is sought.

For most projects involving service stations, the discharge of water will be to a stormwater system via an oil interceptor. This may be a "permitted" activity provided the interceptor meets certain design criteria (for example, those set out in these Guidelines), but the regional council should be contacted to confirm that this is the case for the project under consideration.

Should a resource consent be required, the process set out below has to be worked through. The potential time required for this process should not be under-estimated. It is very important to consult with neighbours and affected persons well in advance of the date planned for final consent. If there is strong objection from affected persons (neighbours), considerable time delays and expense can be incurred. The issue of a resource consent at the end of this process is not guaranteed. Again, it is essential that the regional council is consulted as soon as possible in planning for the project.

Stage 1 - Scoping. Do you need a discharge permit and do you comply with the Resource Management Act?

Surface water discharges are the responsibility of regional councils (or unitary authorities where a regional council does not exist). The rules governing discharges in the regional plan will have been established according to the requirements of the RM Act. You should:

- Identify the water course or land you are discharging to.

- Ascertain the nature and composition of your surface water discharge, and the degree to which it complies with standards in these Guidelines to determine whether the effects are minor.

- Discuss the proposal with the regional council and/or your professional advisers to determine the quality of the receiving water that the regional council is seeking to achieve through the relevant discharge rules and to establish whether a resource consent is required. If you are discharging into the coastal marine area different rules may apply.

If a consent is required:

- Obtain the relevant plans/rules on water discharges from the regional council.

- Determine whether a controlled or discretionary consent is required for the discharge.

- Determine whether there are other consents which you may need to apply for at the same time.

- Determine whom you may need to consult with prior to preparation of your application, e.g., affected parties, iwi, and the Department of Conservation for coastal discharges.

Stage 2. Preparation

The basic information requirements are set out in section 88 and the 4th Schedule of the RM Act. Before drafting your application, consult with the regional council on the extent of any additional information they will require to assess the application, including any specific requirements in their plan. The extent of information provided should match the nature of the discharge and its potential effect on the environment. If you comply with these Guidelines, depending on the receiving environment, the extent of additional information may be minimal. However, as a council can ask for further information and delay processing the application, early quality consultation with all parties is recommended.

What information should you provide with your application?

- A description of the nature and composition of the discharge, the sensitivity of the receiving water to adverse effects, and what other alternative methods of discharge there are.

- An assessment of the actual or potential effects of the discharge on the environment; e.g., if the receiving water is used for or is being managed for the gathering or cultivating of shellfish for human consumption, whether the discharge will affect this. The assessment will need to include whether any of the effects outlined in S 70 of the RM Act arise (see section 2.3.4 below).

- Ways in which adverse effects can be mitigated, e.g., the degree to which the discharge complies with these Guidelines and the nature of other on-site environmental management systems

- You may need to include plans showing the discharge points.

- Any other resource consents required. You are generally required to lodge all required applications at the same time.

- Duration of the consent you are seeking (the RM Act provides for up to 35 years) and any conditions you consider appropriate, e.g., self-monitoring for compliance.

- An outline of who the affected parties are and information on whom you have consulted.

Specialists' reports may be required to obtain this information. If so, they should be attached to and form part of the application.

Stage 3. Notification, assessment, and decision

Notification

The need to publicly notify the application may be stated in the rules in the plan. If they do not, and if you comply with these Guidelines and can demonstrate that there are no affected parties or that the affected parties agree with the application, the regional council is likely to determine that the application need not be notified. The decision on whether or not to notify rests with the council.

Hearings

If a hearing is required you will need to support the application with technical information. You will receive a copy of the recommendations of council staff on the application. This may include conditions on any consent granted. You will need to consider this report and address any matters raised at the hearing. This may require evidence from the experts who have written the specialists' reports accompanying your application.

Decision

If the application is granted it may be subject to conditions. Careful examination of the conditions is required to ensure that they are acceptable and can be complied with. If they are not acceptable you can object to them and seek their amendment or deletion. If the council rejects this objection you may need to appeal any unacceptable conditions. Even if the consent and conditions are acceptable to you, any party who has made submissions to the application may appeal the decision.

If the application is declined you will need to appeal the decision. Alternatively, you may need to work with the council to redesign your interception equipment to meet a higher standard or reassess the method you use to discharge water prior to reapplying for consent. Early consultation with the council at the initial scoping stage of the application should avoid this in most instances.

Costs

Councils can charge fees for processing the application (including the costs of any hearing) and monitoring compliance with the terms of the consent. They can also set financial contributions or alternative means of settlement such as riparian planting (in accordance with the rules in the plan) to offset any environmental effects.

2.3 Provisions of the Resource Management Act

This section explains the provisions of the RM Act which relate to water quality. Much of the information provided is in the form of direct quotes from the Act, and these are printed here in *italic type*. Guidance on the interpretation of the RM Act is provided by case law.

2.3.1 Provisions Related to Contaminants

The RM Act imposes specific responsibilities on individuals and bodies corporate designed to protect natural waters. The most notable of these include:

s.15 (1) No person may discharge any:

(a) Contaminant or water into water;

(b) Contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water; or

(c) Contaminant from any industrial or trade premises into air; or

(d) Contaminant from any industrial or trade premises onto or into land -

unless the discharge is expressly allowed by a rule in a regional plan and in any relevant proposed regional plan, a resource consent, or regulations.

s.15 (2) No person may discharge any contaminant into the air, or into or onto land, from -

(a) Any place, or

(b) Any other source, whether moveable or not -

in a manner that contravenes a rule in a regional plan or proposed regional plan unless the discharge is expressly allowed by a resource consent, or allowed by Section 20 (certain existing lawful activities allowed).

2.3.2 Provisions Related to Adverse Effects

s.17 (1) Every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of that person, whether or not the activity is in accordance with a rule in a plan, a resource consent, section 10, section 10A, or section 20.

(2) The duty referred to in subsection (1) is not of itself enforceable against any person, and no person is liable to any other person for a breach of that duty.

(3) Notwithstanding subsection (2), an enforcement order or abatement notice may be made or served under Part XII to -

(a) Require a person to cease, or prohibit a person from commencing, anything that, in the opinion of the Environment Court or an enforcement officer, is or is likely to be noxious, dangerous, offensive, or objectionable to such an extent that it has or is likely to have an adverse effect on the environment; or

(b) Require a person to do something that, in the opinion of the Planning Tribunal or an enforcement officer, is necessary in order to avoid, remedy, or mitigate any actual or likely adverse effect on the environment caused by, or on behalf of, that person.

(4) Subsection (3) is subject to section 319(2) (which specifies when a Planning Tribunal shall not make an enforcement order).

2.3.3 Functions, Powers, and Duties of Local Authorities

The functions, powers, and duties of local authorities under the RM Act are set out in sections 30-38. Clauses having particular relevance to water quality occur in s.30, which states:

s.30 Functions of regional councils under this Act -

(1) Every regional council shall have the following functions for giving effect to this Act in its region:

…

(c) The control of the use of land for the purpose of -

…

(ii) The maintenance and enhancement of the quality of water in water bodies and coastal water.

…

(d) In respect of any coastal marine area in the region, the control (in conjunction with the Minister of Conservation) of -

…

(iv) discharges of contaminants into or onto land, air, or water and discharges of water into water.

2.3.4 Rules about Discharges

Under the RM Act, regional councils may use various methods to meet water quality objectives. One method is the power to make rules relating to discharges.

s.70 *(1) Before a regional council includes in a regional plan a rule that allows as a permitted activity -*

(a) A discharge of a contaminant or water into water; or

(b) A discharge of a contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water; -

the regional council shall be satisfied that none of the following effects are likely to arise in the receiving waters, after reasonable mixing, as a result of the discharge of the contaminant (either by itself or in combination with the same, similar, or other contaminants).

(c) The production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials:

(d) Any conspicuous change in the colour or visual clarity:

(e) Any emission of objectionable odour:

(f) The rendering of fresh water unsuitable for consumption by farm animals:

(g) Any significant adverse effects on aquatic life.

(2) Before a regional council includes in a regional plan a rule requiring the adoption of the best practicable option to prevent or minimise any actual or likely adverse effect on the environment of any discharge of a contaminant, the regional council shall be satisfied that, having regard to -

(a) The nature of the discharge and the receiving environment; and

(b) Other alternatives, including a rule requiring the observance of minimum standards of quality of the environment, -

The inclusion of that rule in the plan is the most efficient and effective means of preventing or minimising those adverse effects on the environment.

s.107 *(1) Except as provided in subsection (2), a consent authority shall not grant a discharge permit or a coastal permit to do something that would otherwise contravene section 15 allowing -*

(a) The discharge of a contaminant or water into water; or

(b) A discharge of a contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water, -

if, after reasonable mixing, the contaminant or water discharged (either by itself or in combination with the same, similar or other contaminants or water) is likely to give rise to all or any of the following effects in the receiving waters:

(c) The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials:

(d) Any conspicuous change in the colour or visual clarity:

(e) Any emission of objectionable odour:

(f) The rendering of fresh water unsuitable for consumption by farm animals:

(g) Any significant adverse effects on aquatic life.

(2) A consent authority may grant a discharge permit or a coastal permit to do something that would otherwise contravene section 15 that may allow any of the effects described in subsection (1) if it is satisfied -

(a) That exceptional circumstances justify the granting of the permit; or

(b) That the discharge is of a temporary nature; or

(c) That the discharge is associated with necessary maintenance work -

and that it is consistent with the purpose of this Act to do so.

(3) In addition to any other conditions imposed under this Act, a discharge permit or coastal permit may include conditions requiring the holder of the permit to undertake such works in such stages throughout the term of the permit as will ensure that upon the expiry of the permit the holder can meet the requirements of subsection (1) and of any relevant regional rules.

2.3.5 Rules Relating to Water Quality

s.69 (1) Where a regional council -

(a) Provides in a plan that certain waters are to be managed for any purpose described in respect of any of the classes specified in the Third Schedule; and

(b) Includes rules in the plan about the quality of water in those waters, -

the rules shall require the observance of the standards specified in that Schedule in respect of the appropriate class or classes unless, in the council's opinion, those standards are not adequate or appropriate in respect of those waters in which case the rules may state standards that are more stringent or specific.

(2) Where a regional council provides in a plan that certain waters are to be managed for any purpose for which the classes specified in the Third Schedule are not adequate or appropriate, the council may state in the plan new classes and standards about the quality of water in those waters.

(3) Subject to the need to allow for reasonable mixing of a discharged contaminant or water, a regional council shall not set standards in a plan which result, or may result, in a reduction of the quality of the water in any waters at the time of the public notification of the proposed plan unless it is consistent with the purpose of this Act to do so.

2.4 The ANZECC Water Quality Guidelines

The ANZECC *Australian Water Quality Guidelines for Fresh and Marine Waters*, although not adopted in New Zealand, establish desirable water quality for a number of environments, namely aquatic ecosystems, recreational water, water for drinking, agricultural water and industrial water (for use in boilers, cooling systems, etc.).

2.5 Other Water Quality Guidelines

The Ministry for the Environment has developed the following guidelines for receiving water quality management.

Water Quality Guidelines No. 1, June 1992. (Guidelines for the Control of Undesirable Biological Growths in Water).

Water Quality Guidelines No. 2, June 1994. (Guidelines for the Management of Water Colour and Clarity).

Resource Management Ideas: No. 10. (A discussion of reasonable mixing in water quality management).

A Methodology for Deriving Aquatic Guideline Values for Toxic Contaminants.

PART B

BEST MANAGEMENT PRACTICES

3. RETAIL SERVICE STATIONS

3.1 Chapter Summary

This chapter discusses the drainage systems needed for dealing with water discharges from retail service stations. Section 3.2 specifies basic system design requirements, and section 3.3 discusses the different types of drainage systems that are needed. Figure 3.1 shows the drainage systems in graphical form. Further information on best practice in service station forecourt management is given in Appendix 3, and a detailed site plan for a service station is given in Appendix 8.

For requirements common to all classes of site, see Chapters 7-9.

3.2 Categories of Site Usage

Drainage systems within a site fall into the four basic categories described below. (See also Figure 3.1.)

Category 1 **- drainage systems are dedicated to the capture and disposal of stormwater from the following areas where the presence of oil contaminants is unlikely to occur**

(i) Roofed areas.

(ii) Paved open areas within the site which are utilised for vehicle movement, driveways, and parking areas should be graded so that runoff discharges into stormwater collector sumps before subsequently draining into a dedicated stormwater system.

(iii) Unpaved areas (i.e., metalled or grassed areas) should be graded such that runoff discharges into underground drains or gutters, soakage areas, or natural water courses as approved by the local authority. The discharges should pass through appropriate stormwater collector sumps before entering the drainage system.

Stormwater runoff from all Category 1 areas should be discharged directly to dedicated stormwater drains and should be segregated from site drainage which services oil-contaminated areas.

Category 2 **- drainage systems are dedicated to the capture of stormwater (and wash water, if permitted by a resource consent) which contains oil contaminants generated from forecourts, etc. and which requires appropriate treatment prior to disposal to stormwater drains or sewers. Such water is likely to come from two main areas.**

i) Paved forecourt areas beneath the canopy, where vehicle refuelling takes place, tanks are filled (at some sites), and waste oil containers are stored; together with areas immediately beyond the canopy "footprint" which lead to the same drainage system. Drainage from paved forecourt areas should be directed by appropriate surface grading into grated sumps, gutters, and/or grated drains leading to drainage systems or treatment devices dedicated only to rainwater runoff, which finally discharge into stormwater drains, soakage trenches, or natural water courses as approved by local authorities.

(ii) Slabs surrounding remote fill points for UST's. (where present). Drainage from hardstanding areas immediately surrounding filling points for underground storage tanks should be directed by appropriate surface grading into grated sumps, gutters, and/or grated drains leading to drainage systems or treatment devices dedicated only to rainwater runoff, which finally discharge into stormwater drain or sewer systems, soakage trenches, or natural water courses as approved by local authorities.

Category 3 **- drainage systems are dedicated to the capture of wastes from car washes or toilets, ablutions, and kitchens and similar wastes for disposal direct to sewers or, where no sewer exists, at the direction of the local authority**

Special designs and conditions apply to the drainage systems for car wash areas (automatic or manual). Each is considered as a specific case having regard to effluent generation, effluent segregation, output quality, treatment required, and disposal. The question of whether to discharge or recycle car wash effluent should be evaluated in consultation with the network utility operator.

In **sewered areas,** systems should be initially discussed with local network utility operators to confirm the acceptability of the effluent or if pre-treatment is required before effluent finally discharges to the network utility operators' systems. Consents will be required for industrial "trade" discharges to sewers.

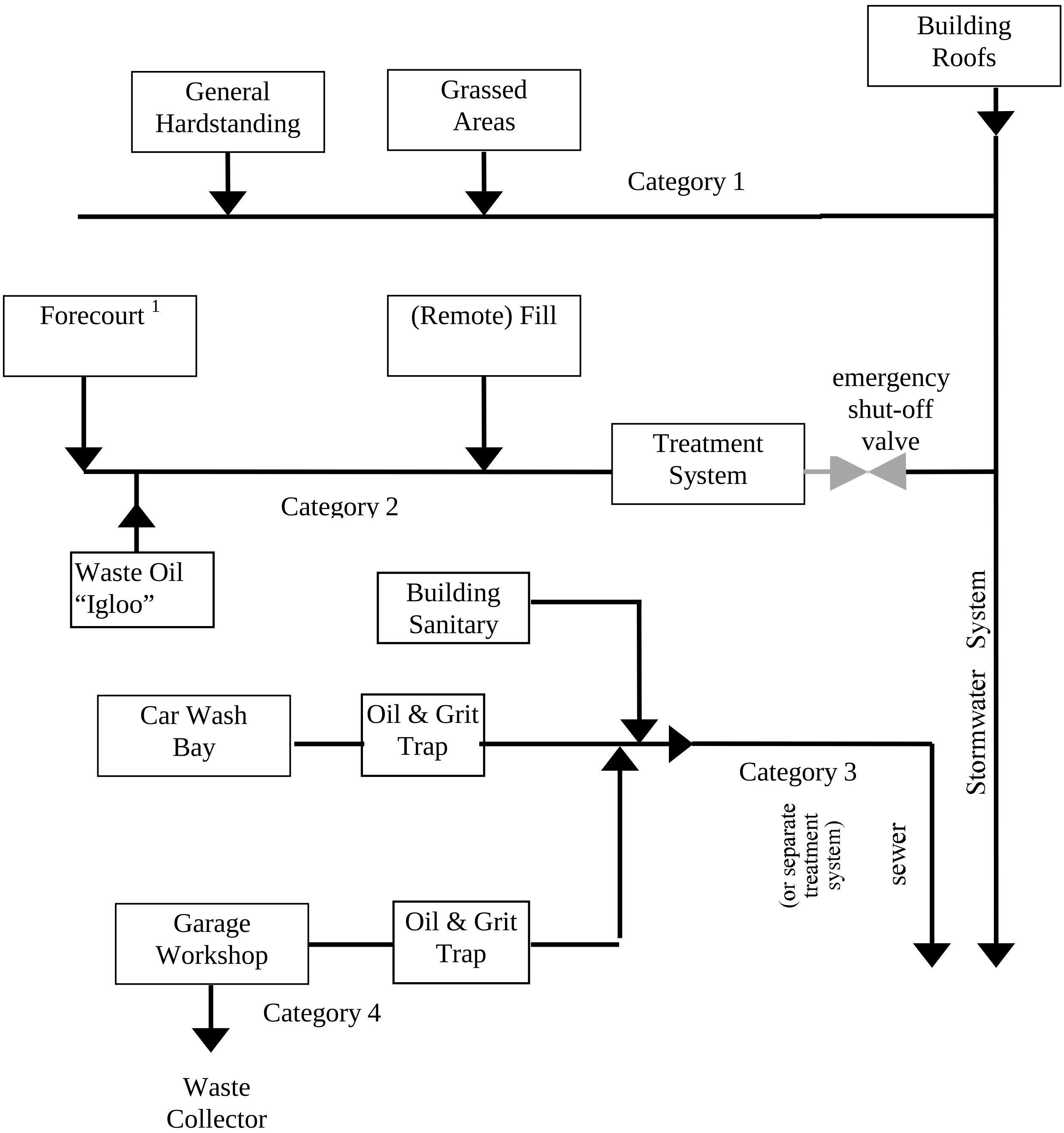
In **unsewered areas,** systems should be initially reviewed with local authorities to determine disposal options.

Category 4 **- drainage systems are dedicated to the capture of washings and waste from workshops. All internal floor areas should be graded into floor sumps with silt collectors leading via dedicated drains to an effective effluent collection and treatment device before final discharge to systems as directed by local authorities and/or network utility operators**

Changes in grade at the entrances to such work areas should be such as to prevent external surface water entering workshop drainage and vice versa.

Hazardous waste for off-site disposal must be collected by an approved waste management contractor (see Definitions) and transported in accordance with NZ5433:1988 "Code of Practice for the Transport of Hazardous Substances on Land".

Figure 3.1. A typical flow diagram for surface waters reticulated from a retail service station site.



Notes

1. Forecourt stormwater runoff is acceptable as a Category 2 discharge; but forecourt washings should be directed to sewer or collected for disposal if they are not permitted by a discharge consent.

4. TRUCK STOPS

4.1 Chapter Summary

This chapter discusses the drainage systems needed for dealing with water discharges from truck stops. Section 4.2 specifies basic system design requirements, and section 4.3 discusses the different types of drainage systems that are needed. Figure 4.1 shows the drainage systems in graphical form. A detailed site plan for a truck stop is given in Appendix 8. The overall approach for handling surface water runoff from truck stops is similar to that for retail service stations.

For requirements common to all classes of site, see Chapters 7-9.

4.2 Categories of Site Usage

Drainage systems within a site fall into two basic categories, as follows:

Category 1 **- drainage systems are dedicated to the capture and disposal of stormwater from areas where the presence of oil contaminants is unlikely to occur. These include:**

(i) Roofed areas.

(ii) Paved open areas within the site which are utilised for vehicle movement, driveways, and parking areas should be graded so that runoff discharges into stormwater collector sumps before subsequently draining into a dedicated stormwater system.

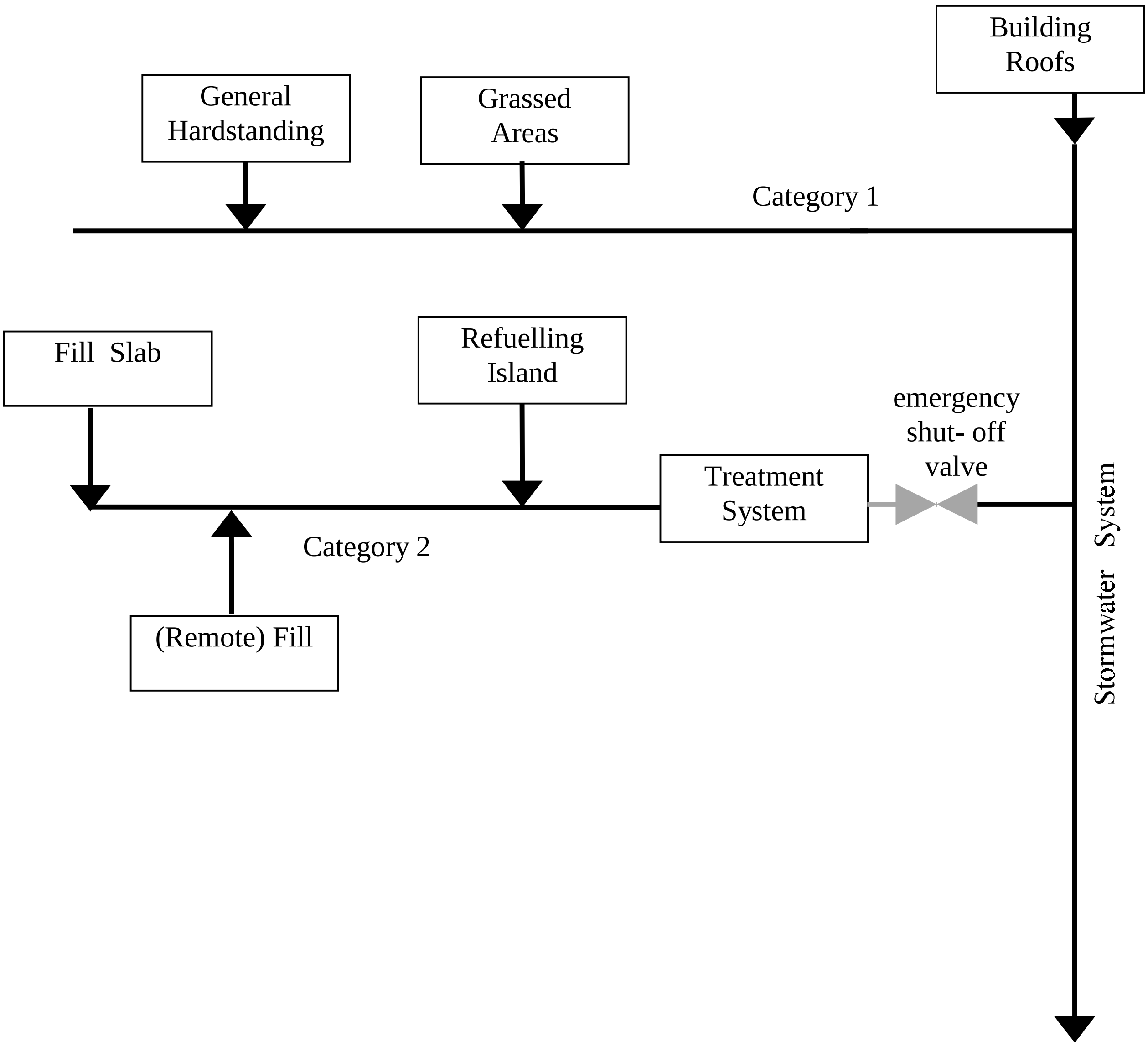
(iii) Unpaved areas (metalled or grassed areas) should be graded so that runoff discharges into underground drains or gutters, soakage areas, or natural water courses as approved by the local authority. Discharges should pass through appropriate stormwater collector sumps before entering the drainage system.

Stormwater runoff from all Category 1 areas should be discharged directly to dedicated stormwater drains and should be segregated from site drainage which services oil-contaminated areas.

Category 2 **- drainage systems are dedicated to the capture of wash water and stormwater which contains oil contaminants from refuelling areas and which requires appropriate treatment prior to disposal to stormwater drains or to sewers.**

Drainage from paved areas should be directed by appropriate surface grading into grated sumps, gutters, and/or grated drains leading to drainage systems or treatment devices dedicated only to rainwater runoff, which finally discharge into stormwater drains, sewers, soakage trenches, or natural water courses as approved by local authorities.

Figure 4.1. A typical flow diagram for surface waters reticulated from a truck stop site.



5. TERMINALS AND DEPOTS

5.1 Chapter Summary

This chapter discusses the drainage systems needed for dealing with water discharges from terminals and depots. Section 5.2 specifies basic system design requirements, and section 5.3 discusses the different types of drainage systems that are needed. Figure 5.1 shows the drainage systems in graphical form. A detailed site plan for a bulk storage site is given in Appendix 8.

For requirements common to all classes of site, see Chapters 7-9.

5.2 Use of Areas

Drainage systems within a bulk storage site may consist of some or all of the following elements:

***Category 1A* - drainage systems are dedicated to the capture and disposal of stormwater from areas where the presence of oil contaminants is unlikely to occur.**

***Category 1B* - drainage systems are dedicated to the capture of operational water. This is typically of similar quality to stormwater, but may or may not require treatment. The definition of operational water includes:**

(i) The release of fire system water under test conditions or during an incident

(ii) New storage system hydrotest water

(iii) Older storage system hydrotest water

(iv) Water released from tank bottoms

(v) Stormwater from compounds and truck parks.

If these discharges are shown to contain negligible quantities of hydrocarbons, they may be discharged to stormwater drains; if not, they should be directed to a suitable treatment device (see Figure 5.1).

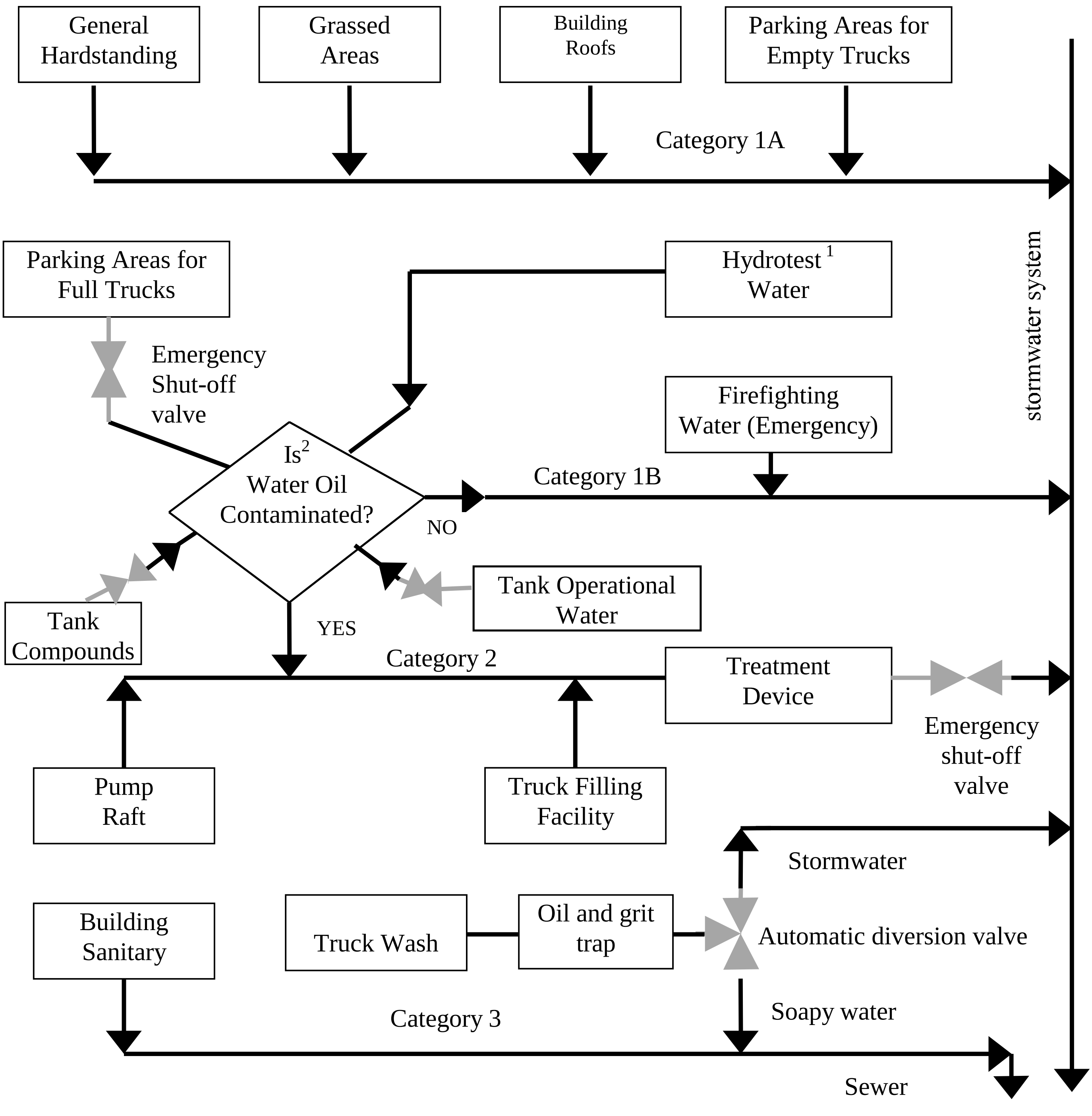
***Category 2* - drainage systems are dedicated to the capture of operational water, wash water and stormwater which may contain oil contaminants, and which requires treatment prior to disposal to stormwater drains. Such water may be:**

(i) From pump rafts and filling transfer facilities

(ii) Contaminated category 1 water

***Category 3* drainage systems are dedicated to capture of waste from truck washes or toilets, ablutions, and kitchens and similar wastes for disposal direct to sewer.**

Figure 5.1. A typical flow diagram for surface waters reticulated from a bulk storage site.



Notes

1. Release of hydrotest water and tank operational water may be to stormwater drains if permitted by a discharge consent.

2. Hydrotest water and tank operational water may require testing before it may be released.

6. LUBRICATING OIL AND GREASE MANUFACTURING PLANTS

6.1 Chapter Summary

This chapter discusses the drainage systems needed for dealing with water discharges from manufacturing plant sites. Section 6.2 specifies basic system design requirements, and section 6.3 discusses the different types of drainage systems that are needed. Figure 6.1 shows the drainage systems in graphical form. A detailed site plan for a manufacturing plant site is given in Appendix 8.

For requirements common to all classes of site, see Chapters 7-9.

6.2 Use of Areas

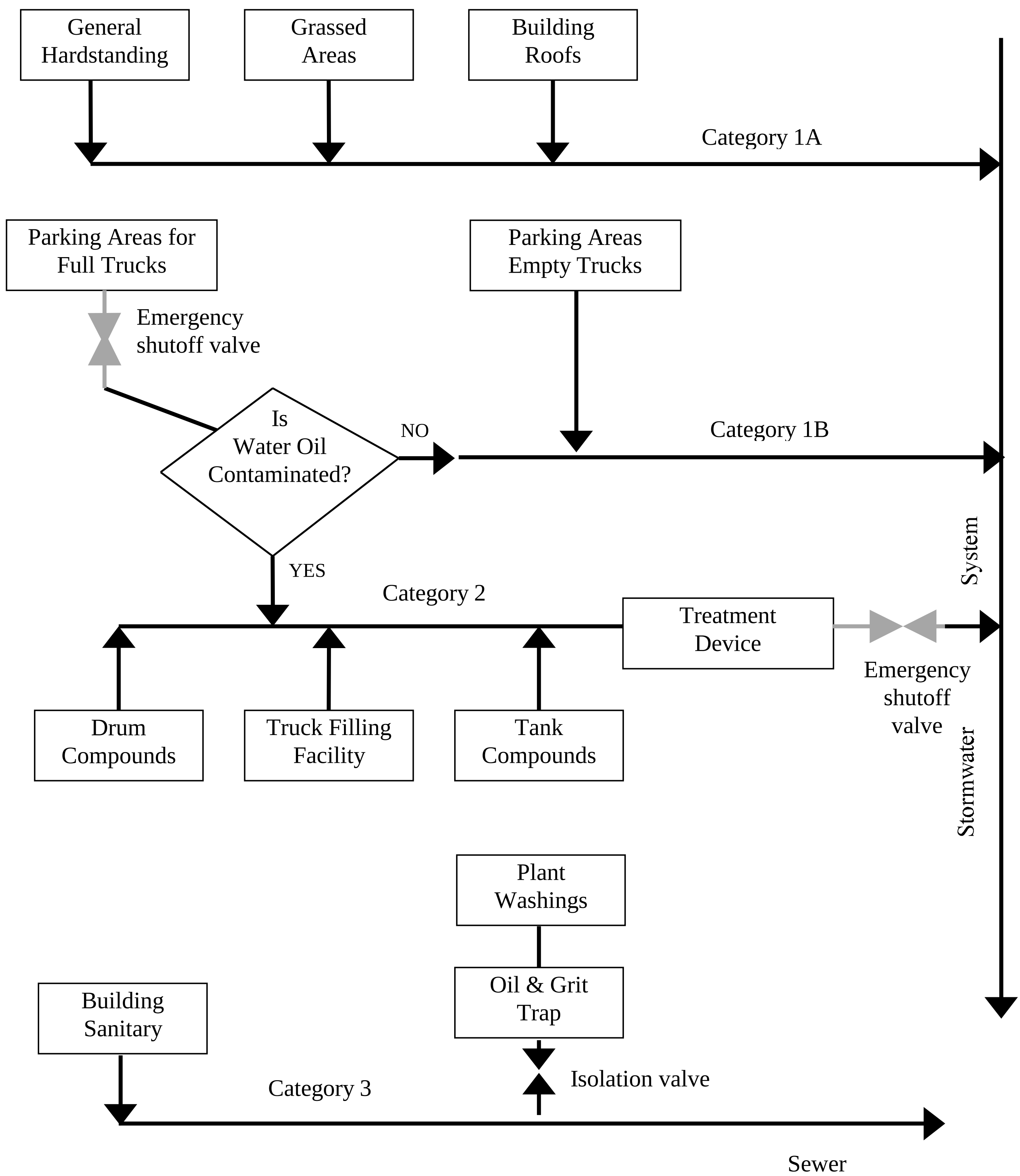
Drainage systems within a site consist of the following areas:

Category 1 (1A and 1B) **- drainage systems are dedicated to the capture and disposal of stormwater from areas where the presence of oil contaminants is unlikely to occur.**

Category 2 **- drainage systems are dedicated to the capture of operational water, wash water, and stormwater which may contain oil contaminants and which requires treatment prior to disposal to stormwater drains.**

Category 3 **- drainage systems are dedicated to the capture of waste from toilets, ablutions, and kitchens and similar wastes, and plant washings which may have contaminants such as detergents or other cleansing agents.**

Figure 6.1. A typical flow diagram for surface waters reticulated from a manufacturing plant site.



7. DESIGN REQUIREMENTS

7.1 Chapter Summary

This chapter deals with the design of water treatment systems for all the generic classes of sites discussed in Chapters 3-6. Section 7.2 discusses how to estimate the total capacity needed in such systems, which depends on flow conditions. Sections 7.3 and 7.4 deal with containment systems, and section 7.5 discusses different types of treatment devices.

7.2 Flow Conditions

Treatment systems for oil-contaminated water should have sufficient capacity to treat 90-95% of stormwater runoff from the potentially contaminated catchment areas on a long-term basis. A design flow rate to achieve this objective is dependent on rainfall intensity which varies throughout the country. Appendix 4.1 gives rainfall statistics and the corresponding design rainfall intensities at various locations.

Additional provisions to consider are: (i) a downstream flow-control device such as an orifice plate which will restrict the flow rate and thereby restrict the effluent contaminant concentration; and (ii) a downstream overflow weir to ensure that separated oil does not discharge over the sides of the oil/water separator during extreme storm events such as the 10-year-return-period storm events shown by isohyets in Appendix 4.2 (extracted from the New Zealand Building Code Handbook). Examples of how to configure flow-control devices may be found in Appendix 4.3.

Furthermore, provision should be made for the collection and treatment of "washdown" water. This may or may not be combined with the stormwater, depending on local requirements and the nature of the effluent.

7.2.1 Non-bunded Areas

For non-bunded sites, grades and levels should enable separation of potentially oil-contaminated areas from the remainder of the site.

For potentially contaminated catchment areas, the design discharge Q is determined by the greater of the two values below:

(i)	Q	=	C.i.A, as a consequence of a storm event
where	C	=	runoff coefficient (0.9 to 1.0 for impermeable surfaces)
	i	=	rainfall intensity (see Appendix 4)
	A	=	catchment area

For service station canopies, it is assumed that rain falls on a one metre strip beneath the longest side of the canopy together with areas immediately beyond the canopy "footprint" which drain to the under-canopy drainage system.

(ii) where a consent or by-law allows discharge of washdown water, Q = the discharge from the washdown hose (typically 20-30 litres per minute).

Other conditions relevant to the design of interceptors are:

- Water temperature: take average winter conditions.

- Contaminant density (specific gravity): use the highest density value for the principal products stored at the site. Average densities are: diesel, 0.85 kg/litre; kerosene, 0.79 kg/litre; gasoline: 0.75 kg/litre.

- Minimum diameter of globule to ensure nominal 98% capture of entrained petroleum products.

Oil-contaminated water discharges typically contain a wide range of oil globule diameters, and effluent quality can be managed by designing systems to capture the larger globules. The API nominates 150 micrometres, which is supported by oil industry monitoring and other historical data in Appendix 2 (the low incidence of spillage would suggest that rarely will devices be required to perform to their ability). However, greater assurance of water quality can be given if a 60 micrometre minimum globule size is targeted for capture.

7.2.2 Bunded Areas

For bunded or controlled areas, the system should be capable of removing contaminants at the maximum discharge rate resulting from the release of impounded water (e.g., water which accumulates over a weekend).

7.3 Spill Retention Provision - Truck Stops and Service Stations

A statistical review of past spill events demonstrates that the following containment volumes will ensure containment of 99.9% of historical spills. Spills outside these parameters will be managed according to an appropriate site-specific contingency plan (see Chapter 8).

(i) Retail service station: 2500 litres
(ii) Truck stop: 2500 litres

The selection of the above spill containment volumes is supported by oil industry spillage records from 1992-1995 and to some extent by a risk assessment study commissioned by Caltex and undertaken by Woodward-Clyde. These are summarised in Appendices 1 and 2.

7.4 Spill Retention Provision - Terminals, Depots, and Manufacturing Plants

Containment of spills within the tank farm bunded area is addressed in the AGCS guideline, referred to in Sections 1.4 and 5.2 of these Guidelines. Areas outside the AGCS system should have enough capacity to contain the largest single storage unit, e.g., the largest compartment on a road tanker, which is nominally 8000 litres, or 30,000 litres for non-compartmented or manifolded vehicles such as aviation tankers.

7.5 Treatment Devices

7.5.1 Devices for the Capture of Oil Contaminants (and Suspended Solids)

Treatment devices which use the gravity separation principle to remove oil from water are the most practicable option to achieve the desired discharge quality outcome of section 8.2. Several different types are currently recommended, and they include:

- corrugated-plate separators (CPIs)
- American Petroleum Institute Separators (APIs) - single channel only
- or equivalent new technologies such as vertical gravity separators (VGSs).

Such treatment devices should normally be designed using the methodologies in Appendix 6.

The performance of triple-interceptor-trap separators (TITs) has often been effective in the past, but because their performance cannot be guaranteed to the level of the other options listed above, they should not be used for new installations, unless their effectiveness is proven to the regulatory authorities. Proof will require a simulated 2500 litre spill to coincide with the Guideline Design Storm and compliance with the discharge water quality of 15 mg/litre TPH (section 8.2).

Devices such as hydrocyclones, which remove oil from water by centrifugal action rather than by gravity separation, are also an effective option for water treatment but are not considered in these Guidelines.

The use of grassed swales, reed beds, etc. should be considered to provide treatment of discharges where appropriate, e.g., for general stormwater.

7.5.2 Protection from Other Contaminants

Where hardstanding areas are cleaned by methods other than those listed in section 8.3, either the resulting effluent should be recovered or change-over valves or systems should be provided to enable surfactants to be diverted to sewers. Typical change-over equipment is shown in Appendix 7 (courtesy of Christchurch City Council).

Consumable items such as those available from service stations (a typical inventory is shown in Appendix 1.2) need not be considered in the design of treatment devices, but accidental release of these products must be mitigated as described in Appendix 1.2.

Additional treatment devices such as those used to enable wash water to be recycled are outside the scope of these Guidelines.

7.5.3 Underground Drains

All underground drains should be designed to local authority requirements, and should be of sufficient capacity to discharge the design storms laid down by the Building Act New Zealand standards [refer to B.A.N.Z. isohyets located in Appendix 4.2] or, alternatively, storms nominated by the local authority. Drains, including any elastomeric joints, for oil-contaminated systems should be resistant to hydrocarbons and fuel aromatics.

7.5.4 Sampling Points

Accessible effluent sampling points and discharge outlets should be provided for all new sites and for sites undergoing significant redevelopment.

7.5.5 Storm Flow By-Passes

By-passes are sometimes installed at depots to enable release of large volumes of stormwater. Their use is not normally required at retail or truck stop sites because the capacity of the separator is sufficient to absorb the extreme storm event (see Appendices 4 and 6).

If by-passes are installed, they need to be carefully designed to ensure that they do not cause other problems such as releasing large quantities of oil products following a spill event. They must also be maintained to ensure that they continue to function as intended.

7.5.6 As-Built Plans

A set of as-built plans showing the location of the discharge point and oil separator and the layout of the stormwater system showing all access points on the site should be made available, where requested, to the appropriate authority within three months of the completion of the stormwater system.

8. MANAGEMENT OF SYSTEMS

8.1 Chapter Summary

This chapter deals with the day-to-day management of water treatment systems. Section 8.2 sets out the goals of such systems. Section 8.3 deals with the impact of site cleaning on the water treatment systems. Section 8.4 deals with risk mitigation. Sections 8.5 and 8.6 discuss maintenance and inspection of water treatment systems, and Section 8.7 deals with operating procedures. Section 8.8 briefly discusses other potential contaminants.

8.2 Discharge Water Quality

The basic goal of site water treatment systems is the protection of the environment. When evaluating the effects of discharges on the environment it is necessary to consult widely to gain an understanding of, and consensus on, the environmental objectives to be achieved. It is through this process and the informal hearing process that agreed, often staged improvements can be determined. If the matter cannot be resolved by this means, a formal hearing may be required to achieve a decision.

In order to minimise the impact of discharges on the environment it is important to assess their impacts on the receiving waters and to take steps to avoid any adverse effects. In practice this is done by setting water quality targets.

In order to comply with the provisions of the RM Act and preserve receiving water quality, every site manager should endeavour to minimise releases of contaminants to the environment. The point of compliance is usually the point at which the discharger loses control of the effluent. Generally, the maximum levels of contaminants allowable in stormwater systems which discharge into the environment or into reticulated district systems are:

Total petroleum hydrocarbons = 15 mg/litre	) averaged over the
Total suspended solids = 100 mg/litre	) design storm event

Unless other levels can be justified by either a site-specific or generic assessment of effects.

A separator system which is designed to remove 60 (or 150) micrometre oil globules, and which is appropriately maintained, should remove hydrocarbon product such that total hydrocarbon concentrations in the discharge water, averaged over the design storm event, are significantly less than 15 mg/litre.

However, in setting these limits:

(a) It is recognised that there will sometimes be periodic excursions under extraordinary storm conditions (see Sections 7.2 and 7.5.4).

(b) It is the responsibility of site owners and operators to encourage lower levels of contaminant release.

Operating within these limits will ensure minimal adverse toxic effects; and working well within them will generally minimise the period of conspicuous discolouration.

These thresholds are justified on the following bases:

- Monitoring in Auckland by NIWA (see Appendix 2) and internationally (e.g., in California) by the oil industry has demonstrated that discharges from oil industry sites are no worse (and often better) than discharges from the general roads and quick-stop parks but dirtier than discharges from long-term parks.

- The majority of the “contaminated” discharges enter reticulated district systems where they typically contribute only a small percentage of the total load. The oil-contaminated catchments of sites such as service stations and truck stops are particularly small, typically about 100 square metres.

- Modelling work by Woodward-Clyde using PAH as a surrogate for typical “oil” discharges demonstrated that, except for the most sensitive sites, there will be no significant adverse effects on the receiving water, but that discharges to estuarine beaches are generally deposited and often retained there, as for general stormwater deposits. BTEX compounds were not considered to be the critical ones in stormwater discharges because they tend to volatilise before they can do harm. The findings of the Woodward-Clyde study are summarised in Appendix 1.3.

Sites which discharge into environments which are very sensitive to storm discharges should be the subject of individual assessments (or alternatively, generic assessments for sites of that nature).

8.3 Cleaning of Hardstanding Areas

It has been demonstrated (see Appendix 2.5) that degreasers such as PES-51 (distributed by Process Lubricants of Auckland) do not affect the operation of oil-water separators or result in the carry-over of substances that have a significant adverse effect on receiving waters.   Dry processes using absorbent materials, vacuum cleaning methods, and methods whereby the effluent is collected for removal off-site are also acceptable. Also refer to Appendix A 3.1.4.

Where receiving waters are very sensitive to wash-down effluents, the potential impact of these effluents can be negated by closing the interceptor outlet valve during cleaning and slowly opening the valve on completion, if releases are allowed for by a discharge permit.

8.4 Risk Mitigation

Each site should have an appropriate response plan to be followed in case of any release of product which should be consistent with the Maritime Safety Act “Tier 1/Category 1” contingency plan requirements. On request, the petroleum marketing companies can provide site owners and operators with details of generic plans which may be used as a basis for the development of site-specific response plans. Appendix 3.2 contains an example of such a generic service station plan.

Should a surface spillage occur on a site, the immediate essential steps, some of which can be taken concurrently, are:

- Stop the release at source
- Contain the release where possible (close the isolating valve, if present)
- Respond to any emergencies
- Report the release to the appropriate authorities and to the owner
- Assess the degree of contamination
- Develop a corrective action plan in conjunction with the appropriate authority and clean up the released product.

The above steps should be included in the contingency plan.

When the immediate problems have been dealt with, the owner and the operator must review all the circumstances leading up to the product release and make any changes needed to avoid a repetition of the incident.

The changes needed may include, but are not limited to:

- Repair or replacement of worn or faulty equipment
- Revision of operating procedures
- Improved staff training
- Improvements to equipment or facilities

Site staff should be trained to respond to accidental product releases.

Sites should be equipped with appropriate recovery equipment such as absorbent pads or booms to enable the contingency plan to be effectively implemented.

8.5 Maintenance of Stormwater Drainage Systems

Drains should be labelled to indicate the function they perform, e.g., stormwater drain, sewer.

Open drains and gratings must be kept clear of any rubbish or debris. Clean as required.

Piped drains may become partially blocked. Watch for local flooding around gratings and entry points. Clean them out if there is evidence that the blockage has caused flooding and clean up any surface slick or staining caused by the flooding event.

Grit traps should be inspected monthly (or as appropriate, based on experience) and cleaned as required.

Oil separators should be inspected weekly and reasonably soon after deliveries and following any spillage of product on the site. Clean them out if there is any significant quantity of product or oily material (more than 3 mm) or sediment (more than 150 mm) in the device.

Other stormwater treatment devices, where installed, must be inspected and cleaned in accordance with a programme of regular maintenance appropriate for the device, and designed to maintain efficient and effective operation.

Overall inspections of the stormwater drainage system must be made by the site occupier at least once every month. Any deficiencies that may affect the proper performance of the system must be noted and promptly remedied.

Detergents, cleaning agents, or other washing methods that will cause a reduction in performance outside the oil separator device design parameters should not be used on a forecourt and other areas draining to oil separators. A washing method using proven, acceptable cleaners that will allow the oil separator to operate to the required standard should be identified in the stormwater management plan for the site.

Maintenance schedules should be listed in consent terms and operating procedures.

8.6 Records of Inspections

The site manager must ensure that a record of maintenance and inspections, i.e., cleaning activities, which notes the date of each inspection, observations made, and any action taken, is maintained on site. Each entry should be signed by the person making the inspection.

The record must be made available to the authority for inspection on request.

8.7 Operating Procedures

Each site should be equipped with operating procedures and mitigation equipment appropriate for that site. Sites should retain evidence that staff and contractors are fully trained in the functions for which they have responsibility. An example of best management practices can be found in Appendix 3.

Fuel card customers using unmanned facilities such as truck stops should be provided with advice on emergency procedures.

Tanker driver attendance is mandatory while underground tanks are being replenished. Under no circumstances are tanks to be filled beyond their licensed capacity. Drivers and staff should be made aware of and trained in the operation of the interceptor emergency shut-off valve, if present, so that they will be able to operate it promptly if necessary in the event of a fuel spillage occurring.

8.8 Other Potential Contaminants of Concern

BOD levels, although they sometimes exceed normally acceptable limits, are not a serious concern because release is generally of short duration and their magnitude is not dissimilar to what is found in general stormwater systems. Makepeace, Smith & Stanley record an international stormwater (total) BOD_5 <u>range</u> of 1.0 to 770 mg/litre and a <u>mean range</u> of 9 to 31 mg/litre.

BTEX compounds are rarely detected in water discharges from oil/water separators, particularly separators designed in accordance with this guideline. This is because spilled gasoline, the source of BTEX, generally volatilises before it reaches the separator, unless the spilled volume is large. The small proportions of BTEX compounds which are discharged to the stormwater systems or surface water bodies disappear quickly as a result of volatilisation or biodegradation. Reference[1] considers the effects of BTEX compounds to be 'minor' which is in contrast to the 'major' concern assigned to some PAH's.

A schedule of other potential contaminants of concern may be found in the petroleum marketing companies' guideline *Sampling Protocols and Analytical Methods for Determining Petroleum Products in Soil and Water*. Experience from oil industry testing programmes would indicate that other contaminants are of such low concentrations that they do not lead to significant adverse effects in receiving waters. Appendix 2 gives some results from oil industry monitoring studies.

Reference

Makepeace, David K.; Smith, Daniel W. and Stanley, Stephen J. *Urban Stormwater Quality : Summary of Contaminant Data.* Environmental Engineering and Science, Department of Civil Engineering, University of Alberta, Edmonton, Alberta T6G 2G7.

9. MONITORING BY SITE MANAGEMENT

9.1 Chapter Summary

This chapter deals with the monitoring of the performance of water treatment systems. Section 9.2 refers to earlier work on monitoring oil industry sites. Section 9.3 describes self-monitoring, and Section 9.4 deals with monitoring by regional councils. Section 9.5 describes appropriate sampling protocols.

9.2 Results from Previous Oil Industry Monitoring Programmes

The results from some previous industry monitoring programmes are given in Appendix 2. They include the self-monitoring of effluents from oil industry sites undertaken over the years 1991-1995, the results of studies by NIWA of effluent from an oil company site, and the results of an API interceptor spill trial in 1998.

9.3 Continuing Self Monitoring

On-going monitoring of stormwater effluent streams for hydrocarbons and suspended solids, where required, should be undertaken under flow conditions which may be natural, e.g., during storm or other events (such as bunded area releases), or induced.

9.3.1 Facilities Designed In Accordance With these Guidelines

Initial monitoring is required to establish performance, and thereafter monitoring is reduced to a minimal level.

9.3.2 Facilities Designed to a Lesser Standard

Initial monitoring is required to establish performance, and then monthly monitoring is required, although this may be reduced to a lower frequency by agreement with the consenting authority, following contamination trend analysis.

9.4 Monitoring by Regional Councils

Regional councils will often monitor the exercise of a consent to determine compliance with conditions and the effect on the environment. In many cases this monitoring is carried out on a routine or regular basis and involves the sampling of a number of sites in the programme to maximise efficiency and spread costs. In situations where there is a history of poor management or non-compliance, the monitoring can become focused on that site. Should this occur, most councils will charge for the full amount for the monitoring carried out and the advantages of scale are lost to that poor performer.

9.5 Sampling Protocol

Monitoring programmes to check for the degree of compliance (self-monitoring) should be of a standard that is acceptable to the regional council. When setting up a monitoring programme reference should be made to the council before it is initiated. This will avoid duplication and provide consistent data for comparison with any limits set.

9.5.1 General

Samples should typically be taken of a flowing effluent and be collected from the nearest practical point to the outlet of the treatment device. In some situations, especially in older installations, this may not be possible, and samples will have to be taken from inside the treatment device as close as possible to the outlet. Details of sampling and analytical protocols should be discussed and agreed to with the local authority concerned.

9.5.2 Analytical Laboratories

Analyses should be carried out by laboratories which are Telarc-registered (or have been externally audited for compliance with ISO Technical Guideline 25) for the contaminant analyses proposed.

9.5.3 Methods of Analysis

Samples should be analysed for total petroleum hydrocarbons (TPH) and total suspended solids (TSS) in accordance with the relevant method in the petroleum marketing companies' guideline *Sampling Protocols and Analytical Methods for Determining Petroleum Products in Soil and Water*.

APPENDICES

APPENDIX 1

RISK ASSESSMENTS

APPENDIX 1 RISK ASSESSMENTS

This appendix contains some results of risk assessment studies undertaken by Woodward-Clyde Ltd and BP Oil New Zealand Limited. It is in three parts. Appendix 1.1 (Woodward-Clyde Ltd) gives estimates of the risks posed by spillages of fuel. It also contains comments by Waitakere City Council on spillages observed in their area. Appendix 1.2 (BP Oil New Zealand Limited) deals with the environmental effects of other, general automotive products commonly used at retail sites (i.e., sold at service station shops) and recommends best management practices. Appendix 1.3 (Woodward-Clyde Ltd) summarises the results of a modelling study of the potential effects of stormwater discharges from oil interceptors on four different types of aquatic environment.

A1.1 Spill risk assessment data. The focus is on retail service stations and truck stops, in particular.

Potential spill event		Frequency of operation that could cause spill	Systems in place to minimise spill event/effect	Estimated yearly frequency of spill occurrence at any service station	Maximum estimated spill volume (litres)
Tanker unloading					
(a)	Drips from dipstick	Daily	PT200 spill container.	360	0.2
(b)	Failure of tanker bottom valve	3 per week	Backed up by discharge valve.	0.05	2000
(c)	Leaks from tanker hose connections	3 per week	Regular hose and fitting inspection. Oil/water separator.	2.0	6
(d)	Drips at fill point connection	3 per week	OPWI spill container.	48	2
(e)	Drips from tanker hose after disconnection	3 per week	Oil/water separator.	48	10
(f)	Failure of overfill protection valve	3 per week	Valve checked annually.	0.1	50
(g)	Rupture of a tanker compartment	-	Unlikely to occur at a service station. Oil/water separator.	0.000003	7000
(h)	Failure of the delivery hose	3 per week	Regular hose and fitting inspection. Oil/water separator.	0.32	10
(i)	Escape from vent	3 per week	Programmed deliveries. Tanks dipped prior to filling. Overfill prevention valve.	0.2	20
Car refuelling					
(a)	Misuse of nozzle	100/day	Automatic shut-off nozzle. Oil/water separator.	360	1
(b)	Vehicle drive off with nozzle attached	100/day	Automatic shut-off nozzle. Hose break away coupling. Dispenser shear valve. Oil/water separator.	12	1
(c)	Faulty nozzle	100/day	Regular service check. Oil/water separator	24	15
(d)	Person tripping on hose	100/day	Automatic shut-off nozzle. Oil/water separator	4	1
(e)	Nozzle falling from car	100/day	Automatic shut-off nozzle. Oil/water separator	12	1
(f)	Demolition of pump/dispenser	100/day	Raised concrete island. Crash barriers. Dispenser shear valve. Emergency stop buttons. Oil/water separator.	1	2
(g)	Blowback while filling	100/day	Automatic shut-off nozzle. Oil/water separator.	360	1
Truck refuelling					
(a)	Misuse of nozzle	20/day	Automatic shut-off nozzle. Oil/water separator.	48	10
(b)	Truck drive-off with nozzle attached	20/day	Automatic shut-off nozzle. Hose breakaway coupling.	4	10
(c)	Faulty nozzle	20/day	Regular service check. Oil/water separator.	12	40
(d)	Person tripping on hose	20/day	Automatic shut-off nozzle. Oil/water separator.	4	10
(e)	Nozzle falling from truck	20/day	Automatic shut-off nozzle. Oil/water separator.	12	10
(f)	Demolition of pump/dispenser	20/day	Raised concrete island. Crash barriers. Dispenser shear valve. Emergency stop buttons. Oil/water separator.	1	1

A1.1 Spill risk assessment data (continued).

The table below gives alternative risk estimates, based on the practical experience of a local authority (Waitakere City Council).

Potential spill event		Frequency of operation that could cause spill	Estimated yearly frequency of spill occurrence at any service station	Maximum estimated spill volume (litres)
Tanker unloading				
(c)	Leaks from tanker hose connections	3 per week	12	50
(e)	Drips from tanker hose after disconnection	3 per week	150	10
(h)	Failure of the delivery hose	3 per week	0.32	100
(i)	Escape from vent	3 per week	1	20
Car refuelling				
(a)	Misuse of nozzle	500/day	1500	1
(b)	Vehicle drive off with nozzle attached	500/day	52	1
(c)	Faulty nozzle	500/day	24	50
(d)	Person tripping on hose	500/day	4	10
(e)	Nozzle falling from car	500/day	50	50
(f)	Demolition of pump/dispenser	500/day	1	2
(g)	Blowback while filling	500/day	360	1
Truck refuelling				
(a)	Misuse of nozzle	20/day	360	100
(b)	Truck drive-off with nozzle attached	20/day	4	10
(c)	Faulty nozzle	20/day	12	100
(d)	Person tripping on hose	20/day	4	10
(e)	Nozzle falling from truck	20/day	12	100
(f)	Demolition of pump/dispenser	20/day	1	1

A1.2 Environmental Effects of General Automotive Products Sold at Service Station Shops

The potential environmental impact of general automotive products sold at service station shops has also been considered. This work included the compilation of an inventory of product types, assessment of their use and toxicity, and management options available to avoid adverse environmental effects.

A1.2.1 Products

The products fall into two categories: Category A products, which are not used on the forecourt, and Category B products, which may be used on the forecourt. Material Safety Data Sheets are available for all of these products and can be obtained direct from the suppliers.

Category A products that were identified and considered were:

Radiator flush
Cooling system treatment
Heavy-duty engine degreaser
Hand cleanser
Rubberised undercoat
Sun of a Gun
Tuff Stuff
Spitfire

In all circumstances, the storage, use, and disposal of these products should be in accordance with the manufacturers' recommendations.

Category B products that were identified and considered were:

Diesel conditioner
Engine stop-leak
Radiator stop-leak
Injector cleaner
Friction proofing (various oil additives)
Engine tune-up
Anti-freeze

Data on the composition and the environmental effects of these products were obtained from the suppliers' Material Safety Data Sheets. Observations of how the products were handled and used on service station forecourts were then made.

The conclusion of this work is that all the products are toxic to some degree and have the potential to have an adverse impact on the environment. However, if the products are handled correctly and used according to the manufacturers' recommendations, no special facilities are required at service station forecourts.

A1.2.2 Best Management Practices

The best management practices that should be implemented when storing and handling these products are:

- Always follow the manufacturers' instructions for use and disposal.

- Ensure that spills from broken containers are cleaned up using absorbent materials which are disposed of correctly. **Do not hose them down drains**.

- Ensure that spills and drips from handling and transfer activities are cleaned up using absorbent materials which are disposed of correctly. **Do not hose them down drains**.

- Empty packages should be disposed of to an appropriate waste-disposal facility.

- On sites which have reticulated trade waste sewers, ensure that the utility network operator will accept any material planned to be disposed of to the sewers.

- On sites which do not have reticulated trade waste sewers, collect and retain the waste for off-site disposal to an appropriate waste-disposal facility.

- Site operators should provide training for all site staff in the handling and disposal of these general automotive products.

A1.3 Assessment of the Effects of Stormwater Discharges from Oil Interceptors at Petroleum Product Sites

This section presents a summary of a dispersion modelling study carried out by Woodward-Clyde Ltd on the potential effects of stormwater discharges from oil interceptors on four different types of aquatic environment.

A1.3.1 How the Study was Done

The study considered the potential impact of runoff from facilities on four aquatic environments: streams, estuaries, lakes, and major harbours. High-energy coastal waters were not included in the study, as they were not considered to be at risk from discharges.

The total petroleum hydrocarbons (TPH) concentration in the discharged water was assumed to be 20 ppm, discharging at the design flow condition nominated in these Guidelines.

Polycyclic aromatic hydrocarbons (PAH) were adopted as a TPH surrogate, and it was assumed that the proportion of PAH in the petroleum phase was the same as that in typical

Wiri Oil Terminal diesel (5.6 %). [PAH proportions in effluent diesel phases are much lower].

The CORMIX model was used. This has been developed by Cornell University in association with the US Environmental Protection Agency (USEPA) and other organisations.

The mixing criteria adopted were the USEPA "special mixing zone" requirements.

The toxicity of the discharges was evaluated against the ANZECC water quality chronic limit for PAH of 3 μg/L (0.003 ppm). An acute limit of 0.03 ppm was derived from the chronic limit.

The discharge was considered to be in isolation from other site discharges.

A1.3.2 Conclusions of the Study

Streams - Moony's Creek in Auckland was modelled and shown to be at risk under low flow conditions of 2.5 litres/second (corresponding to a flow velocity of 0.01 metres/second) and with a stream width of 1 metre; however, the effects of discharges at moderate and high flows were not deleterious.

Estuaries - It was not practicable to model estuaries because of the absence of water at low tide. However, this would also apply to all stormwater discharges at low tide.

Lakes - Lakes were considered not to be at risk because of their large body of water.

Major harbours - Timaru Harbour was modelled and found not to be at risk, because of the large body of water which it contained.

APPENDIX 2

RESULTS FROM MONITORING

APPENDIX 2 RESULTS FROM MONITORING

This appendix contains some results from monitoring studies.

Appendix 2.1 gives the results of two monitoring projects undertaken by NIWA Ltd for the oil industry and for the Auckland Regional Council (ARC). The oil industry project dealt with suspended solids and hydrocarbons, and the ARC project dealt only with suspended solids.

Appendix 2.2 provides the results from a spill trial of an API interceptor in May 1998

Appendix 2.3 shows the notified spill records of the petroleum marketing companies in New Zealand for the period 1992-95 in both graphical and tabular form.

Appendix 2.4 shows the size distribution of oil particles in the discharges from different types of pumps run at various speeds.

Appendix 2.5 shows the results of trials of the effect of a degreaser on the effectiveness of separators.

A2.1 NIWA Monitoring for the Oil Industry and the Auckland Regional Council

Two separate projects were undertaken by NIWA, as follows:

(1) Monitoring the runoff from a service station site (Mobil Mount Richmond) and an adjacent control site (Panama Road, Auckland).

(2) Monitoring the runoff from several different types of sites for the Auckland Regional Council (ARC).

A2.1.1 Oil Industry Project

The primary aim of this project was to determine the levels of suspended solids and their constituents in effluent waters (a) downstream of an oil separator and (b) from an adjacent roadway. The results of these monitoring programmes are given in the following pages.

A secondary aim was to establish the level of hydrocarbon contamination in the separator’s effluent water and in the Panama Road effluents. This limited programme established that treated stormwater from the service station site had hydrocarbon levels no higher than those in the Panama Road stormwaters. The comparison is tabulated in Appendix A 2.3.

A2.1.2 ARC Project

The ARC project dealt only with suspended solids and their constituents. The results have been incorporated with the oil industry results on the following pages. From these results, it is clear that point-source discharges of suspended solids from service station sites are no worse than those from adjacent property and do not warrant special treatment devices. This has subsequently been confirmed in an ARC technical bulletin.

A2.1.3 Schedule of Sites Monitored

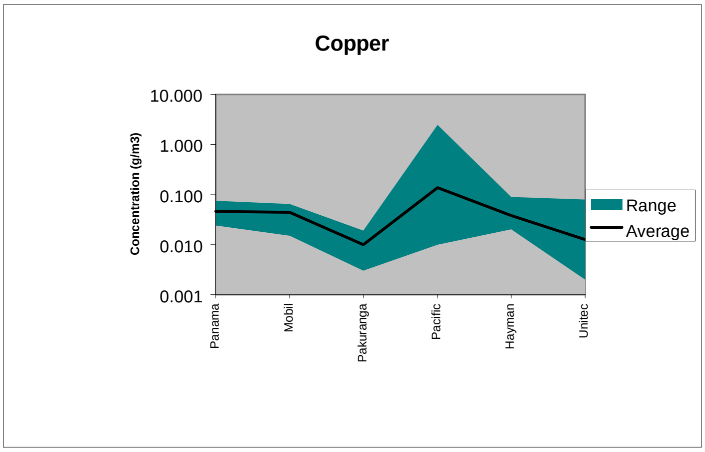
Site no.	*Description*
1	Panama Road (road)
2	Mobil Mount Richmond (service station)
3	Pakuranga (residential)
4	Pacific Steel (heavy industrial)
5	Hayman Park Road (commercial)
6	Unitec Sand Filter (car park)

These site numbers are used in the diagrams on the following pages.

Table A2.1.1 Concentrations of Various Contaminants in runoff from sites monitored by NIWA.

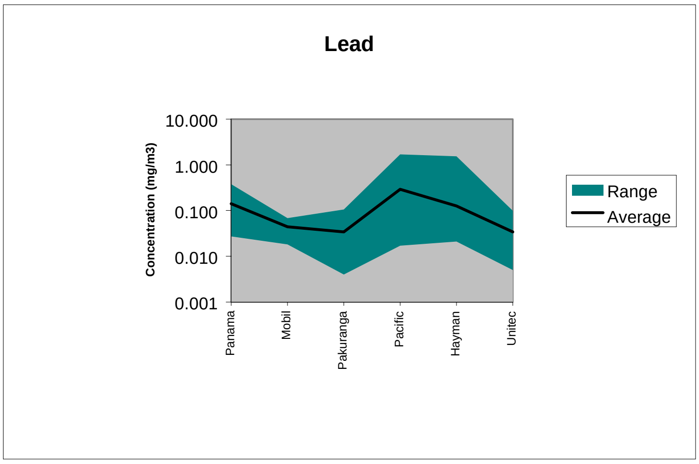
Copper

Site	Low	Average	High
Panama	0.024	0.046	0.050
Mobil	0.015	0.044	0.050
Pakuranga	0.003	0.010	0.016
Pacific	0.010	0.138	2.420
Hayman	0.020	0.038	0.070
Unitec	0.002	0.013	0.077



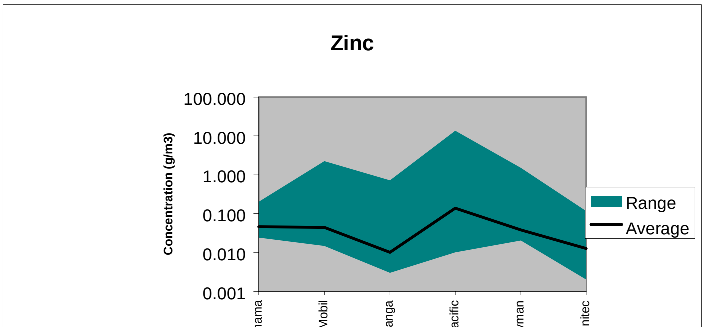
Lead

Site	Low	Average	High
Panama	0.027	0.140	0.350
Mobil	0.018	0.044	0.050
Pakuranga	0.004	0.034	0.101
Pacific	0.017	0.291	1.660
Hayman	0.021	0.124	1.510
Unitec	0.005	0.034	0.094



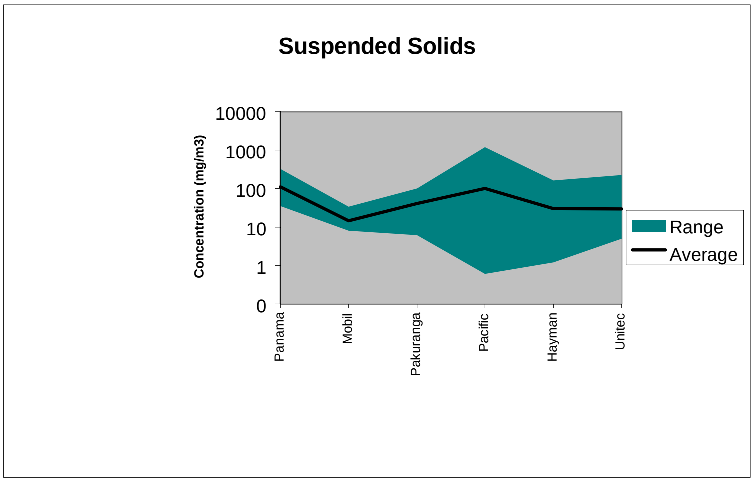
Zinc

Site	Low	Average	High
Panama	0.073	0.132	0.179
Mobil	0.095	1.570	2.250
Pakuranga	0.063	0.285	0.709
Pacific	0.050	1.500	13.500
Hayman	0.021	0.249	1.510
Unitec	0.013	0.052	0.115



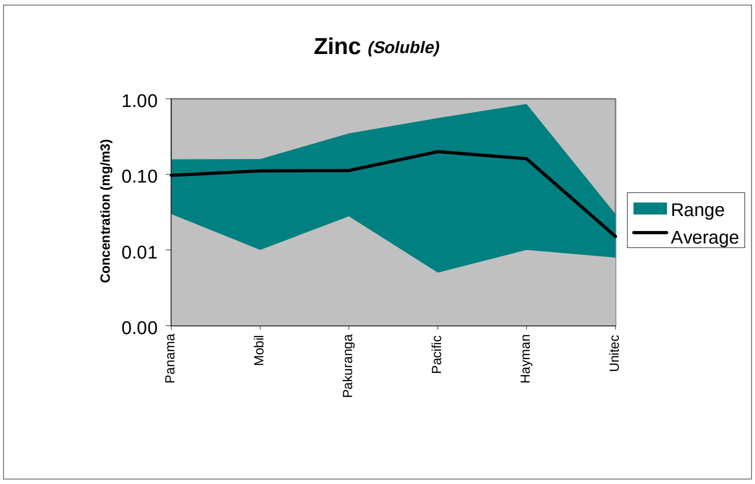
Suspended Solids

Site	Low	Average	High
Panama	35	112	286
Mobil	8	15	26
Pakuranga	6	41	95
Pacific	1	101	1174
Hayman	1	30	160
Unitec	5	30	223



Zinc (Soluble)

Site	Low	Average	High
Panama	0.030	0.098	0.129
Mobil	0.010	0.112	0.150
Pakuranga	0.028	0.113	0.321
Pacific	0.005	0.201	0.553
Hayman	0.010	0.161	0.840
Unitec	0.008	0.015	0.022



A2.2 API spill trial

Following the development of the draft ‘Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand’ in which performance criteria for interceptors are defined, the Auckland Regional Council requested that the Industry (BP, Mobil, Shell and Caltex) prove through practical trial the performance of the interceptor design recommended by the Guideline for Service Station forecourts.

To this end a trial was arranged in Masterton for 20 May 1998. The test was witnessed by representatives from a number of organisations, including the Auckland Regional Council.

The minimum sized tank of 2.5 metres length was selected for the test on the basis that should the smallest device be able to contain the spill volume then the larger tanks with a greater capacity above and below the normal static water level, would be also be able to perform satisfactorily.

Results

Visual observations confirmed that for the spill of 2500 litres of diesel the device captured the spill without rising through the top of the tank, and after settling contained the product behind the baffle. The results of the sampling indicated that the discharge effluent met the design standard of 15 mg/litre.

The test procedure and results of the tests are appended to the report (A2.2.2 and A2.2.3)

This analysis confirmed the interceptor met the requisite performance standards, specifically to contain a 2,500 litre spill with the outlet valve in the open position while achieving the effluent quality criteria of less than 15 ppm TPH.

A2.2.2 API interceptor test protocol

A test is to be conducted on an API Interceptor for spill capture.

The test is required to confirm that the API tank will capture the maximum credible spill of 2500 litres without discharge of product above the 15 mg/litre standard set.

Should this be achieved , this will confirm that tankers may be unloaded without the need for a stop valve to be operated prior to commencing the discharge of fuel.

1 Run water from a contributing area at a rate of 15mm per hour for one hour. (*Contributing area to be determined relative to API to be tested.)*

2 Diesel is to be discharged from a tank holding 2500 litres via a 4 inch hose running at full flow. This will equate to an emergency from a delivery tanker hose. The discharge will commence at ten minutes until the diesel tank is empty.

3 The effluent from the first API tank is to be sampled with duplicate samples being collected at 15, 30, 45 and 60 minutes after the commencement of the test, with a further sample being taken shortly before quiescent water level is reached. The duplicate samples shall be collected in clean glass containers each holding 1 litre.

4 A visual check of the sample shall be made to determine the presence of any sheen on the surface of the sample.

5 Each sample shall be analysed for TPH by using GC/FID technique for TPH.

A2.2.3 Results of API test - petroleum hydrocarbons.

Analysis undertaken by RJ Hill Laboratories Ltd using GC-FID, carbon banding (g m^{-3})

	Pre-test	**15 min**	**30 min**	**45 min**	**60 min**	**Quiescent**
C7-C9	<0.03	<0.03	0.09	0.16	0.19	0.42
C10-C11	<0.03	0.06	0.10	0.19	0.24	0.32
C12-C14	<0.03	0.17	0.10	0.20	0.29	0.47
C15-C20	0.06	0.95	0.04	0.08	0.52	1.17
C21-C25	0.05	0.27	<0.03	<0.03	0.15	0.30
C26-C29	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
C30-C44	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Total hydrocarbons (C7-C44)	<0.2	1.4	0.3	0.3	1.4	2.7

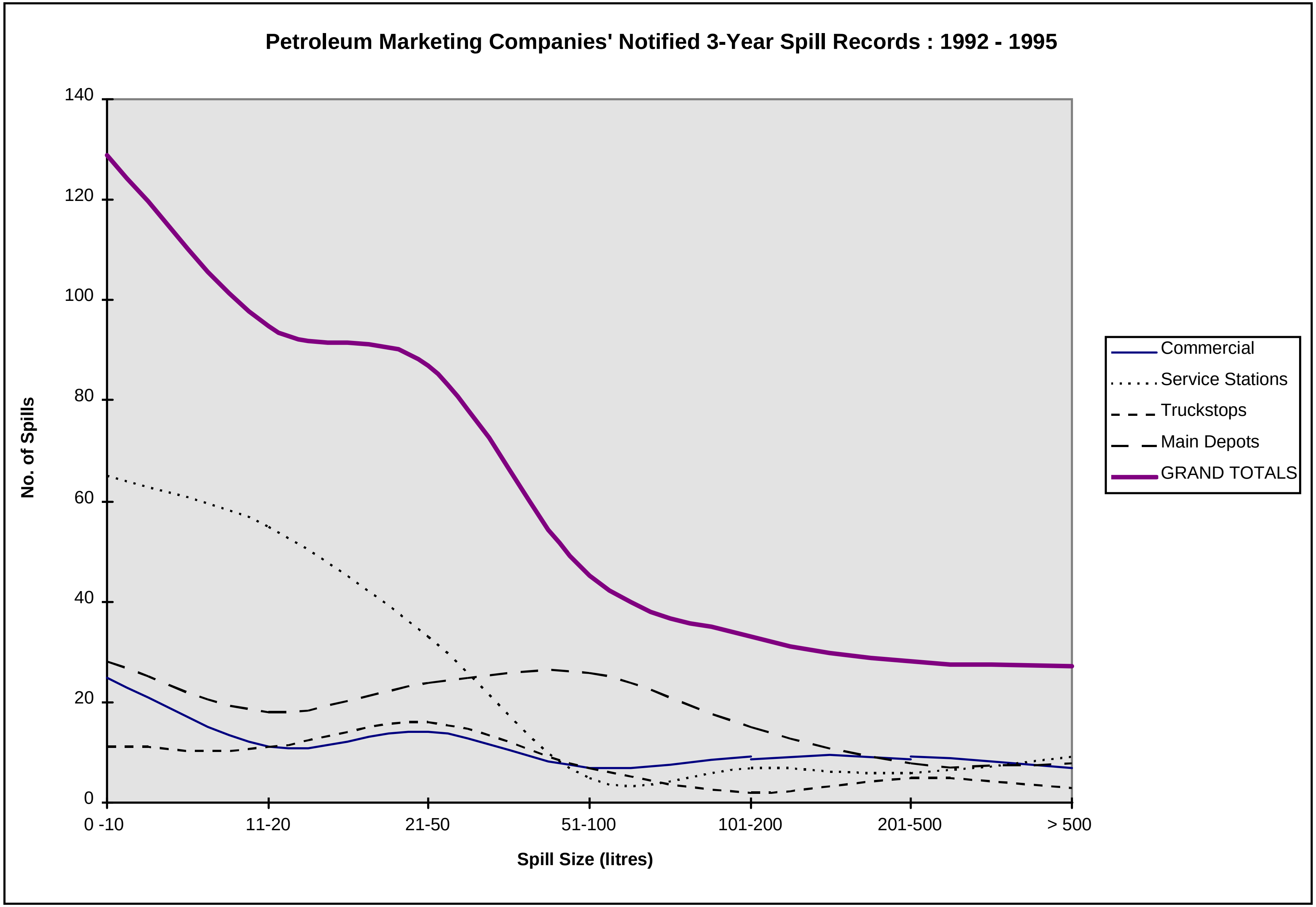
Appendix 2.3

Petroleum Marketing Companies' Notified Spill Records: 1992 - 1995

Site category	Oil co.	0 -10 litres	11-20 litres	21-50 litres	51 -100 litres	101 -200 litres	201 - 500 litres	> 500 litres	
Commercial	#1	9	5	2	1	3	1	2	
	#2	3	0	6	3	4	4	4	
	#3	6	3	0	3	0	3	0	
	#4	6	2	6	0	1	0	1	
	TOTALS	24	10	14	7	8	8	7	
Farm	#1	1	1	0	0	1	1	0	
	#2	-	-	-	-	-	-	-	
	#3	-	-	-	-	-	-	-	
	#4	-	-	-	-	-	-	-	
	TOTALS	1	1	0	0	1	1	0	
Service stations	#1	29	5	7	2	0	1	0	
	#2	9	6	6	3	2	2	2	
	#3	21	39	18	0	3	0	6	
	#4	6	5	2	0	2	3	1	
	TOTALS	65	55	33	5	7	6	9	
Truck stops	#1	2	2	1	0	0	2	0	
	#2	0	0	0	3	2	2	2	
	#3	3	6	9	3	0	0	0	
	#4	*6*	*3*	*6*	*1*	*0*	*1*	*1*	
	TOTALS	11	11	16	7	2	5	3	
Main depots	*#1*	*8*	*5*	*6*	*7*	*4*	*2*	*2*	
	#2	0	3	0	6	2	2	2	
	#3	*7*	*5*	*7*	*7*	*4*	*2*	*2*	
	#4	13	5	11	6	5	2	2	
	TOTALS	28	18	24	26	15	8	8	
	GRAND TOTALS	129	95	87	45	33	28	27	**444**

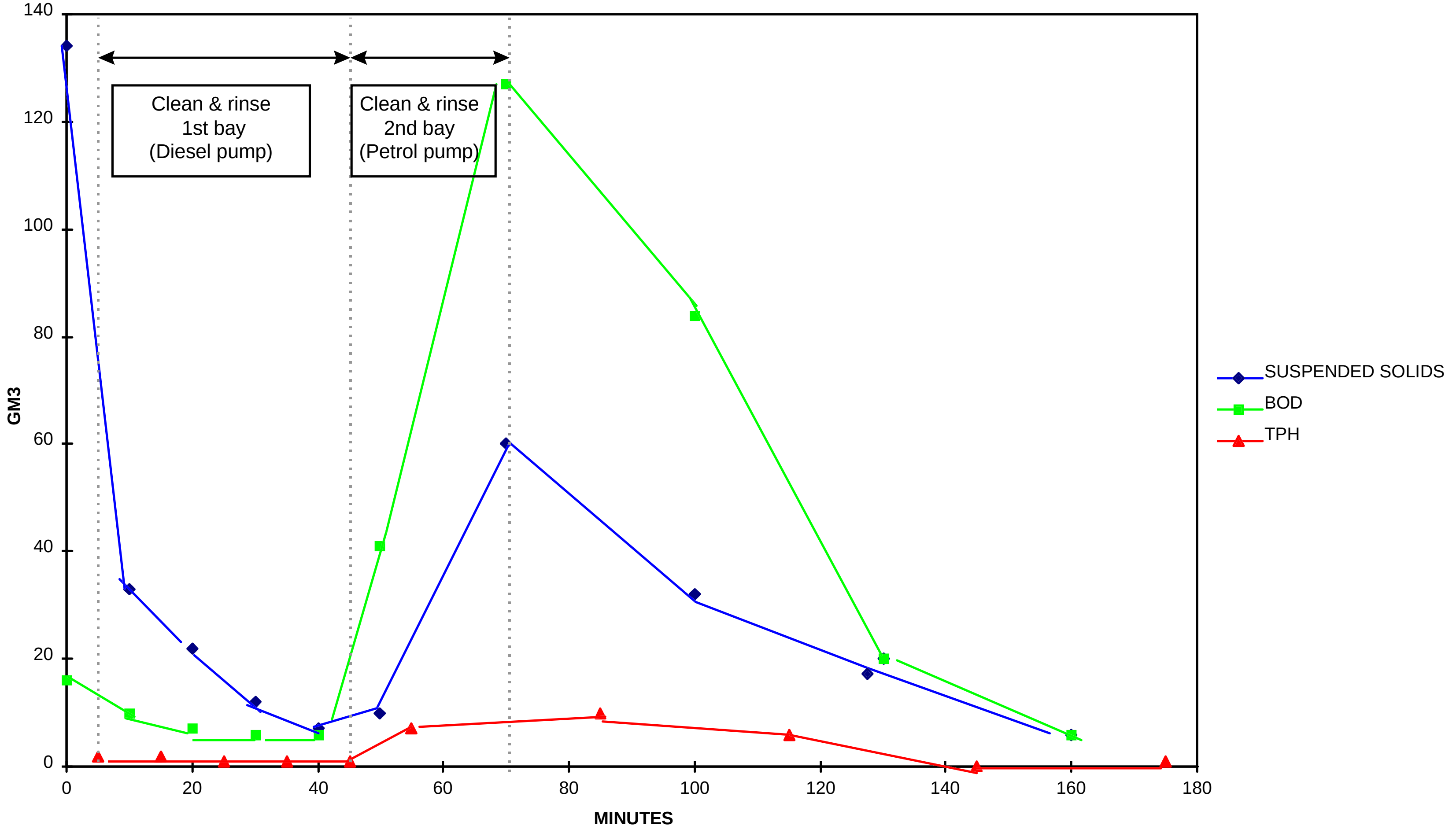
Notes--#1: Records for 1992-1995; depots not included.
#2: Records for 1995 only; farm sites included under "Commercial".
#3: Records for 1995 only; truck stops and service stations targeted; includes service station 'driveaways' and hose fitting failures.
#4: Records for 1993-1995 (includes pipe fractures); truckstops and farm sites included under "Commercial".
Gen: *Italicised figures estimated from other data supplied .* **Final figures adjusted to 3-year time base.**

An estimated 1,600,000 deliveries to sites by truck were made in the 3-year period (i.e., approx. 1 spill per 4000 deliveries).



Petroleum Marketing Companies' Notified 3-Year Spill Records : 1992 - 1995
No. of Spills
140
120
100
80
60
40
20
0
0 -10
11-20
21-50
51-100
101-200
201-500
> 500
Spill Size (litres)
Commercial
Service Stations
Truckstops
Main Depots
GRAND TOTALS

Appendix 2.5 Effects of degreaser on separator performance



Appendix 2.4 Historical graphs demonstrating pumped oil particle size distribution

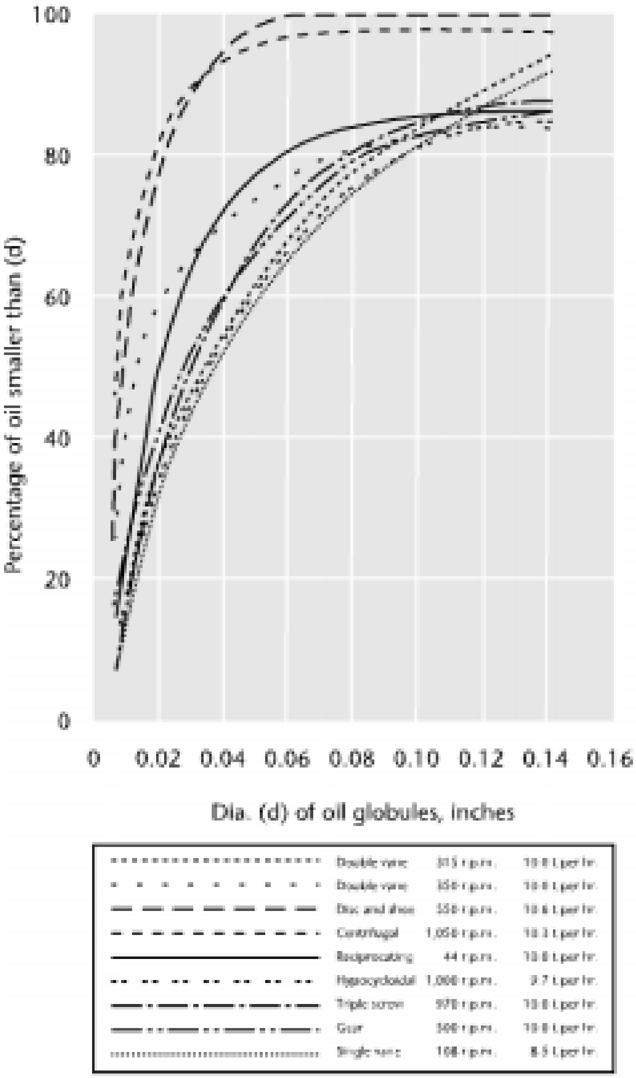


Fig. 1 Comparitive size distribution curves for the oil in the discharged mixtures from pumps operating at rated loads (discharge pressure 15*lb./sq.in.*)

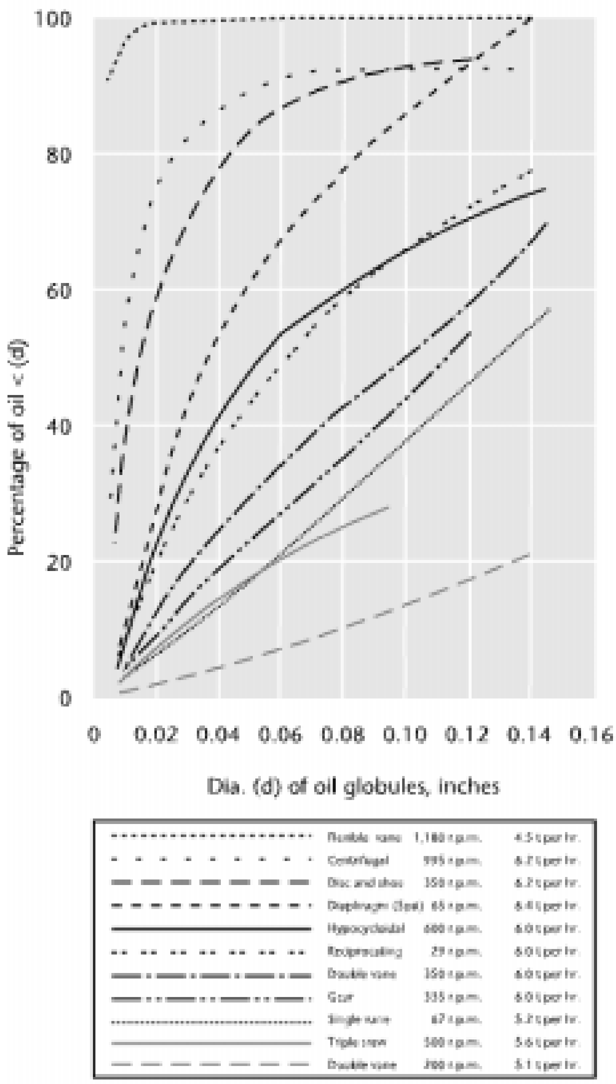


Fig. 2 Comparitive size distribution curves for the oil in the discharged mixtures from pumps operating at reduced loads (discharge pressure 15*lb./sq.in.*)

APPENDIX 3

BEST MANAGEMENT PRACTICES
FOR SERVICE STATION FORECOURTS

APPENDIX 3 BEST MANAGEMENT PRACTICES FOR SERVICE STATION FORECOURTS

This appendix provides more detail for service station owners and operators. It is in two parts. Appendix 3.1 sets out best management practices and is based on a recent publication of the Australian Institution of Petroleum. Appendix 3.2 is a generic surface spillage mitigation plan for service stations.

A3.1 Best Management Practices for Service Station Forecourts

A3.1.1 General Requirements

Do not pour fuel down drains or sumps. Separators can only remove so much oil. If too much enters they start to pass it out rather than remove it. If the oil doesn't get into the separator in the first place, it won't have to be removed.

Do not introduce detergents into the drainage system. Detergents are a major enemy of separator operation because they promote the formation of an oil/water emulsion (mixture) which will not separate under the influence of gravity. It should also be noted that detergents are a pollutant in their own right and should not be discharged to the wider environment. If cleansing agents are to be used they should be used sparingly and must be of an approved type. Decantings from windshield detergent bottles and the like should be disposed of to the sewer and not to the stormwater system.

Under no circumstances should underground tanks be filled beyond their licensed capacity.

A3.1.2 Staff Training

It is important that all staff involved in forecourt operations are familiar with the drainage system and the best management practices outlined here, and especially with the location and operation of the interceptor outlet valve if present. It is the responsibility of site managers to ensure that all staff are familiar with site systems and procedures, and evidence of this bearing the signatures of trained staff should be retained on site for inspection by the authorities.

A3.1.3 Spill Control

Prevention of product spills is a matter of priority in all operations. Equipment, facilities design, and operational procedures must address minimisation of spill potential.

A3.1.3.1 Dispensing Equipment

Current fuel dispensing equipment incorporates a range of in-built safety features designed to avoid or limit accidental spills.

The practice of “topping off” fuel tanks during fuelling should be avoided. The proper use of “hold open” latches can facilitate automated filling and can minimise spills. Improper fuelling methods should be guarded against.

Should a spill occur it may require:

- Temporary closure of forecourt operations.
- Blockage of adjacent drains unless they can be used to direct product into a containment area.
- Recovery of product from such a containment area or its absorption using industrial absorbents or rags.
- Spot cleaning of the area with rags or absorbents and hosing into collection pits for effluent separator treatment.

If gasoline is spilled, vapour generation may become the prime hazard source.

If diesel is spilled, evaporation is minimal, so the driveway surface may be hazardous until it is thoroughly cleaned.

If hosing is involved, the volume of water used should be kept to a minimum, and the effluent should be directed into on-site drainage which leads to an interceptor. No product should be permitted to enter drains and escape to stormwater or off-site.

A3.1.3.2 Delivery Spills

Under normal circumstances the delivery driver will take control of a delivery spill or overfill situation. Generally, the following procedure should be adhered to:

- Close all vehicle valves.
- Isolate the spill area and contain any spill.
- Stop all operation in the immediate area of concern; remove or shut down ignition sources; isolate all electrics.
- Close the interceptor valve and block any drains leading to areas beyond the station boundaries.
- Avoid any water flush of product into drain streams creating overload conditions and escape of product off-site.
- Alert emergency contact personnel and relevant authorities.

Site staff should visually inspect the drainage systems for signs of free product after tanker deliveries and after any spill events on site. Free product and contaminated materials must be disposed of in an appropriate manner. Note the restrictions on the handling of gasoline fuel by waste contractors under Appendix 3.1.5 Waste Disposal Methods.

A3.1.3.3 Other Sources

Spills may occur from lube oil top-up, brake fluid top-up, and similar minor servicing needs. A drip pan should be placed under a vehicle if disconnecting hoses, unscrewing filters, or removing other parts to capture the automotive fluids.

If fluids are leaked into exposed surfaces, proper spill response procedures should be performed. For minor spills, spill control should centre on the use of rags or absorbents only. Contaminated residue should be treated as outlined below under Appendix 3.1.5 Waste Disposal Methods.

A3.1.4 Procedures for Cleaning Forecourts

Preferred cleaning methods are those involving a minimum use of water as the cleaning medium.

- Using an industrial class broom, the entire pavement area should be swept free of surface materials. Deposit paper, litter, loose waste, etc. in waste bins.

  Alternatively

- Using a mechanical or powered sweeper or industrial vacuum unit follow the same procedure as above, depositing all collected material in trade waste bins. Because of the forecourt environment, operation of powered equipment must be restricted to personnel who are mature, familiar with forecourt operational hazards, and safety conscious.

- Identify any product spills, stains, etc. and, initially using industrial absorbents, remove and collect any product. Wipe clean remaining stains with rags soaked in an approved cleansing agent. *Minimise the use of solvents of any type for this purpose*. An alternative to the use of rags is to spot-spray stains with the same approved cleansing agent. A*pply only those detergents to the forecourt area which are permitted by the consent conditions. Refer also to section 7.5.2.*

- Broom the area where the cleaning agent has been applied, allow 5 minutes, and then wash off the area concerned using a 15 mm hose.

Use the above dry cleaning methods before washing down the forecourt to reduce the quantity of water used and minimise the volume of effluent generated.

- Spent absorbents, waste materials, and litter should be disposed of in an environmentally acceptable manner as described under Waste Disposal Methods below.

- Thorough washing of the forecourt should not normally be necessary more frequently than once weekly, provided regular dry cleaning is conducted. Traffic conditions and loading may require more frequent wash-down by the operator.

- Cleaning agents should be used only in accordance with manufacturers' recommendations.

- All drains, silt traps, etc. must be kept clean and free of obstruction.

- All sludges, waste materials, etc. recovered from silt traps, drains, settlement pits, and separators must be disposed of in an environmentally acceptable manner as described under Waste Disposal Methods below.

- Where forecourt wash-down is practised, surplus surface water should be squeegeed from the pavement surface to avoid the potential for accidents.

A3.1.5 Waste Disposal Methods

Sources of waste on service stations vary. Certain wastes require specific disposal methods. Unless local authorities direct otherwise, disposal of wastes should be as follows:

- **Trash and solids** cleaned from drains, grated drains, and trash arresters should be deposited in conventional industrial trade waste bins.

- **Silt** from silt arresters, drains, and grated drains should be placed in conventional industrial trade waste bins.

- **Domestic grease and sediment from grease traps** should be disposed of using licensed contractors appropriately equipped and operating to local regulatory authority requirements.

- **Used oil and customer "cocktails"** of materials and fuels should be disposed of using approved contractors. Oil and grease trapped by either buried or above-ground separators must be similarly disposed of by approved contractors or at the same time as sediment is removed from such equipment by approved trade waste contractors.

- **Gasoline** is not to be handled in vacuum or suction trucks for either suction or cartage due to the presence of flammable fumes. If present, gasoline should be removed using either a hand- or air-operated pump and drummed for removal.

- **Sediment and waste** from sediment collection pits servicing above-ground separators or from in-ground separators must be disposed of through licensed trade waste contractors operating to local authority requirements.

A3.1.6 Separator Cleaning Procedures

Because equipment configuration will vary somewhat between sites, cleaning procedures will most likely do so too.

The following procedures should be regarded as being "good guidelines", but they should not necessarily take precedence over local work instructions relating to this task.

- Obtain a Confined Space Entry Permit if the pit exceeds 1.5 metres in depth.

- Wear adequate clothing and personal protective equipment.

- Close the interceptor valve or block off the clean water outlet if required.

- Remove all liquid and solids from within each chamber using an approved, licensed trade waste contractor.

- Remove any further silt or solids that may have become lodged in the system.

- Flush through all drains leading to the interceptor.

- Hose all internal surface areas using **controlled quantities** of cleansing agent only, if necessary.

- Again remove all effluent and solids from each chamber.

- Remove the plug from the clean water outlet.

- Recharge the pit with clean water to operating level.

- Reinstate pit covers.

A3.1.7 Inspection and Maintenance Schedule

With any oil separation device, maintenance is essential to avoid gross re-entrainment of previously separated contaminants. Both oil and solids accumulations can be re-entrained in a storm event if the pollutants are allowed to build up to excessive levels. The maintenance programme is designed to prevent this accumulation and to ensure that the design flow conditions continue to prevail in the device.

A3.1.7.1 Frequency

The attached Inspection and Maintenance Schedule must be carried out monthly.

A3.1.7.2 Catchment

Grates and sumps in the catchment area will need to be clear of debris and sediments. Any evidence of water ponding or product spillage needs to be reported.

The use of detergents on site needs to be guarded against as these will emulsify the oil and degrade the separator performance. Any evidence of their use should be reported.

A3.1.7.3 Oil Removal

The separator should be inspected to determine the amount of oil collected. Oil should be removed if necessary by pumping or decanting. The oil can be removed by the following methods:

- Removal by pumping or decanting the surface oil layer in a dry period between storms. Do not try and remove the oil while there is a flow through the device. The invert of the orifice or slotted pipe used to withdraw the oil can be set at the separator orifice invert level. Since there is no flow in the separator when the oil is being removed, and the oil outlet is set at the appropriate level, there should be a minimal withdrawal of water as the oil is being removed.

- Use of oil absorption pads. These will soak up some oil, which then cannot be re-entrained into the flow. Such pads have a limited uptake capacity, and may present a disposal problem.

A3.1.7.4 Oil in By-Pass (where applicable)

The by-pass should be inspected for evidence of any accumulated oil. Report any evidence of this, as modifications may be required to the flow control devices if this is occurring.

A3.1.7.5 Removal of Sediment

The slurry at the bottom of tanks needs to be removed if it has built up to a level greater than 150 mm. Use a dip tape to determine the depth of the accumulated sediment. It should be removed by an approved waste disposal contractor. Sediment should also be removed from the by-pass as required.

A3.1.7.6 Flow Control (where applicable)

Flow is controlled by both the plate orifice and the position of the by-pass weir (where applicable). Check for evidence of poor flow control, e.g., evidence of flooding in the by-pass weir chamber, flooding in sump chambers, etc.

Orifice and weir positions may need to be adjusted if problems are encountered with flow conditions. Persistent clogging should be reported, as screening may be required to prevent debris causing blockages.

API Oily Water Separator

INSPECTION AND MAINTENANCE SCHEDULE

Site ....…………………….. *Date* ....…….................

1. Catchment

	Yes	No
Are grates and sumps clear of debris and sediments?	☐	☐

Corrective Action Taken ....……….................

	Yes	No
Is there evidence of water ponding or product spillage?	☐	☐

Corrective Action Taken ....…………................

	Yes	No
Is there evidence of detergents being used on site?	☐	☐

Comments ....………..........................

2. Oil Removal

What is the depth of free oil in the main chamber? ....…………....

	Yes	No
Has it been removed? (*if greater than 3 mm it should be)*	☐	☐

	Yes	No
Is there any evidence of oil accumulating in the by-pass?	☐	☐

Corrective Action Taken ....…………....................…

3. Sediment Removal

What is the depth of sediment in the bottom of the main chamber? ....

	Yes	No
Has it been removed? (*if greater than 150 mm it should be)*	☐	☐

	Yes	No
Is there evidence of sediment accumulating in the by-pass?	☐	☐

Corrective Action Taken ....……..................

4. Flow Control

	Yes	No
Is there any evidence of poor flow control?	☐	☐

Corrective Action Required ....….........

	Yes	No
Is there any evidence clogging or debris accumulation in either the orifice plate or by-pass device?	☐	☐

Corrective Action Taken ....……...............................

Signed: ....

(Name): ....…..................

A3.2 Service Station Surface Spill Mitigation Plan

Risk	Preventive measures	Responsible party	Document/procedure	Emergency procedure/action	By	Follow up action	By
1. Pump knocked over/ pulled over	*Pumps bolted down *Pump suction flex or shear valve breaks in preference to pipework *Shear groove in spout *Breakaway coupling on hose *Emergency pump shut-off *Pump power & comms isolation switch *Under pump sumps	Contractor - Oil company Oil company Oil company Oil company Oil company	Oil co. specs & UST COP Electrical regulations Oil co. specs & UST COP	*Isolate pump, power & comms *Use spill response kit if necessary *Contact contractor *Contact oil co. if spill > 5 litres *Shut interceptor outlet valve, if necessary *Clean out sumps	)) Site) operator))) Contractor	*Pump/pipework repaired *Accident/damage report *Inspect/clean out interceptor	Contractor Site operator Contractor
2. Forecourt spills: All types	*Automatic shut-off nozzles *Emergency shut-off switches	Oil company Oil company	Oil co. specs & UST COP Electrical regulations	*Use spill response kit *Contact contractor *Shut interceptor outlet valve *Contact Fire Service if spill > 5 litres *Contact local authority if spill > " " *Close site if spill is major, e.g., >> holding capacity, until cleaned up	) Site) operator	*Incident report/investigate cause *Replenish response kit *Inspect/clean out interceptor *Undertake environmental investigation, if necessary *Implement action points as highlighted by Incident Report	Oil co. Site operator Contractor Oil co. Oil co.
3. Vehicle 'cocktail'	*Site operator training *Latches on some diesel pumps	Site operator Oil company	) Letter to all) site operators Oil co. specs & UST COP	*Arrange safe removal of fuel from vehicle	) Site) operator	*Contact contractor to safely dispose of product	Site operator
4.Leaking pumps	*Automatic shut off nozzles *Under pump sumps *Maintenance contract *Visual observation	Oil company Oil company Contractor Site operator	Oil co. specifications Maintenance contract	*Contact contractor	Site operator	*Rectify leaks *Report any loss/ground contamination	Contractor

A3.2 Service Station Surface Spill Mitigation Plan (continued)

Risk	Preventive measures	Responsible party	Document/procedure	Emergency procedure/action	By	Follow up action	By
5. Tanks overfilled	*Driver dip tanks prior to delivery *Driver fills within licensed capacity *Dipstick calibrated only to licensed tank capacity *Tank filled with over-fill prevention *Tank fill and dip points tagged	Driver Driver Oil company Oil company Contractor	Driver's handbook Oil co. specifications Oil co. specifications	*Control spill *Contain spill *Shut interceptor outlet valve *Contact Fire Brigade, if necessary *Contact duty despatcher	Driver Driver Driver Site Operator Driver	*Incident report/investigate cause *Replenish spill kit *Inspect/clean out interceptor *Advise local authorities *Undertake environmental investigation, if necessary *Implement action points as highlighted by incident report	Oil co./Driver Driver/Site operator Contractor Oil company Oil company Oil company
6. Overfill preventor shuts off during delivery	*Driver dip tanks prior to delivery *Driver fills within licensed capacity *Driver fills within licensed capacity	Driver Driver Oil company	Driver's handbook Oil co. specifications	*Shut valves *Pump product out of tanks	Driver Site operator	*Incident report *Investigate & rectify cause	Driver Oil company
7. Spill during delivery	*Driver training *Equipment maintenance	Driver Site Operator	Driver's handbook Site contingency plan	*Control spill *Contain spill *Shut interceptor outlet valve *Contact Fire Brigade, if necessary *Contact duty despatcher	Driver Site operator	*Incident report/investigate cause *Replenish spill kit *Inspect/clean out interceptor *Advise local authorities *Undertake environmental investigation, if necessary *Implement action points as highlighted by incident report	Oil co./Driver Driver/Site operator Contractor Oil company Oil company Oil company
8. Leaking remote fill point	*Observe at start of fill *Drain plunger in spill container	Driver	Driver's handbook		Driver	*Incident report *Investigate & rectify cause	Driver Oil company

APPENDIX 4

NATIONAL RAINFALL DATA

APPENDIX 4 NATIONAL RAINFALL DATA

This appendix contains selected national rainfall data. Appendix 4.1 gives rainfall data for sites throughout New Zealand, presented in terms of the annual amount of rainfall which falls during storms of a range of intensities. Appendix 4.2 comprises isohyet maps for storms with a 10% annual probability of occurrence. Appendix 4.3 interprets this data in terms of flow device configurations.

It should be noted that the data in Appendix 4.1 are representative only, and that more specific rainfall data for any particular site may be available, for example from the appropriate regional council.

A4.1 National rainfall data

The two tables below show the mean annual depths of rainfall which fall at various places throughout New Zealand during storms with intensity greater than 0.1, 9, … 20, 30 mm/hour. This information can be used in the specification of devices which are intended to treat stormwater runoff.

The general aim is to treat 92-94% of runoff. For example, in Auckland, Albert Park a runoff depth of 243 mm/hr falls more intensely than the 15 mm/hr design storm. If we assume the device treats 2/3 of the extraordinary discharges effectively so that 1/3 is not fully treated, this means that 1/3 of 243 = 81 mm/hr is not fully treated. This means that over the year 81 x 100 / 1150 = 7.04% escapes per year or 92.96% is efficiently treated. This can be compared with the ARC quoted figure of 93%.

Weather station	Mean annual depths of rainfall (mm) for specified intensities								Not fully treated	Design storm	
	Period	>0.1	>9	>12	>15	>18	>20	>30		mm/hr	% treated (min)
Kaitaia Observatory	1986 -1994	1286	421	321	252	204	179	104	84	15	93.47
Leigh 2	1986 -1994	1008	304	221	169	139	122	73	74	12	92.69
Warkworth	1986 -1994	1364	420	305	224	180	158	86	102	12	92.55
Whenuapai Aerodrome	1986 -1993	1219	379	282	221	178	156	97	94	12	92.29
Albany	1986 -1994	1151	320	226	165	124	108	48	54	12	93.45
Auckland, Albert Park	1976 -1985	1150	383	299	243	202	180	111	81	15	92.96
Coromandel	1986 -1994	1685	540	367	266	193	162	67	122	12	92.74
Te Aroha	1986 -1994	1221	329	240	188	147	125	70	80	12	93.45
Tauranga Aerodrome	1986 -1993	1090	308	234	177	141	121	72	78	12	92.84
Taupo N.Z.E.D.	1986 -1994	1051	195	141	106	85	70	39	65	9	93.81
Opotiki	1986 -1994	1137	380	289	235	188	160	82	78	15	93.11
Waimana	1986 -1993	1521	545	399	305	236	205	106	102	15	93.32
Auckland Aerodrome	1986 -1993	1058	293	217	175	140	121	68	72	12	93.16
Ruakura	1986 -1994	1092	280	218	176	145	128	77	73	12	93.35
Taumaranui	1986 -1994	1372	255	163	117	91	76	42	85	9	93.8
New Plymouth Aerodrome	1986 -1994	1343	405	296	228	184	159	86	99	12	92.65
Dannevirke	1986 -1994	973	132	90	66	50	44	24	44	9	95.48
Ruatoria	1986 -1994	1665	468	306	219	164	132	52	102	12	93.87
Gisborne Aerodrome	1986 -1993	969	197	126	96	68	56	29	66	9	93.22
Paraparaumu Aerodrome	1986 -1994	966	192	123	80	59	52	28	64	9	93.37
Ohakea Aerodrome	1986 -1994	840	173	115	83	64	53	28	58	9	93.13
Palmerston North	1986 -1994	943	186	131	97	74	62	27	62	9	93.43
Karori Reservoir	1986 -1993	1239	232	155	108	79	68	32	77	9	93.76
Wellington, Kelburn	1986 -1994	1123	212	142	110	85	73	42	71	9	93.71

Weather station	Mean annual depths of rainfall (mm) for specified intensities								Not fully treated	Design storm	
	Period	>0.1	>9	>12	>15	>18	>20	>30		mm/hr	% treated (min)
Wellington Aerodrome	1986 -1993	880	157	97	67	53	45	24	52	9	94.05
Kaitoke	1986 -1993	1913	346	231	154	109	93	39	122	9	93.97
Kaitoke Headworks	1986 -1993	2238	478	324	232	164	139	64	159	9	92.88
Wallaceville	1986 -1994	1257	195	128	89	67	55	25	65	9	94.83
Waiouru M.W.D.	1986 -1994	1044	105	69	49	39	35	21	35	9	96.65
Wanganui, Cooks Gardens	1986 -1994	896	187	132	101	79	69	33	62	9	93.04
Hokitika Aerodrome	1986 -1994	2849	868	596	432	324	275	146	199	12	93.03
Greymouth Aerodrome	1986 -1993	2147	571	387	274	207	173	84	129	12	93.99
Motueka	1986 -1994	1231	310	216	160	111	92	38	72	12	94.15
Nelson Aerodrome	1986 -1994	911	197	132	96	72	61	31	66	9	92.79
Blenheim Research	1986 -1994	570	59	34	26	17	13	8	20	9	96.55
Highbank Power Stn	1986 -1993	665	55	41	33	26	21	10	18	9	97.24
Winchmore	1986 -1994	655	48	26	16	12	10	3	16	9	97.56
Rangiora	1986 -1994	553	41	33	26	17	16	9	14	9	97.53
Christchurch Aerodrome	1986 -1994	605	42	27	20	13	11	5	14	9	97.69
Greenpark	1986 -1993	612	47	26	18	12	10	4	16	9	97.44
Gleniti Reservoir	1986 -1993	607	63	41	30	18	14	7	21	9	96.54
Makarora Station	1986 -1994	2217	180	86	52	30	25	10	60	9	97.29
Dunedin, Musselburgh	1986 -1994	766	60	34	21	13	10	5	20	9	97.39
Manapouri, West Arm 2	1986 -1993	3590	473	234	148	106	85	50	158	9	95.61
Queenstown	1986 -1994	885	59	20	10	5	3	3	20	9	97.78
Clyde	1986 -1993	390	33	21	15	12	10	7	11	9	97.18
Invercargill Aerodrome	1986 -1994	1137	120	69	48	35	32	16	40	9	96.48
Stewart Island	1986 -1994	1631	120	95	55	38	28	13	40	9	97.55

A 4.3 Flow Device Configurations

Flow conditions outlined in the guideline allow for water treatment devices to treat 90-95% of stormwater runoff on a long term basis. This is achieved by designing for a threshold rainfall intensity associated with 90-95% of the influent. A number of options exist for treatment of the remaining portion which will occur at high rainfall intensity events.

1. **With Flow Balancing**. This option involves using a storage configuration to contain stormwater in excess of the threshold storm for treatment at a time of low flow. This can involve the use of the ullage or head space in the device or by using a separate storage tank. The design needs to demonstrate that the volume of water generated from a storm event of a selected return period can be contained within the storage volume. Alternatively a high level overflow relief device can be installed to cater for storm events in excess of the available storage.
2. **Without Flow Balancing**. Stormwater in excess of the threshold storm either passes through the device at a rate greater than the design flow, or is diverted around the device and not treated at all.
    - ***Flow Through***. A flow rate greater than the design flow, will result in the water being treated less efficiently, however the influent is also likely to have a lower contaminant loading (after the first flush). Reintrainment of previously separated oil can occur if the flow rate becomes too high however and should be guarded against.
    - ***Diversion.*** Here the stormwater flow (or a portion of it) in excess of the design storm is diverted around the treatment device and is not treated. This is done to prevent the degradation of the device's efficiency. Again the contaminant loading is expected to be reduced in the high flow events.

Design solutions should be selected from, or be a combination of the above flow regimes. The choice of flow configuration should be made by the designer with due regard to local requirements.

The following are flow control structures often used in separator designs:-

Orifice Control

There is a specific relationship between the flow through an orifice, its diameter and the head of water behind it. This relationship can be used to restrict the flow to certain maximums and generate a storage of stormwater behind it. The relationship is commonly expressed as:

$$h = 2.6/2g.(Q/A_o)^2$$

h	Head generated (m)
g	Gravitational acceleration (m/s^2)
Q	Flow rate (m^3/s)
A_o	Area of orifice (m^2)

Weir Control

Weirs can used in the same manner, with the relationship between flow rate and head being expressed as:

$$h = (Q/1.7.L)^{2/3}$$

h	Head generated (m)
L	The length of the weir(m)

Q Flow rate (m^3/s)

By-pass

A by-pass can be fitted at the upstream end of the device to be activated when the flow rate through the device reaches a certain point. Generally the height of the by-pass is set to activate once the head of water has been generated behind either an orifice or a weir.

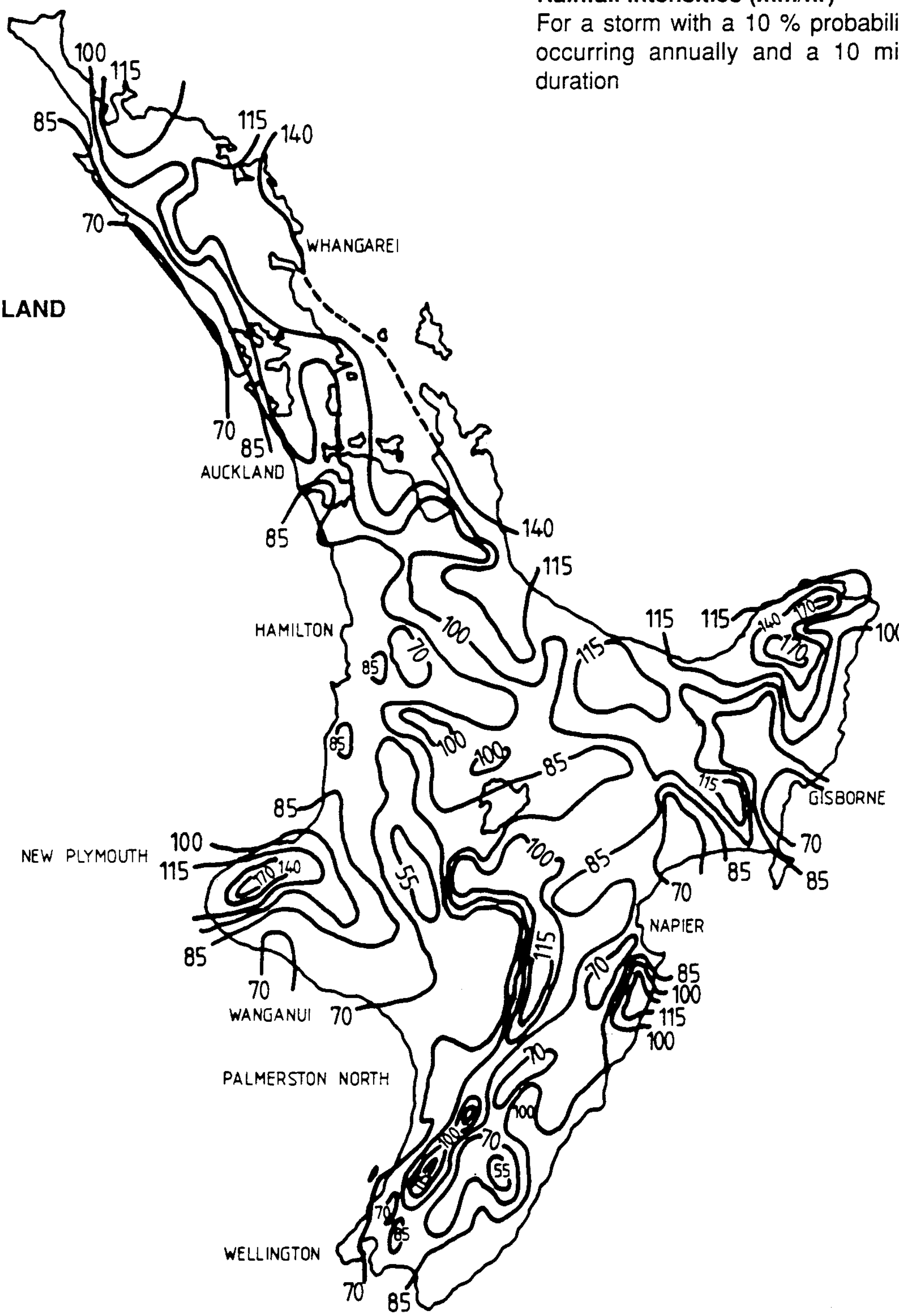
High Flow Relief

A high flow relief is used to relieve flooding in a flow balancing configuration. Generally it consists of a vertical pipe set at the maximum working height of the storage container, adjacent to the discharge point.

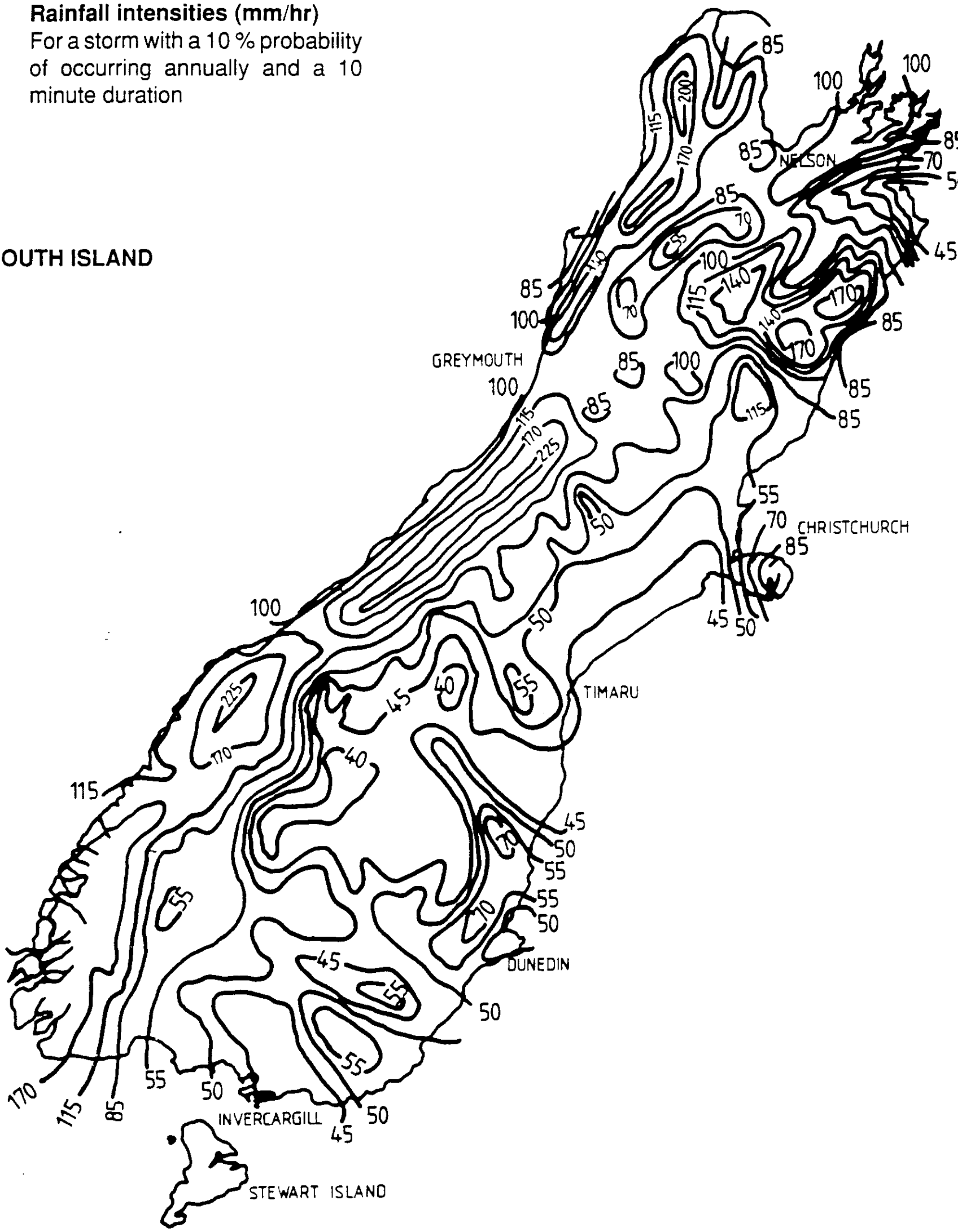
Appendix A RAINFALL INTENSITIES

Rainfall intensities (mm/hr)
For a storm with a 10 % probability of occurring annually and a 10 minute duration

NORTH ISLAND



Rainfall intensities (mm/hr)
For a storm with a 10 % probability of occurring annually and a 10 minute duration



APPENDIX 5

SEPARATOR DESIGN METHODOLOGIES

APPENDIX 5 SEPARATOR DESIGN METHODOLOGIES

This appendix deals with the design of oil-water separators. Appendix 5.1 gives the design calculations for API separators; Appendix 5.2 deals with parallel plate separators; and Appendix 5.3 presents the basic equations for separator design.

Appendices 5.1-5.3 are extracts from API Publication 421 - *Design and Operation of Oil-Water Separators* (first edition, February 1990), but to better reflect the New Zealand situation, the text has been modified as follows:

- dimensions have been converted from imperial to metric (SI) units
- oil/water separator diagrams have been chosen to reflect the state of the art in the New Zealand Petroleum industry
- other departures from the API publication have been underlined

A5.1 Step-by-Step Design Calculations for API Separators

API has established certain design criteria for determining the various critical dimensions and physical features of a separator. These are presented below in a series of step-by-step design calculations. The derivations of the basic equations for oil-water separator design are given in Appendix 5.3.

Oil-water separation theory is based on the rise rate of the oil globules (vertical velocity) and its relationship to the surface-loading rate of the separator. The rise rate is the velocity at which oil particles move toward the separator surface as a result of the differential density of the oil and the aqueous phase of the wastewater. The surface-loading rate is ratio of the flow rate to the separator to the surface area of the separator. The required surface-loading rate for removal of a specified size of oil droplet can be determined from the equation for rise rate.

A5.1.1 General

The following parameters are required for the design of an oil-water separator:

a. Design flow (Q_m), the maximum wastewater flow. The design flow should include allowance for plant expansion and stormwater runoff, if applicable.

b. Wastewater temperature. Lower temperatures are used for conservative design.

c. Wastewater specific gravity (S_w).

d. Wastewater absolute (dynamic) viscosity (μ). Note: Kinematic viscosity (ν) of a fluid of density (ρ) is $\nu = \mu / \rho$.

e. Wastewater oil-fraction specific gravity (S_o). Higher values are used for conservative design.

f. Globule size to be removed. The nominal size is 0.015 centimetres (150 micrometres), although other values can be used if indicated by specific data.

The design of conventional separators is subject to the following constraints:

a. Horizontal velocity (V_H) through the separator should be less than or equal to 1.5 cm/s (0.015 m/s) or equal to 15 times the rise rate of the oil globules (V_t), whichever is smaller.

b. Separator water depth (*d)* should not be less than 1 m, to minimise turbulence caused by oil/sludge flight scrapers and high flows. Additional depth may be necessary for installations equipped with flight scrapers. It is usually not common practice to exceed a water depth of 2.4 m.

c. The ratio of separator depth to separator width (d/B) typically ranges from 0.3 to 0.5 in refinery services.

d. Separator width (B) is typically between 1.8 and 6 m in refinery services. Note: Typical sizes at Petroleum Industry sites in New Zealand are smaller.

e. By providing two separator channels, one channel is available for use when it becomes necessary to remove the other from service for repair or cleaning. In New Zealand Petroleum Industry applications, one channel is usually sufficient.

f. The amount of freeboard specified should be based on consideration of the type of cover to be installed and the maximum hydraulic surge used for design.

g. A length-to-width ratio (L/B) of at least 5 is suggested to provide more uniform flow distribution and to minimise the effects of inlet and outlet turbulence on the main separator channel. This requirement has not been considered necessary for the New Zealand Petroleum Industry sites and a TOTAL length to breadth ratio of at least 2 is preferred.

Figure A5.1.1 shows a typical oil-water separator and depicts the design variables listed above.

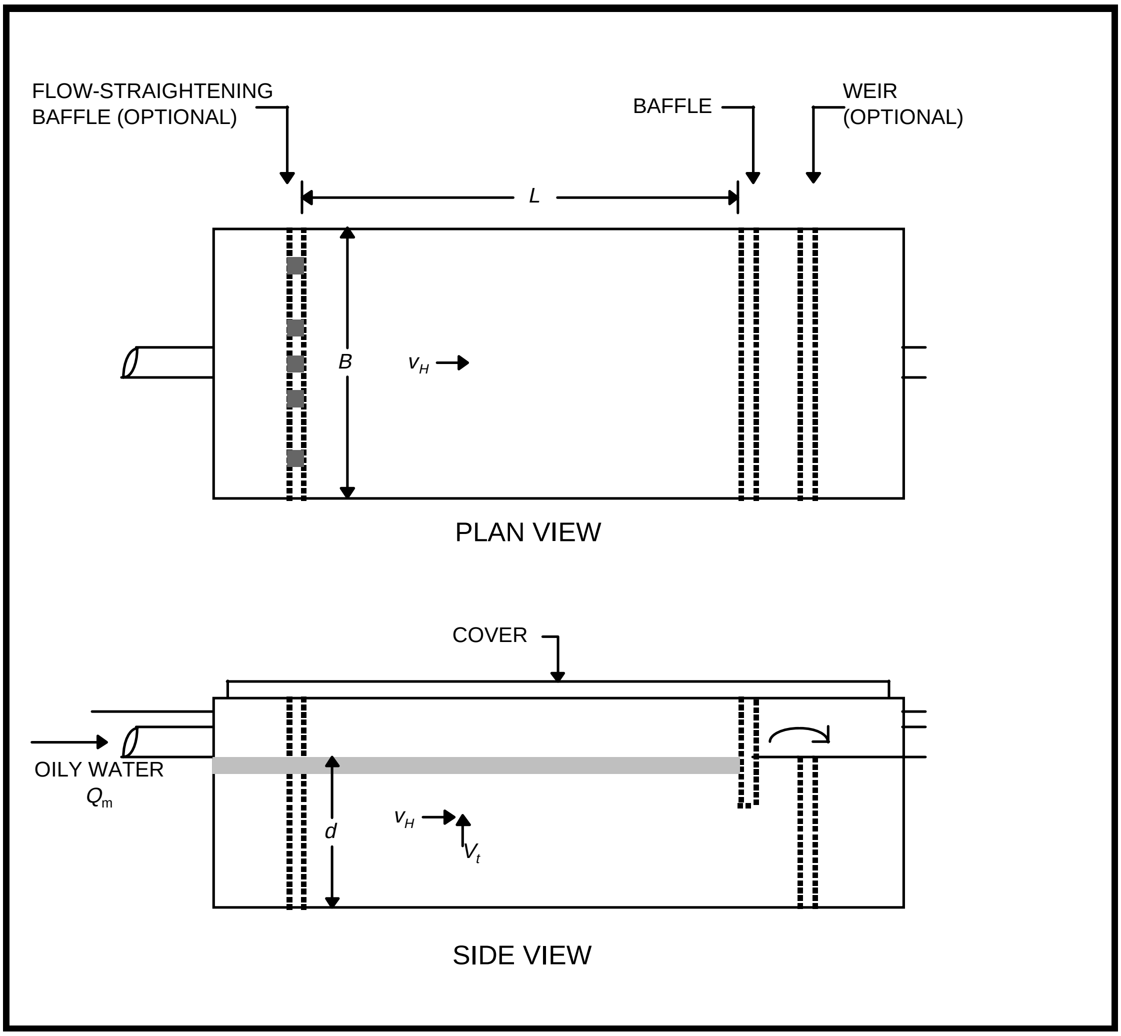


Figure A5.1.1. Design variables for oil interceptors.

The oil-globule rise rate (V_t) can be calculated by Equation 1 or 2 shown below. Equation 1 should be used when the target diameter of the oil globules to be removed is known to be other than 0.015 cm and represents a typical design approach. Equation 2 assumes an oil globule size of 0.015 cm.

$$V_t = \frac{g}{18\mu}\left(\rho_w - \rho_o\right)D^2 \qquad (1)$$

$$V_t = 0.0123\left(\frac{S_w - S_o}{\mu}\right) \qquad \text{(where } D = 0.015 \text{ cm)} \qquad (2)$$

where:

V_t = vertical velocity, or rise rate, of the design oil globule, in cm/s.

g = acceleration due to gravity (981 cm/s^2).

μ = absolute viscosity of wastewater at the design temperature, in poise. Note: 1 P = 1 g/cm.s; 10 P = 1 Pa.s.

ρ_w = density of water at the design temperature, in g/cm^3. Note: 1 g/cm^3 = 1 kg/litre.

ρ_o = density of oil at the design temperature, in g/cm^3.

D = diameter of the oil globule to be removed, in cm.

S_w = specific gravity of the wastewater at the design temperature (dimensionless).

S_o = specific gravity of the oil present in the wastewater (dimensionless, not degrees API).

Alternatively, if using kinematic viscosity, Equations 1 and 2 may be rearranged as follows:

$$V_t = \frac{g}{18\nu}\left(1 - S_o\right)D^2 \qquad (1a)$$

$$V_t = 0.0123\left(\frac{1 - S_o}{\nu}\right) \qquad \text{(where } D = 0.015 \text{ cm)} \qquad (2a)$$

where:

ν = kinematic viscosity of the wastewater at design temperature, in Stokes. Note: 1 Stoke = 1 cm^2/s; 10,000 Stokes = 1 m^2/s.

Once the oil-globule rise rate (V_t) has been obtained from Equation 1 or 2, the remaining design calculations may be carried out as described in Sections A5.1.2 - A5.1.7.

A5.1.2 Horizontal Velocity (v_H)

The design mean horizontal velocity is defined by the smaller of the values for v_H in cm/s obtained from the following two constraints:

$$v_H = 15V_t \leq 1.5 \qquad (3)$$

These constraints have been established based on operating experience with oil-water separators. Although some separators may be able to operate at higher velocities, 1.5 cm/s has been selected as a recommended upper limit for conventional refinery oil-water separators. Most refinery process-water separators operate at horizontal velocities much less than 1.5 cm/s at average flow. All separators surveyed by the API in 1985 had average horizontal velocities of less than 1 cm/s, and more than half had average velocities less than 0.5 cm/s, based on typical or average flow rates. Maximum flow rates were not reported in the survey; however, design flow rates were typically 1.5-3 times the typical average flow rates.

A5.1.3 Minimum Vertical Cross-Sectional Area (A_c)

Using the design flow to the separator (Q_m) and the selected value for horizontal velocity (v_H), the minimum total cross-sectional area of the separator (A_c) can be determined from the following equation:

$$A_c = \frac{Q_m \times 100}{v_H} \qquad (4)$$

Where :

A_c = minimum vertical cross-sectional area, in m^2.

Q_m = design flow to the separator, in m^3/s.

v_H = horizontal velocity, in cm/s.

Note: The 100 factor is to convert from cm/s to m/s.

A5.1.4 Number of Separator Channels Required (n)

Not applicable to this document. In New Zealand oil industry applications, one channel is usually sufficient, i.e., assume $n = 1$.

A5.1.5 Channel Width and Depth

Given the total cross-sectional area of the channels (A_c) and the number of channels desired (n), the width and depth of each channel can be determined. A channel width (B), generally between 1.8 - 6 m, should be substituted into the following equation, solving for depth (d):

$$d = \frac{A_c}{Bn} \qquad (6)$$

where:

d = depth of channel, in m.

A_c = minimum vertical cross-sectional area, in m^2.

B = width of channel, in m.

n = number of channels (dimensionless) = 1.

The channel depth obtained should conform to the accepted ranges for depth (1-2.4 m) and for the depth to width ratio (0.3-0.5).

A5.1.6 Separator Length

Once the separator depth and width have been determined, the final dimension, the channel length (L), is found using the following equation:

$$L = F\left(\frac{v_H}{V_t}\right)d \qquad (7)$$

where:

L = length of channel, in m.

F = turbulence and short-circuiting factor (dimensionless), see Figure 2.

v_H = horizontal velocity, in cm/s.

V_t = vertical velocity of the design oil globule, in cm/s.

d = depth of channel, in m.

If necessary, the separator's length should be adjusted to be at least five times its width, to minimise the disturbing effects of the inlet and outlet zones.

Equation 7 is derived from several basic separator relations:

a. The equation for horizontal velocity ($v_H = Q_m/A_c/$), where A_c is the minimum total cross-sectional area of the separator.

b. The equation for surface-loading rate ($V_t = Q_m/A_H$), where A_H is the minimum total surface area of the separator.

c. Two geometrical relations for separator surface and cross-section area ($A_H = LBn$ and $A_c = dBn$), where n is the number of separator channels.

A derivation of this equation is given in Appendix 5.3.

The turbulence and short-circuiting factor (F) is a composite of an experimentally determined short-cutting factor of 1.21 and a turbulence factor whose value depends on the ratio of mean horizontal velocity (v_H) to the rise rate of the oil globules (V_t). A graph of F versus the ratio v_H/V_t is given in Figure A5.1.2; the data used to generate the graph are also given below.

v_H/V_t	Turbulence factor (F_t)	F=1.2F_t
3	1.07	1.28
6	1.14	1.37
10	1.27	1.52
15	1.37	1.64
20	1.45	1.74

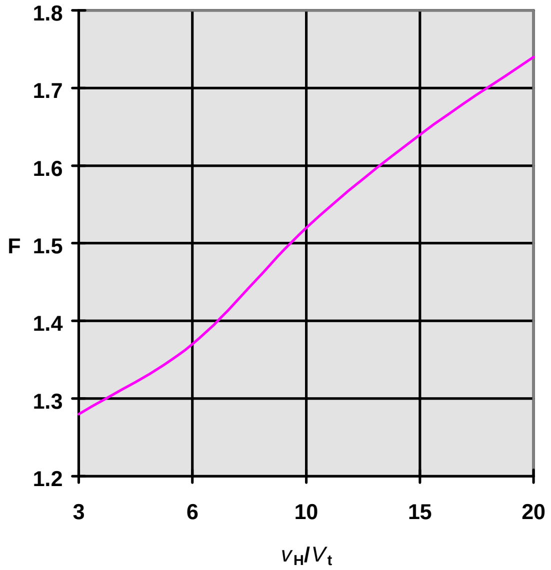


Figure A5.1.2. Recommended values of F for various values of V_h/V_t

A5.1.7 Minimum Horizontal Area

In an ideal separator - one in which there is no short-circuiting, turbulence, or eddies - the removal of a given suspension is a function of the overflow rate, that is, the flow rate divided by the surface area. The overflow rate has the dimensions of velocity. In an ideal separator, any oil globule whose rise rate is greater than or equal to the overflow rate will be removed. This means that any particle whose rise rate is greater than or equal to the water depth divided by the retention time will reach the surface, even if it starts from the bottom of the chamber. When the rise rate is equal to the overflow rate, this relationship is expressed as follows:

$$V_t = \frac{d_i}{T_i} = \frac{100 d_i}{\frac{L_i B_i d_i}{Q_m}} = \frac{100 Q_m}{L_i B_i} = v_o \quad (8)$$

where:

d_i = depth of wastewater in an ideal separator, in cm.

t_i = retention time in an ideal separator, in s.

L_i = length of an ideal separator, in cm.

B_i = width of an ideal separator, in cm.

Q_m = design flow to the separator, in m^3/s.

v_o = overflow rate, in cm/s.

Note: The 100 factor is to convert from cm/s to m/s.

Equation 8 establishes that the surface area required for an ideal separator is equal to the flow of wastewater divided by the rise rate of the oil globules, regardless of any given or assigned depth.

By taking into account the design factor (*F*), the minimum horizontal area (A_H), is obtained as follows:

$$A_H = F\left(\frac{Q_m \times 100}{V_t}\right) \qquad (9)$$

where:

A_H = minimum horizontal area, in m^2.

F = turbulence and short-circuiting factor (dimensionless), see Figure A5.1.2.

Q_m = wastewater flow, in m^3/s.

V_t = vertical velocity of the design oil globule, in cm/s.

A5.2 Parallel-Plate Separators[1,2,3,4]

A5.2.1 Introduction

The efficiency of an oil-water separator is inversely proportional to the ratio of its discharge rate to the unit's surface area. A separator's surface area can be increased by the installation of parallel plates in the separator chamber. The resulting parallel-plate separator will have a surface area increased by the sum of the horizontal projections of the plates added. In cases where available space for a separator is limited, the extra surface area provided by a more compact parallel-plate unit makes the parallel-plate separator an attractive alternative to the conventional separator. Flow through a parallel-plate unit can be two to three times that of an equivalent conventional separator. According to vendors, the spatial requirements of oil-water separators can be reduced up to twofold on width and tenfold on length when a parallel-plate unit is used in place of a conventional one. Current refinery experience using parallel-plate separators on a large scale is not very extensive, however.

In addition to increasing separator surface area, the presence of parallel plates may decrease tendencies toward short-circuiting and reduce turbulence in the separator, thus improving efficiency. The plates are usually installed in an inclined position to encourage oil collected on the undersides of the plates to move toward the surface of the separator, whereas sludge collected on the plates will gravitate toward the bottom of the separator. To improve oil and sludge collection, the plates are usually corrugated. For downflow separators (see Section 5.2.6), vertical gutters adjacent to the plates allow segregation of the separated oil and sludge fractions from the influent stream; these vertical gutters are located at both ends of the plate pack. At the lower (effluent) end of the plate pack, the vertical gutters are placed adjacent to the "valleys" in the corrugated plates to help channel sludge downward. At the higher (influent) end of the plate pack, these gutters are placed adjacent to the "peaks" in the corrugated plates to help convey oil to the surface.

Oil collected from parallel-plate systems is said to have a lower water content than that removed from conventional separators, and the overall effluent oil content has been reported to be up to 60% lower for parallel-plate systems, with a higher proportion of small oil droplets recovered[1].

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[1] J.J. Brunsmann, J. Cornelissen, and H. Eilers, "Improved Oil Separation in Gravity Separators, " *Journal of the Water Pollution Control Federation*, 1962, Volume 34, Number 1, pp. 44-55.

[2] "Tilted-Plate Separator Effortlessly Purifies Water," *Chemical Engineering*, 1969, Volume 76, Number 2, pp. 102-104.

[3] E.C. Shaw and W.L. Caughman, Jr., The Parallel Plate Interceptor, *NLGI Spokesman*, 1970, Volume 33, Number 11, pp. 395-399.

[4] S.J. Thomson, "Report of Investigation on Gravity-Type Oil-Water Separators," *Proceedings of the 28th Industrial Waste Conference*, Purdue University, 1973, pp. 558-563.

A5.2.2 Design

Typical ranges for the basic design variables of parallel-plate separation are given in Table A5.2.1 below.

Table A5.2.1. Typical ranges for the basic design variables of parallel-plate separators.

Variable	Range
Perpendicular distance between plates	2-4 cm
Angle of plate inclination from the horizontal	45^o - 60^o
Type of oil removed	Free oil only
Direction of wastewater flow	Crossflow, downflow

Even with the knowledge of acceptable values for these separator design parameters, it is difficult, if not impossible, to specify a set procedure for the detailed design of parallel-plate separator systems. Manufacturers have empirically determined that certain plate-inclination, flow-pattern and spacing configurations are most effective at removal of free oil over a given range of oily-wastewater conditions. Although in practice a design range is used for these variables as shown in Table A5.2.1, the values used can only be empirically justified. Refinery and vendor experience is the best basis for choosing a value for these empirical parameters that is appropriate for the wastewater being treated.

The determination of the surface area required for the plate pack and the number of packs needed is theoretically based and is standard for most parallel-place configurations. A procedure for determining these parameters is given in Section 5.2.3.

A5.2.3 Wastewater Characteristics Required for Separator Sizing

In general, the parameters used for design of conventional separators are also used for sizing of parallel-plate system maximum (design) wastewater flow, specific gravity and viscosity of the waste water's aqueous phase, and specific gravity of the wastewater oil. An oil-globule size distribution is also useful to determine a design oil-globule size, but in the absence of such data, a design globule diameter of 60 micrometres (0.006 cm) can be assumed. Conventional oil-water separators are designed to achieve complete capture of oil globules 150 micrometres (0.015 cm) and larger in diameter. Because of the greatly increased effective surface area of parallel-plate separators they have been designed to achieve satisfactory effluent quality based on complete removal of oil globules 60 micrometres and larger in diameter. As with conventional separators, wastewater flow should include primarily process flow with allowance for stormwater flow and facility expansion where appropriate. The oil's specific gravity should reflect cold-weather conditions.

A5.2.4 Parallel-Plate Surface Area[5,6]

Several equations have been set forth for sizing the surface area of parallel plates. In general, their basis is Stokes' law. As with conventional separators, the oil globules' rise rate can be equated with the surface-loading rate (Q_m/A_H), assuming a design mean oil-globule diameter of 60 micrometres:

$$\frac{Q_m}{A_H} = 0.00196\frac{(S_w - S_o)}{\mu} \qquad (10)$$

Where:

Q_m = design flow, in m^3/s.

A_H = horizontal separator area, in m^2.

S_w = specific gravity of the waste water's aqueous phase (dimensionless).

S_o = specific gravity of the waste water's oil phase (dimensionless).

μ = waste water's absolute (dynamic) viscosity, in poise. (Note: 1 P = 1 g/cm.s; 10 P = 1 Pa.s).

Solving Equation 9 for A_H provides the total surface area required to separate oil globules with a design diameter of 60 micrometres from the wastewater under a given set of influent conditions.

The number and area configuration of plates required, in conjunction with the open (not plate-filled) surface area of the separator (if significant), comprise the total required surface area, A_H. Owing to the great variability among manufacturers with respect to plate size, spacing, and inclination, it is strongly recommended that a vendor be consulted for specification of these parameters.

Packaged parallel-plate separators are often not in a rectangular configuration. Sludge hoppers, tapered walls, and inlet and outlet arrangements to minimise turbulence vary from supplier to supplier. If a new parallel-plate installation or a major retrofit of an existing unit is contemplated, it may be appropriate to work closely with the equipment supplier during the preliminary and detailed engineering phases. Treatability pilot testing of parallel-plate units is available and highly recommended. Process problems (for example, oil and solids removal, clogging) can be diagnosed at this time and taken into account in equipment selection and separator design.

---

[5] G.J. Iggleden, "The Design and Application of Tilted Plate Separator Oil Interceptors, *Chemistry and Industry,* November 4, 1978, pp. 826-831.

[6] J.G. Miranda, "Designing Parallel-Plate Separators," *Chemical Engineering*, 1977, Volume 84, Number 2, pp. 105-107

A5.2.5 Maintenance

Parallel-plate units may experience clogging problems if the plate inclination is too shallow or the plate-to-plate spacing is too narrow. It has also been reported that sand entering the plate system can collect at the entrance to the plate assembly and reduce flow through the lower plate sections. Should blockages develop, they may be cleared by removing the accumulated solids, flushing the plate pack with water or air, or mechanical cleaning. Operating and maintenance manuals and equipment suppliers should be consulted with regard to approved procedures. Solids accumulation and clogging should be considered before installation and designed for accordingly.

Parallel-plate packs do not generally clog if they are properly designed, installed, and maintained. If significant solids levels are expected, the plate inclination should be about 60^o, which exceeds the angle of repose of practically all solids encountered in such systems. A plate slope of 60^o and periodic blowdown of accumulated solids should help to avoid most parallel-plate separator plugging problems.

A5.2.6 Construction Details

A variety of parallel-plate equipment configurations are commercially available. In the case of conventional separators retrofitted with parallel plates few, if any, additional fitments are required in addition to those already present. New parallel-plate separators have a wide range of design features and may be purchased as packaged units, with oil and sludge-drawoff equipment provided. Consequently, specific construction and fitment details are omitted from this subsection.

Two major types of parallel-plate separators are marketed: the cross-flow inclined plate and the down-flow inclined plate. Cross-flow separators that employ parallel plates oriented vertically and horizontally are also available, although there are few applications for them in refineries.

In a cross-flow separator, shown in Figure A5.2.1, flow enters the plate section from the side and flows horizontally between the plates. Oil and sludge accumulate on the plate surfaces above and below the wastewater flowing between the plates. As the oil and sludge build up, the oil globules rise to the separator surface and sludge gravitates toward the separator bottom.

In a down-flow separator, the wastewater flows down between the parallel plates, sludge deposited on the lower plates flows to the bottom of the separator, and oil accumulated beneath the upper plates flows counter-current to the waste flow to the top of the separator.

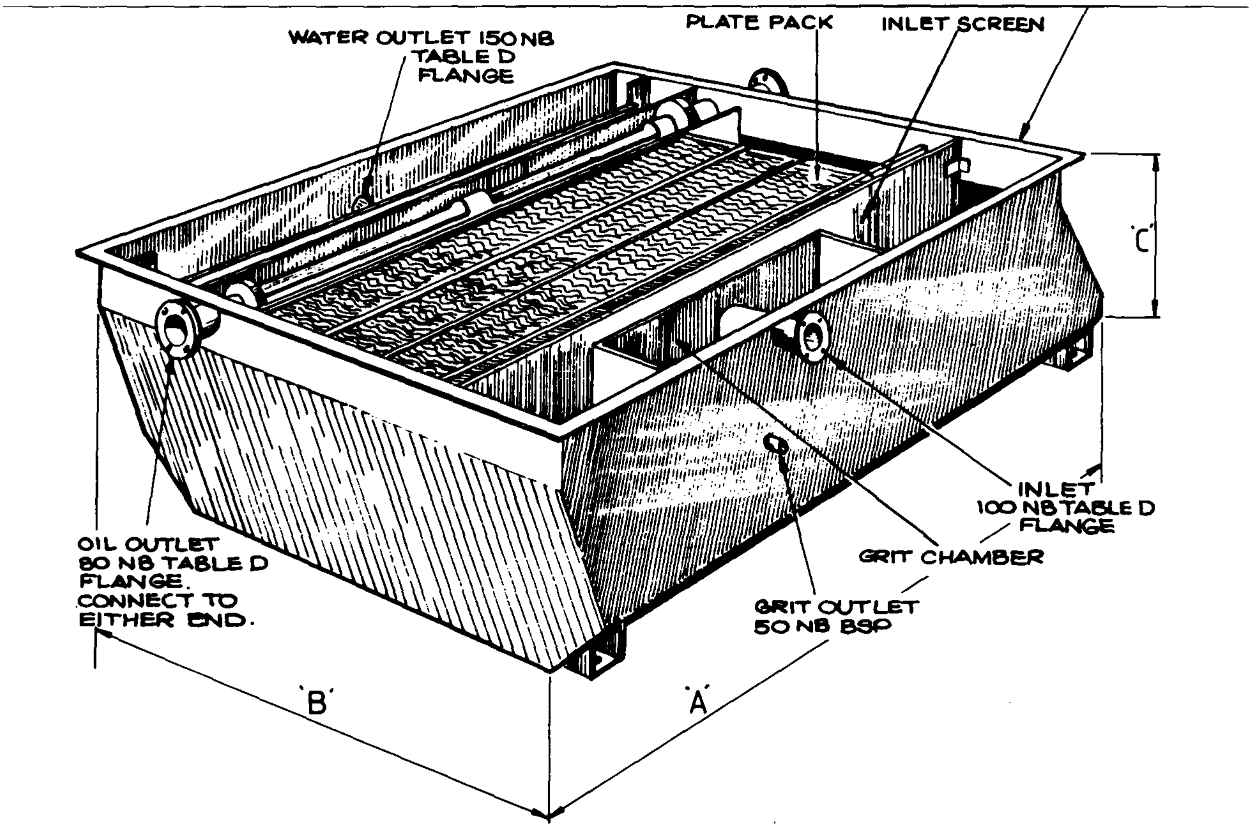


Figure A5.2.1. Parallel plate separator - cross-flow type.

[This illustration has been reproduced by courtesy of Sepa Waste Water Treatment Pty. Ltd., Australia]

A5.3 Derivation of Basic Equations for Design of Oil-Water Separators

A5.3.1 Terminal Velocity of Oil Globules in Water

The basic principles of separation by gravity differential can be expressed mathematically and applied quantitatively. When a particle is allowed to move freely in a fluid and is subjected to gravitational force, its rising or settling velocity with respect to the fluid becomes a constant when the resistance to motion equals the weight of the particle in the fluid. In other words, the resistance to motion of a particle in a liquid medium is equal to the effective weight of the particle when the terminal velocity has been reached, namely, when the acceleration caused by gravity becomes zero. The general equation for this resistance, first proposed by Newton, is as follows:

$$D_{\mathrm{f}} = CA\left(\frac{\rho_{\mathrm{w}} V^2}{2}\right) \tag{11}$$

where:

D_{f} = particle's resistance to motion in a liquid medium, in dynes.

C = coefficient of drag (dimensionless).

A = projected area of the oil globule in cm^2.

ρ_{w} = density of water, in g/cm^3.

V = terminal velocity of the oil globule in water, in cm/s.

The equation for the effective weight of the particle is as follows:

$$W = \left(\frac{\pi D^3}{6}\right)(\rho_{\mathrm{w}} - \rho_{\mathrm{o}})g \tag{12}$$

where:

W = effective weight of the oil globule in water, in dynes.

D = diameter of the oil globule, in cm.

ρ_{o} = density of the oil globule, in g/cm^3.

g = acceleration caused by the force of gravity (981 cm/s^2).

Equating Equations 11 and 12, then:

$$CA\left(\frac{\rho_{\mathrm{w}} V^2}{2}\right) = \left(\frac{\pi D^3}{6}\right)(\rho_{\mathrm{w}} - \rho_{\mathrm{o}})g \tag{13}$$

Given that, for a sphere,

$$A = \frac{\pi D^2}{4} \tag{14}$$

then the rate of rise is as follows:

$$V = \sqrt{\left(\frac{4D}{3}\right)\left[\frac{(\rho_w - \rho_o)g}{C\rho_w}\right]} \qquad (15)$$

The equation for the resistance to motion of a small spherical particle at its terminal velocity is as follows:

$$D_f = 3\pi\mu VD \qquad (16)$$

Where:

μ = absolute viscosity of wastewater at the design temperature, in poises.

If W in Equation 12 is equated to D_f in Equation 16, a new expression for V is obtained. By the substitution of V_t, the oil globules' velocity of rise (in cm/s) for the general term V, the well-known form of Stokes' law for the terminal velocity of spheres in a liquid medium becomes applicable to the rate of rise of oil globules in water.

$$V_t = \left(\frac{g}{18\mu}\right)(\rho_w - \rho_o)D^2 \qquad (17)$$

Equation 17 should theoretically include a deformation coefficient that depends on the relative viscosities of the oil and the water; however, in practice, the coefficient is not required to estimate the rate of rise of small oil globules in wastewater.

Note: Theoretically, consideration should be given to the deformation of an oil globule as it rises through a liquid medium, because of a change of shape caused by its contact with the liquid through which it is rising. This change of shape results from internal flow so that the particle's resistance to motion is minimised and a higher rise rate results. W.N. Bond[7] has expressed this effect in terms of the viscosities of the particle and the medium as follows:

$$C_v = \frac{\frac{2}{3} + \frac{\mu_1}{\mu_2}}{1 + \frac{\mu_1}{\mu_2}}$$

[7] WN Bond, "Bubbles and Drops and Stokes' Law", *The Philosophical Magazine*, November 1927, Series 7, Volume 4, Number 24, pp.889-898.

where:

C_v = *deformation coefficient theoretically applicable to Equation 17, (dimensionless), see the following equation.*

μ_1 = *absolute viscosity of the particle, in poises.*

μ_2 = *absolute viscosity of the medium, in poises.*

If this correction for internal flow is applied to Equation 17, Stokes' law for determining the rate of rise of an oil particle in water would become the following:

$$v_t = \left(\frac{1}{C_v}\right)\left(\frac{1}{18}\right)\left(\frac{g}{\mu}\right)(\rho_w - \rho_o)D^2$$

where:

v_t = *rise rate of oil globule (0.015 cm in diameter) in wastewater, in cm/s.*

However, in the application of this equation to the design of wastewater separators, the factor $1/C_v$ *may be omitted for practical purposes, because its value is very close to unity for the viscosities of oil to be separated from refinery wastewaters.*

Equations 16 and 17 are strictly correct only when the rising particle's Reynolds number (based on the particle diameter) is less than 0.5. For the range of Reynolds numbers resulting from the computations in this chapter (all substantially less than unity), however, the deviation from Stokes' law is negligible for design purposes.

A5.3.2 Size and Gravity of Oil Globules

The applicability of Equation 17 to oil globules in wastewater has been investigated. From the results of experiments and from plant operating data, it has been determined that the design of wastewater separators should be based on the rise rate of oil globules with a diameter of 0.015 cm (150 micrometres).

With a value of 0.015 for *D* in Equation 17, the rise rate of such oil globules in wastewater may be expressed as follows:

$$V_t = 0.0123\left(\frac{S_w - S_o}{\mu}\right) \qquad (18)$$

where:

V_t = rise rate of oil globule (0.015 cm in diameter) in wastewater, in cm/s.

S_w = specific gravity of wastewater at the design temperature of flow.

S_o = specific gravity of oil in wastewater at the design temperature of flow.

Note: S_w and S_o are specific gravities and are nearly the same numerically but differ dimensionally from ρ_w and ρ_o which they replace.

To check the dimensions of this formula, it is necessary to note that the number 0.0123 was obtained from dimensional factors and therefore has the dimensions of its factors, which are as follows:

$$\left(\frac{981cm}{\sec^2}\right)\left(\frac{1}{18}\right)\left(0.000225cm^2\right) = \frac{0.0123cm^3}{\sec^2}$$

<u>If the globule diameter is 60 micrometres (i.e., D = 0.006), the factor is 0.0020, rather than 0.0123.</u>

A5.3.3 Derivation of Equation for Separator Length

Separator length is calculated from the following equation:

$$L = F\left(\frac{\sqrt{H}}{\sqrt{t}}\right)d \qquad (19)$$

The basic equations used to derive the equation for separator length are as follows:

$$A_H = \frac{FQ_m}{\sqrt{t}} \qquad (20)$$

$$A_c = \frac{Q_m}{\sqrt{H}} \qquad (21)$$

$$A_c = dBn \qquad (22)$$

Equation 19 is derived from Equations 20, 21, and 22 as follows:

$$L = \frac{A_H}{Bn}$$

$$= \frac{A_H}{\frac{A_c}{d}}$$

$$= \frac{A_H d}{A_c}$$

$$= \frac{\frac{FQ_m}{\sqrt{t}} d}{\frac{Q_m}{\sqrt{H}}}$$

$$= F\left(\frac{\sqrt{H}}{\sqrt{t}}\right)d$$

where:

A_H = total separator surface area.

L = length of separator channel.

B = width of separator channel.

n = number of separator channels.

F = turbulence and short-circuiting factor (dimensionless).

Q_m = total design flow to the separator.

$\sqrt{t}$ = separator's surface-loading rate.

A_c = separator's total cross-sectional area.

$\sqrt{H}$ = separator's horizontal velocity.

d = depth of separator channel.

APPENDIX 6

TYPICAL DESIGN EXAMPLES

APPENDIX 6 TYPICAL DESIGN EXAMPLES

This appendix contains worked examples of how to specify the oil-water separator needed on a typical site. Appendix 6.1 gives the calculations for an API interceptor; and Appendix 6.2, for a corrugated plate interceptor.

A6.1 Typical Retail Site - A.P.I. Interceptor Sizing

A6.1.1 Catchment

Impermeable area to be served: 166 m^2
<=> 0.0166 hectares

A6.1.2 Design Flows

The rainfall intensity equating to 96% mean depth is: 15 mm/hr (ex NIWA)

$$Q_{design} = Q_m = \frac{C i_{design} Ac}{360}$$

Where:

Q_m	is the design flow
C	is the runoff coefficient for an impervious area given the design rainfall intensity
i_{design}	design rainfall intensity
Ac	Catchment area
360	Constant

Here:

C	is	1
i_{design}	is	15 mm/hr
Ac	is	0.0166 ha

So: Q_m = 0.000692 m^3/sec

or 2.49 m^3/hr

A6.1.3 Size the Separator (60 micrometre oil droplet size)

Calculate the rise velocity (V_t) based on a 60 μm oil droplet of specific gravity of (s) for ADF.

$$V_t = \frac{gd^2(1-S)}{18v}$$

Where:

V_t	is the rise velocity, m/s
g	is the acceleration due to gravity (9.81 m/s^2)
d	is the diameter of the oil droplet, m
S	is the specific gravity for the oil droplet
v	is the kinematic viscosity of water, m^2/s

Here:

d	6.00E-05 m
S_{ADF}	0.83
v	at the average winter temperature of 9.00°C means:
v=	1.38E-06 m^2/s

So:

V_t= 0.000242 m/sec

or

0.869 m/hr

Through velocity V_H <or= $15V_t$

Therefore V_H = 13.04 m/hr

Cross sectional area of API:

A_c = 0.191 m^2 0.191

Therefore minimum width and depth requirements will determine area,
ie., Depth = .75m, Width = 1.5,m

Which makes V_H = Q_m/A_c

Therefore V_H = 2.21 m/hr

Calculate surface area:

A_H = FQ_m/V_t

The F factor accounts for short circuiting and turbulence in the tank which degrades the tank performance. F is determined by the ratio of V_H to V_t.

Here: V_H/V_t = 2.55

=> F = 1.26

So: A_H = 3.61 m^2

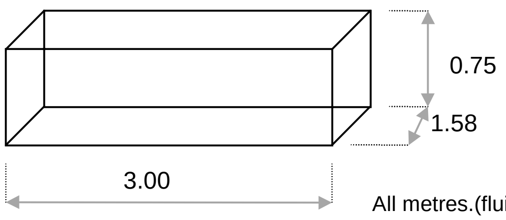
Length L = A_H/B (B = Width)

=>L = 2.41 m

Allowing .6 m exit, overall length is:

L_{tot}	3.01 m	Catchment area	166 m^2
Width is	1.58 m	Design rainfall density	15 mm/hr
H1 is	0.75 m	Design flow	2.49 m^3/hr

ie:



All metres.(fluid dimensions)

Upstream of the exit baffle,
Hydraulic volume = 2844 litres
Intercepted volume,
= Hydraulic vol. / S.G. of A.G.O. 3346 litres
(these are minimum static vols.)

API Oily Water Separator Sizing

A6.1.4 Spill Retention

A separator having the "fluid" dimensions shown above would clearly be capable of retaining a spill volume of 2500 litres adequately.

A6.1.5 Sizing of Orifice Plate

$$A_o = \frac{Qm}{SQR.(h_g 2g/2.6)}$$

A_o is the area of the orifice
h_g is the head behind the orifice
g is the acceleration due to gravity (9.81 m/s^2)
D_o is the diameter of the orifice

h_o(metre)	Q_m(m^3/hr)	A_o (mm^2)	D_o(mm)
0.25	2.00	0.40	23
0.25	2.48	0.50	25
0.25	2.96	0.60	28
0.25	3.43	0.69	30
0.25	3.89	0.79	32
0.25	4.34	0.88	33
0.25	4.78	0.97	35

A6.2 Typical Site - Corrugated Plate Interceptor Design

A6.2.1 Catchment

Impermeable area to be served:		166.5 m^2
	<=>	0.01655 hectares

A6.2.2 Estimated Design Flows

The rainfall intensity equating to 96% mean depth is: 15 mm/hr (ex NIWA)

$$Q_{design} = Q_m = \frac{C i_{design} Ac}{360}$$

Where:

Q_{design}	is the design flow
C	is the runoff coefficient for an impervious area given the design rainfall intensity
i_{design}	design rainfall intensity
Ac	Catchment area
360	Constant

Here:

C	is	1
i_{design}	is	15 mm/hr
Ac	is	0.01655 ha

So: Q_{design} = 0.000690 m^3/sec

or 2.48 m^3/hr

Therefore if a 4 m^3/hr capacity device is used it should be adequate for most circumstances.

A6.2.3 Influent and Effluent Oil Concentrations

The Australian Institute of Petroleum has conducted testing which indicated influent oil concentrations of 750 mg/l are possible. Generally for retail fuel outlet applications system designs are based around 1000 mg/l. Each of the three scenarios listed is possible. Both 15 mg/l and 20 mg/l effluent qualities are achievable; however, approximately 25% more plates are required to reduce the effluent oil concentration from 20 to 15 mg/l.

A6.2.4 Flow Status

Gravity flow situations are preferred where there are no pumps to cause mechanical emulsification and that due to pipework is negligible. Any emulsification (mechanical) due to any pumps and piping must be taken into account.

A6.2.5 Maximum Spill

Generally procedures need to be implemented to handle maximum spill volumes; however, in this case a 100 litre spill will be easily contained by this type of system. (A 2500 litre spill will need a pre-treatment trap.)

A6.2.6 Developing an Appropriate Oil Droplet Distribution

Unless specific information provided by the client suggests otherwise, a normal distribution of oil droplets is assumed.

The normal distribution is specified by the mean and standard deviation.

For three given scenarios (gravity flow - 500, 750 and 1000 mg/l influent) oil droplet distributions are approximated by:

Influent Oil Concentrati (mg/l)	Mean Diameter	Standard Deviation
500	177	2.5
750	188	2.5
1000	195	2.5

A6.2.7 Determine oil droplet size to be 100% removed

From these distribution curves and the required effluent quality the minimum size of the oil droplet to be 100% removed can be determined: e.g. for an influent concentration of 1000 mg/l and a required effluent concentration of 20 mg/l, it is necessary to remove 98% of the oil in the waste water.

Thus, using a normal distribution curve with a known mean and standard deviation we are able to determine the 98th percentile of the curve by volume and consequently the size of the oil droplet.

The size of the droplet to be 100% removed is a function of:

1. The influent oil concentration
2. The level of emulsification (mechanical)
3. The effluent quality required

Required Oil Droplet Removal for Gravity Flow Applications

Influent Concentration (mg/l)	Oil droplet to be 100% removed to achieve	
	20 mg/l	15 mg/l
500	50 μ	44 μ
750	45 μ	40 μ
1000	41 μ	37 μ

A6.2.8 Determine number of plates required

Once the droplet size (to be 100% removed) is determined, Stokes' Law is used to calculate the rise velocity of these droplets. Using this velocity and the maximum vertical distance between plates, the residence time required for this can be determined.

Calculate the rise velocity (V_t) based on a 60 μm oil droplet of specific gravity of (S) for ADF.

$$V_r = \frac{gd^2(1-S)}{18\varphi}$$

Where:

V_r	is the rise velocity, m/s
g	is the acceleration due to gravity (9.81 m/s^2)
d	is the diameter of the oil droplet
S	is the specific gravity for the oil droplet
φ	is the kinematic viscosity of water

Here:

d	6.00E-05
S_{ADF}	0.83
φ	at the average winter temperature in "Wherever" of 9.00^{o}C means:
φ=	1.38E-06

So:

V_r= 0.000242 m/sec

or

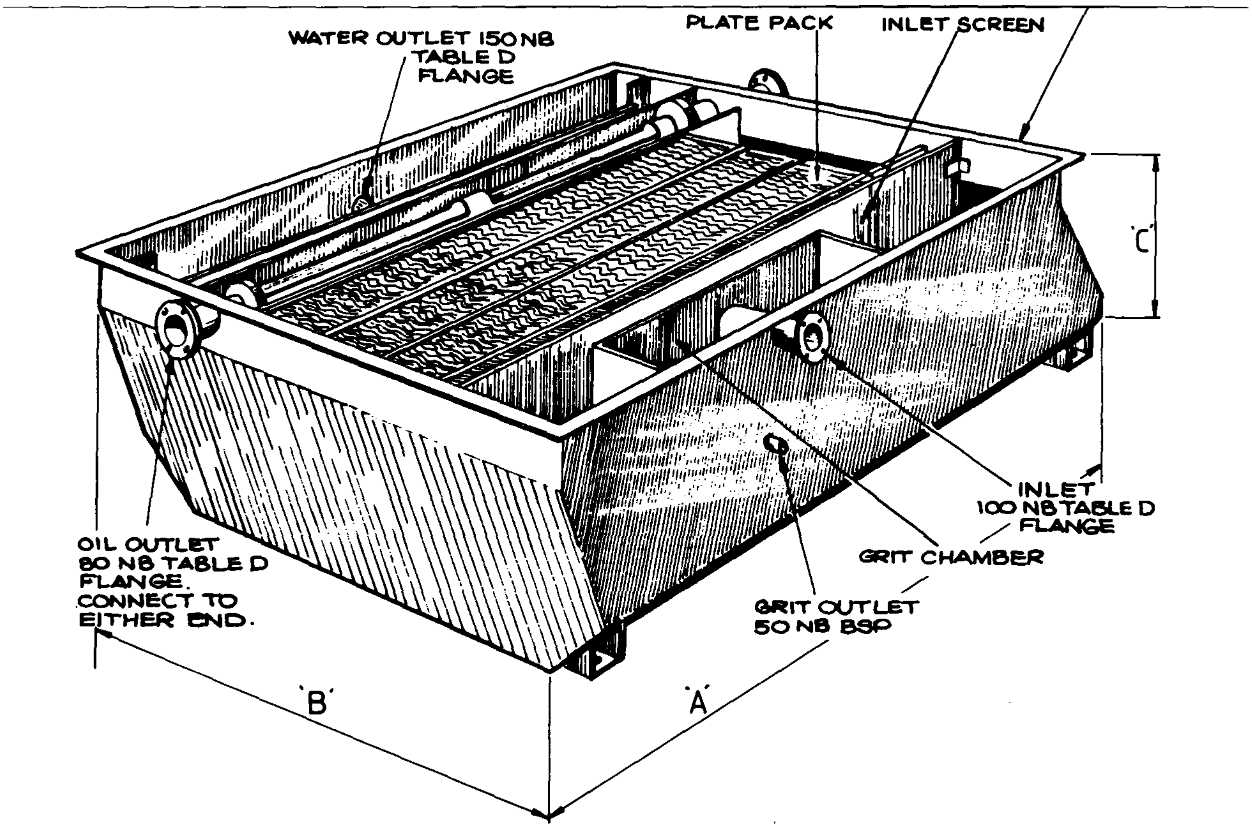
0.869 m/hr

A6.2.9 Configuration of System

The configuration of the system is not particularly important provided the correct volume of plates has been selected to provide the required residence time: e.g., if 1.7 cu metres of plates are needed it does not matter if the plates are arranged as 1 row 900 mm high, 600mm long or as 2 rows 900 mm wide, 450 mm high and 600 mm long. However, the system must be configured such that the flow through the plates will be laminar. This will ensure that oil droplets will not be re-entrained into the flow once they have been removed. Laminar flow is also imperative as Stokes' Law is only valid under these conditions, hence an accurate rise velocity of the oil droplets can only be predicted under laminar flow conditions.

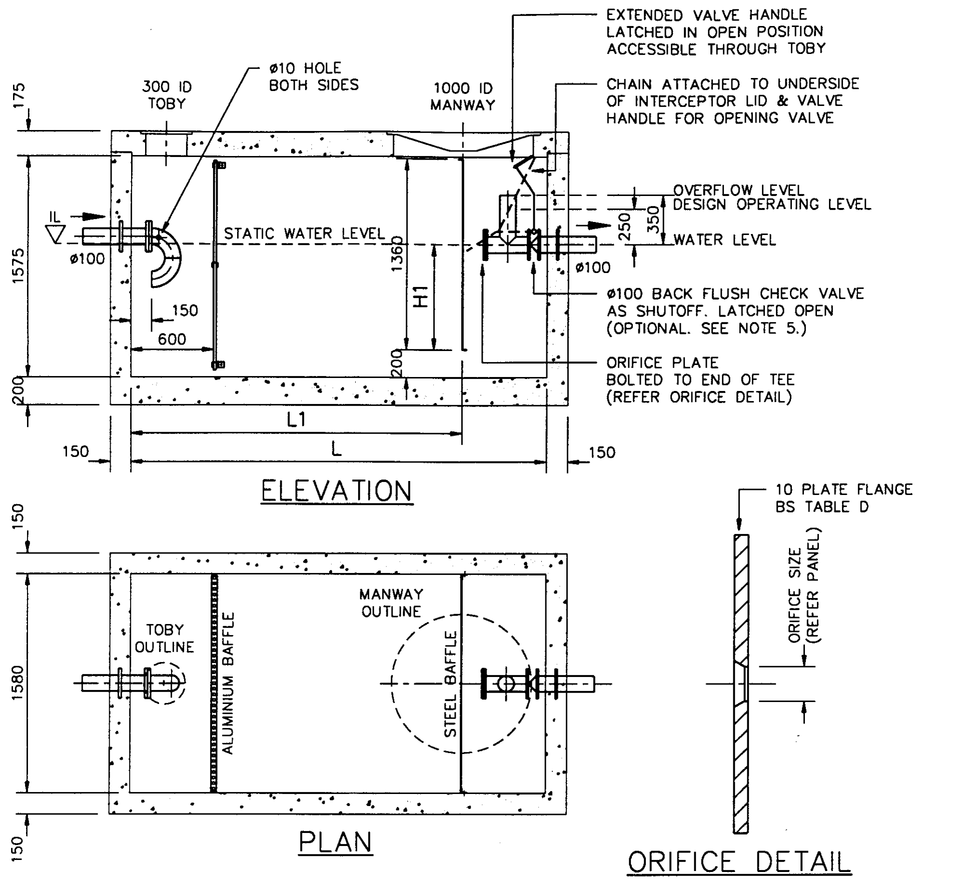
A6.2.10 Tank and Pit Sizing

Once the configuration of the plate packs has been selected the tank and pit dimensions can be calculated. For this a computer program is used which sizes the pit/tank based on the fluid velocity. A typical schematic is shown:



A6.2.1 Typical Corrugated Plate Interceptor

Appendix 6.1



NOTES :

1. INTERCEPTOR SPILL CAPACITY IS THE VOLUME OF HYDROCARBON RESTRAINED UPSTREAM OF THE BAFFLE UNDER STATIC FLOW CONDITIONS. (L1 X H1 X INSIDE WIDTH)/DENSITY OF HYDROCARBON.
2. DESIGN OPERATING LEVEL IS THE WATER LEVEL ON THE INLET OF THE ORIFICE AT THE INTERCEPTOR DESIGN FLOW.
3. OVERFLOW LEVEL IS DESIGNED THAT EVEN UNDER EXTREME FLOW CONDITIONS THE DESIGN CAPACITY OF MOTORSPIRIT WILL NOT OVER TOP THE BAFFLE OR WALLS.
4. UPON COMPLETION A SYSTEM TEST IS TO BE CARRIED OUT. CLOSE OUTLET VALVE AND WATER FILL SYSTEM TO CAPACITY, ANY LOSS OF WATER LEVEL OVER 4 HOURS MIN TEST PERIOD TO BE INVESTIGATED.
5. TEE PIECE IS ONLY REQUIRED WHERE SEPARATOR HAS RESTRICTED EXCESS STORM RETENTION CAPACITY ORIFICE PLATE IS MANDATORY IN ALL SITUATIONS.

MODEL REF	INTERNAL LENGTH (L) (mm)	INTERCEPTED LENGTH (L1) (mm)	APPROX WEIGHT (T)	CAPACITY FOR AGO (m^3)	DESIGN FLOW RATE (m^3/hr)	ORIFICE SIZE (ømm)	CATCHMENT AREA (m2)		
							9mm/hr	12mm/hr	15mm/hr
APISNZ2.5	2500	1900	9.5	2.5	1.98	23	220	165	130
APISNZ3	3000	2400	11.0	3.16	2.48	25	275	205	165
APISNZ3.5	3500	2900	12.5	3.81	2.97	28	330	245	200
APISNZ4	4000	3400	14.0	4.48	3.42	30	380	285	230
APISNZ4.5	4500	3900	15.5	5.14	3.87	32	430	325	260
APISNZ5	5000	4400	17.0	5.79	4.32	33	480	360	290
APISNZ5.5	5500	4900	18.5	6.45	4.78	35	530	400	320

SK3054

APPENDIX 7

CHANGEOVER VALVES

APPENDIX 7 CHANGEOVER VALVES

The information in this appendix on changeover valves has been supplied by Christchurch City Council. This is an example of a mechanism for diverting flow to sewer but is not intended as a preferred solution.

CHRISTCHURCH CITY COUNCIL
WASTE MANAGEMENT UNIT
Trade Wastes Section
Contact Colin Johnson/Norm Fitt

<u>MISSION STATEMENT</u>
To provide a level of service to Industrial and Commercial users to attain an Environmental Standard acceptable to the Community

BUS/TRUCK WASH FACILITY
DESIGN REQUIREMENTS

Using a Hydraulically Operated Liquid Separation System (Wilkinson Valve)

1. The installation will require the permission of the Christchurch City Council Waste Management Unit, Trade Wastes Section. A Building Consent is also required. These drawings show layouts and plumbing and drainage of a typical installation and may be modified to suit other applications providing the design requirements of these T.W.I.'s and the Building Code are complied with.

2. Other proprietary manufactured valves may be suitable for this purpose but may only be used if they
   (a) are a recognised 'brand'
   (b) are noted for reliable operation
   (c) have a local ready supply of spare parts and service personnel
   (d) are approved by the Christchurch City Council Trade Wastes Office

3. In order for the Wilkinson hydraulic system to work adequately, an incoming water pressure of 500 kPa is necessary. The wash hose is to be connected at all times and be a minimum of 15 metres in length. An appropriate dedicated backflow preventer is to be fitted with a permanent label wired to it "Hydraulic Valve and Wash".

4. The Hydraulically Operated cylinder with stainless steel shaft, spring and tie rods together with the galvanised mounting bracket and plug can be obtained from Mr Alan Wilkinson. Every effort has been made to manufacture the hydraulically operated valve from corrosion resistant materials, absolutely no responsibility is accepted for problems or damage that may result from corrosion from contact with the various liquids that the valve may encounter. It is the owners or specifiers responsibility to ensure that the liquids encountered within the separation system are compatible with the metals used in the valve construction. However, specify the valves intended use so that it may be supplied with an appropriate seal.

5. The valve must be installed in the sewer petrol/oil interceptor as shown. When installing the valve, withdraw the four bolts securing the bracket legs to the bottom flange. (Note positions of mating arrows and the orientation of the hose connection.) Cement the bottom flange and lugs into the wall of the interceptor.

(Ensure that the top of the flange is kept clean.) When the cement has hardened, carefully re-bolt the bracket legs to the bottom flange, taking care not to bend the valve shaft.

6. When electrically operated washdown equipment is used eg - waterblaster - the electric solenoid valve switching arrangement shown is to be used. The only manually operated valve permitted is the isolation valve shown on the drawing. If the waterblaster (or the like) has an "in built" ON/OFF switch it is preferable that it be by-passed and removed **or** it must be permanently labelled. "LEAVE THIS SWITCH ON". All washing equipment is then fully under the control of the switch labelled "WASH".

7. Finally, the wash system shall not be put in use without first preparing an Environmental Management Plan in conjunction with the Trade Wastes Officer. The Trade Wastes Officer will supply signage free of charge to assist the operation and maintenance of the separation system.

8. Associated Drawings.

Drawing	8000 sheet 113/B
	8000 sheet 113/D
	8000 sheet 122/1
	8000 sheet 122/2
	8000 sheet 122/3
	8000 sheet 122/4
	8000 sheet 122/5

HYDRAULICALLY OPERATED LIQUID SEPARATION SYSTEM

- Patent Applied For -

Mr Alan Wilkinson
90 Greenhaven Drive
CHRISTCHURCH 9
Phone: (03) 383-1853

Please make Trade Wastes Enquires to:

Colin Johnson, Trade Wastes Officer, DDI 371-1276
or
Norm Fitt, Trade Wastes Manager, DDI 371-1368
Christchurch City Council
P.O. Box 237
CHRISTCHURCH
Fax: (03) 371-1384

NOTES: Sheet 122/1

1. Gradient to be such that the flow velocities will prevent the settlement of solids and grit in the pipeline (Ref. BIA G 14 Para 2.1.3)
2. Piping system to be to the requirements of BIA G13. If invert levels are such that compliance with BIA G13 cannot be achieved then install a pumped system to BIA G14 Para 2.4.3. figure 2(b).
3. Piping system to be to the requirements of BIA E1 except that disposal to a soak pit is not acceptable unless specifically approved.
4. Maximum carry distance to sumps is 6m (ref. BIA G14). See sheet 2 for detail of sump.
5. Draining directions shown thus. Gradient to be 1 in 40 or better ref. BIA G14 Para 2.2 (b).
6. Drainage channel to have easily removable grating maximum hole size 20mm to prevent entry of stones etc. to drainage system. Grating to be resistant to corrosion.
7. Slab to be concrete and of suitable strength to withstand anticipated usage. Surface to have smooth 'float machined' surface to aid drainage. The top of the slab to be higher than the finished level of the surrounding land.
8. If wash overspray is likely to cause nuisance to others or unacceptable pollution levels then provide spray screens each side of wash.
9. It is preferred to position petrol and oil interceptor on sewer as close to wash slab as possible to maximise available gradient and so facilitate drainage of solids to interceptor.

NOTES: Sheet 122/2

1. Grating to have maximum hole size of 20mm to prevent entry of stones etc. to drainage system. Grating to be resistant to corrosion.
2. This is bottom of drainage channel at entry to sump. The 20Omm corresponds to 1.40 grade at a travel distance of 5m to the sump for the wash slab shown on sheet 1.
3. Bottom of sump to be haunched as shown to direct silt to sewer petrol oil interceptor.
4. The top of both interceptors and wash slab is to be above surrounding finished ground level to prevent entry of surface water.
5. Pipe size 100 diameter and gradient to be such that the flow velocities will prevent the settlement of solids and grit in the pipeline (Ref. BIA G14 Para 2.1.3)
6. Piping system from here on to be to the requirements of BIA G13. If invert levels are such that compliance with BIA G 13 cannot be achieved then install a pumped system to BIA G 14 Para 2.4.3 figure 2 (b).
7. Piping system from here on to be to requirements of BIA E1 except that disposal to a soak pit is not acceptable unless specifically approved.

NOTES: Sheet 122/3

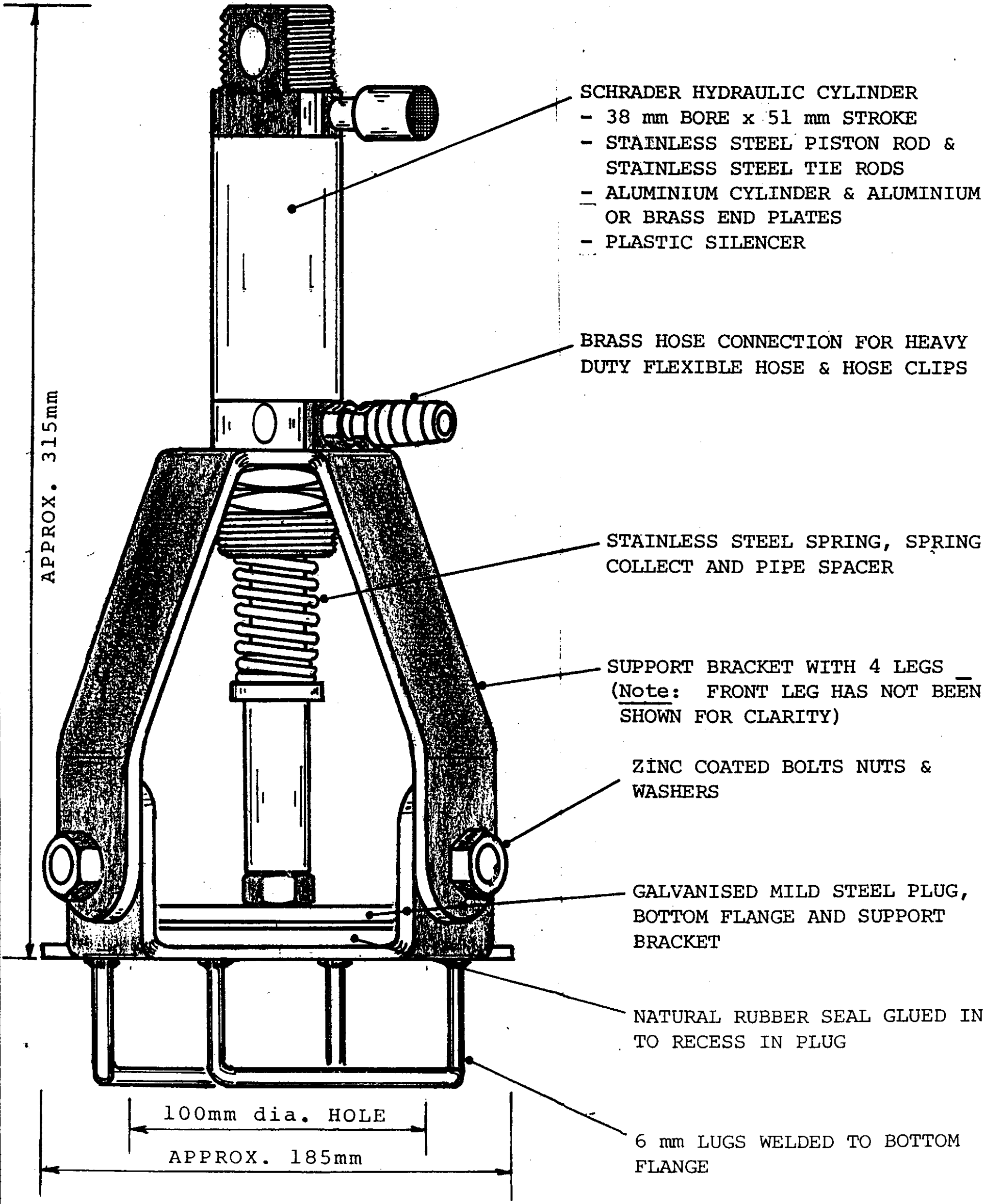
1. Minimum acceptable size is 1 cu metre working capacity. For Humes type 1050 diameter this corresponds to 1155 cm of depth below the invert level of the sewer outflow pipe. Size interceptor relative to the amount of solids expected in relation to desired frequency of cleaning by authorised Liquid Wastes contractor.
   The Trade Wastes Officer reserves the right to require a high liquid level alarm if considered necessary. This alarm may also be required to render the wash inoperative.
2. For water supply see sheet 5. Adequate support is to be provided for the pipe connection to ensure there is no relative movement between the pipe and valve/interceptor.
3. Grating to be easily removable for cleaning purposes and be resistant to corrosion.
4. Top of interceptor to be above surrounding finished ground level.
5. Gully trap may be remote from interceptor.
6. Piping system from here on to be to the requirements of BIA G13. If invert levels are such that compliance with BIA G13 cannot be achieved then install a pumped system to BIA 614 Para 2.4.3 figure 2 (b).

NOTES: Sheet 122/4

1. Cover grating to have maximum hole size 20min to prevent entry of stones etc. to drainage system. Grating to be easily removable for cleaning purposes and be resistant to corrosion.
2. Top of interceptor to be above surrounding finished ground level. This interceptor is for the BUS/TRUCK WASH facility only.
3. Gully trap not required. Piping system from here on to be to requirements of BIA EI except that disposal to a soak pit is not acceptable unless specifically approved.

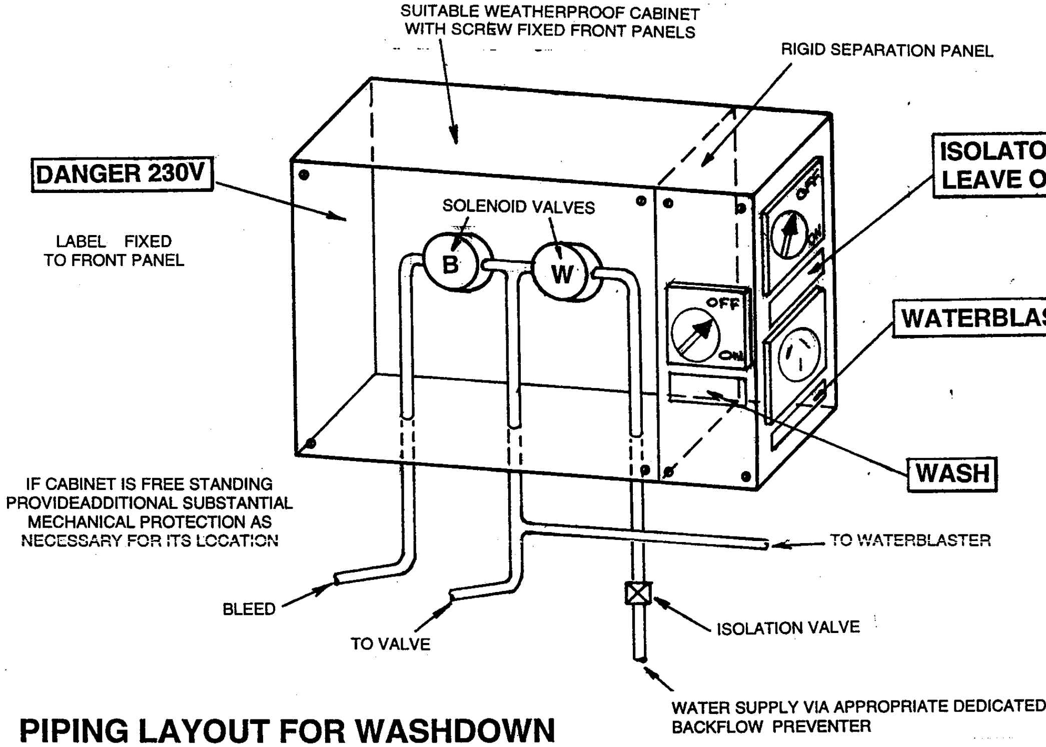
NOTES: Sheet 122/5

1. The Wilkinson hydraulic valve requires 500 Kpa to operate satisfactorily. The use of any other valve will only be at the discretion of the Trade Wastes Officer.
2. A wash hose of minimum length 15m is to be connected at all times to ensure satisfactory operation of the hydraulic valve.
3. To be mounted in a position readily accessible to the wash operator. The Trade Wastes Officer will supply a label 'MAIN VALVE' at the time of inspection. Valve and associated pipework to be protected from mechanical damage.
4. Install in a position readily accessible and free from likelihood of mechanical damage.
5. The vent should drain to the wash slab sump or sewer petrol oil interceptor.

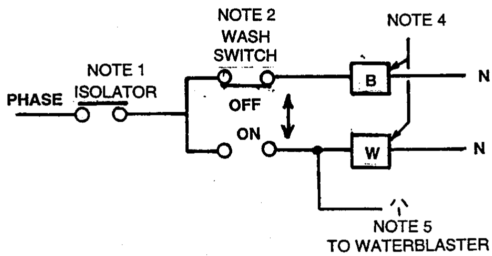


VALVE & MOUNTING BRACKET

DRAWN BY KEN SIBLY UTILITY MAPPING	HYDRAULICALLY OPERATED LIQUID SEPARATION SYSTEM	8000
DATE | |	CHRISTCHURCH CITY COUNCIL — WASTE MANAGEMENT UNIT	SHEET 113B



PIPING LAYOUT FOR WASHDOWN HOSE USING ELECTRICALLY OPERATED EQUIPMENT
(NOT STEAM CLEANERS)



ELECTRICAL

NOTES:

1 ISOLATOR TO BE LABELLED **ISOLATOR LEAVE ON**

2 WASH SWITCH TO BE LABELLED **WASH**
(SHOWN IN THE "OFF" POSITION)

3 THE INBUILT ON/OFF SWITCH ON THE WATERBLASTER IS TO BE PERMANENTLY LABELLED **"LEAVE THIS SWITCH ON"** OR BYPASSED AND REMOVED

4 "B" AND "W" 230V COIL SOLENOID VALVES ENERGISE TO OPEN

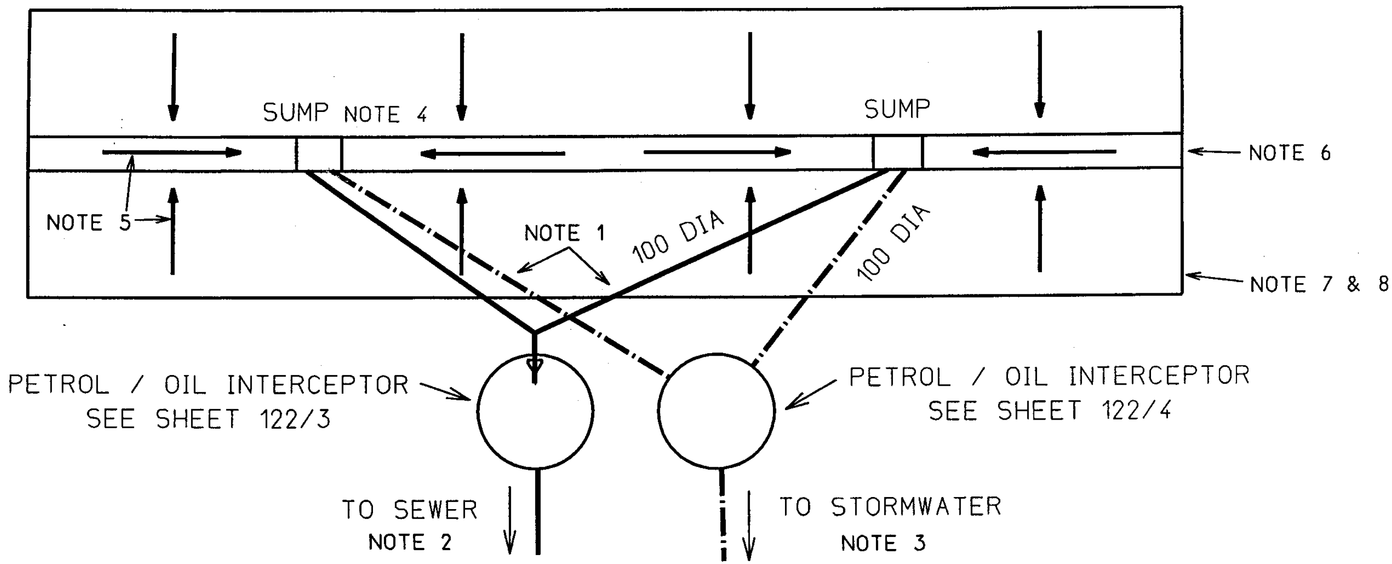
5 LABEL SUPPLY **WATERBLASTER**

6 USE SUITABLE HOSEPROOF/WEATHERPROOF SWITCHES AND SOCKET OUTLETS

7 SEE OTHER SHEETS FOR DETAIL OF SEPARATION VALVE WASHDOWN SUMP

DRAWN BY KEN SIBLY UTILITY MAPPING 12/2/1996	**HYDRAULICALLY OPERATED LIQUID SEPARATION SYSTEM**	8000
	CHRISTCHURCH CITY COUNCIL -- WASTE MANAGEMENT UNIT	SHEET 113D

SLAB SIZE 20M X 5M APPROX OR TO SUIT



WASH SLAB AND POSITIONING OF INTERCEPTORS NOTE 9

NOTES:
SEE REVERSE OF THIS SHEET FOR ASSOCIATED NOTES

BUS / TRUCK WASH FACILITY DESIGN REQUIREMENTS	8000
	SHEET 122/1
DESIGNED C.C.C. TRADE WASTE	

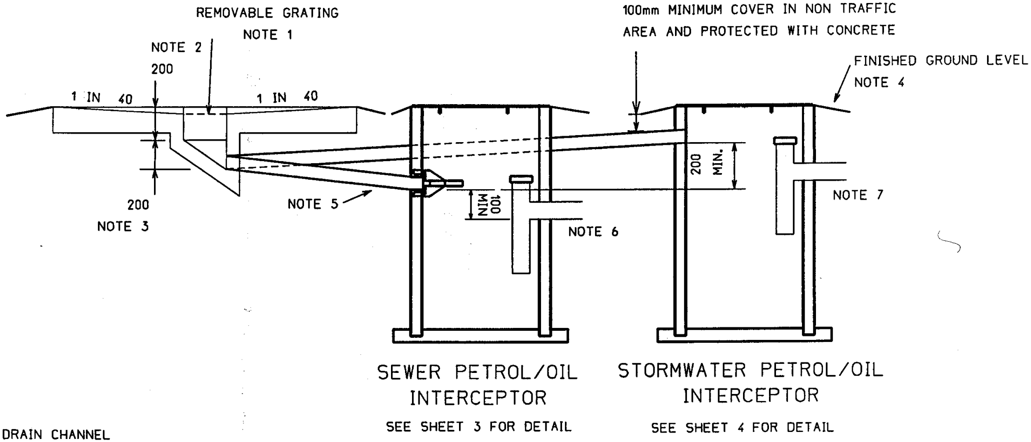
PRODUCED BY UTILITY MAPPING
WASTE MANAGEMENT
JUNE 1998

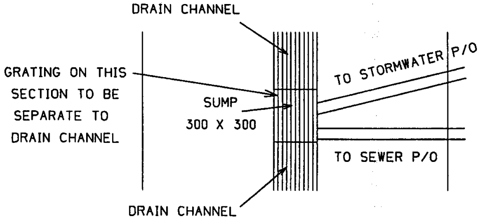
NOT TO SCALE

PETROL/OILINT.DGN

SECTIONAL VIEW

(ONLY ONE SUMP SHOWN FOR CLARITY)





SUMP DETAIL
(PLAN VIEW)

NOTE:
SEE REVERSE SIDE OF THIS SHEET
FOR ASSOCIATED NOTES.

BUS / TRUCK WASH FACILITY DESIGN REQUIREMENTS	8000
	SHEET 122/2
DESIGNED C.C.C. TRADE WASTE	

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PETROL/OIL INT.DGN

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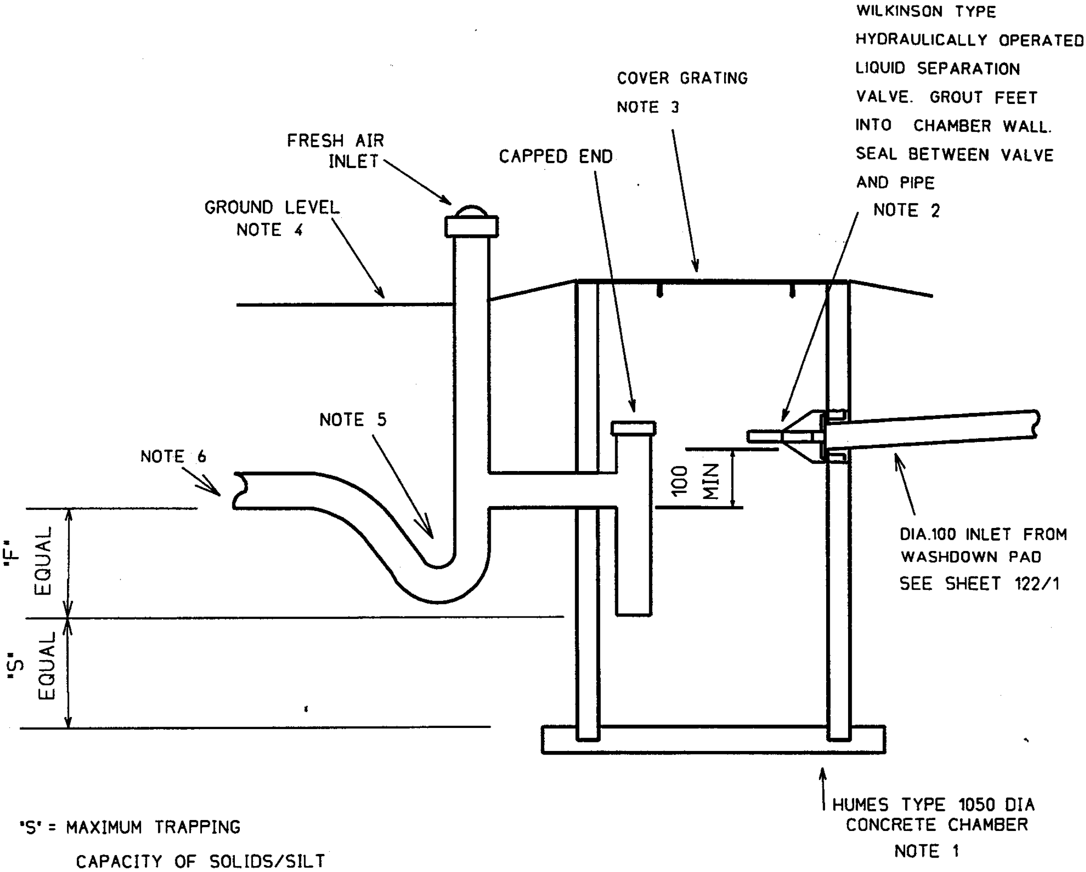

"S" = MAXIMUM TRAPPING CAPACITY OF SOLIDS/SILT

"F" = MAXIMUM TRAPPING CAPACITY OF FLOATABLES. E.G. PETROL/OIL ETC.

NOTES:
SEE REVERSE OF THIS SHEET FOR ASSOCIATED NOTES

SEWER
PETROL & OIL INTERCEPTOR
INCORPORATING WILKINSON VALVE

BUS / TRUCK WASH FACILITY DESIGN REQUIREMENTS	8000
	SHEET 122/3
DESIGNED C.C.C. TRADE WASTE	

NOT TO SCALE

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WASTE MANAGEMENT
APRIL 1998

PETROL/OILINT.DGN

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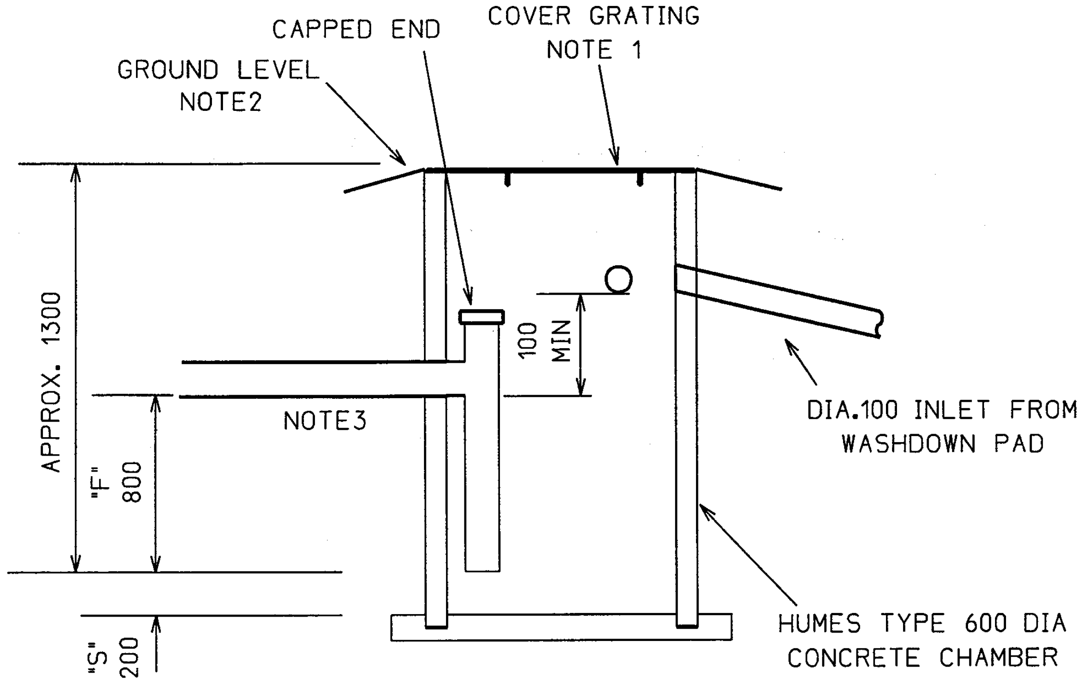

"S" = MAXIMUM TRAPPING CAPACITY OF SOLIDS/SILT

"F" = MAXIMUM TRAPPING CAPACITY OF FLOATABLES. E.G. PETROL/OIL ETC.

NOTES:
SEE REVERSE OF THIS SHEET FOR ASSOCIATED NOTES

STORMWATER
PETROL & OIL INTERCEPTOR

NOT TO SCALE

PRODUCED BY UTILITY MAPPING
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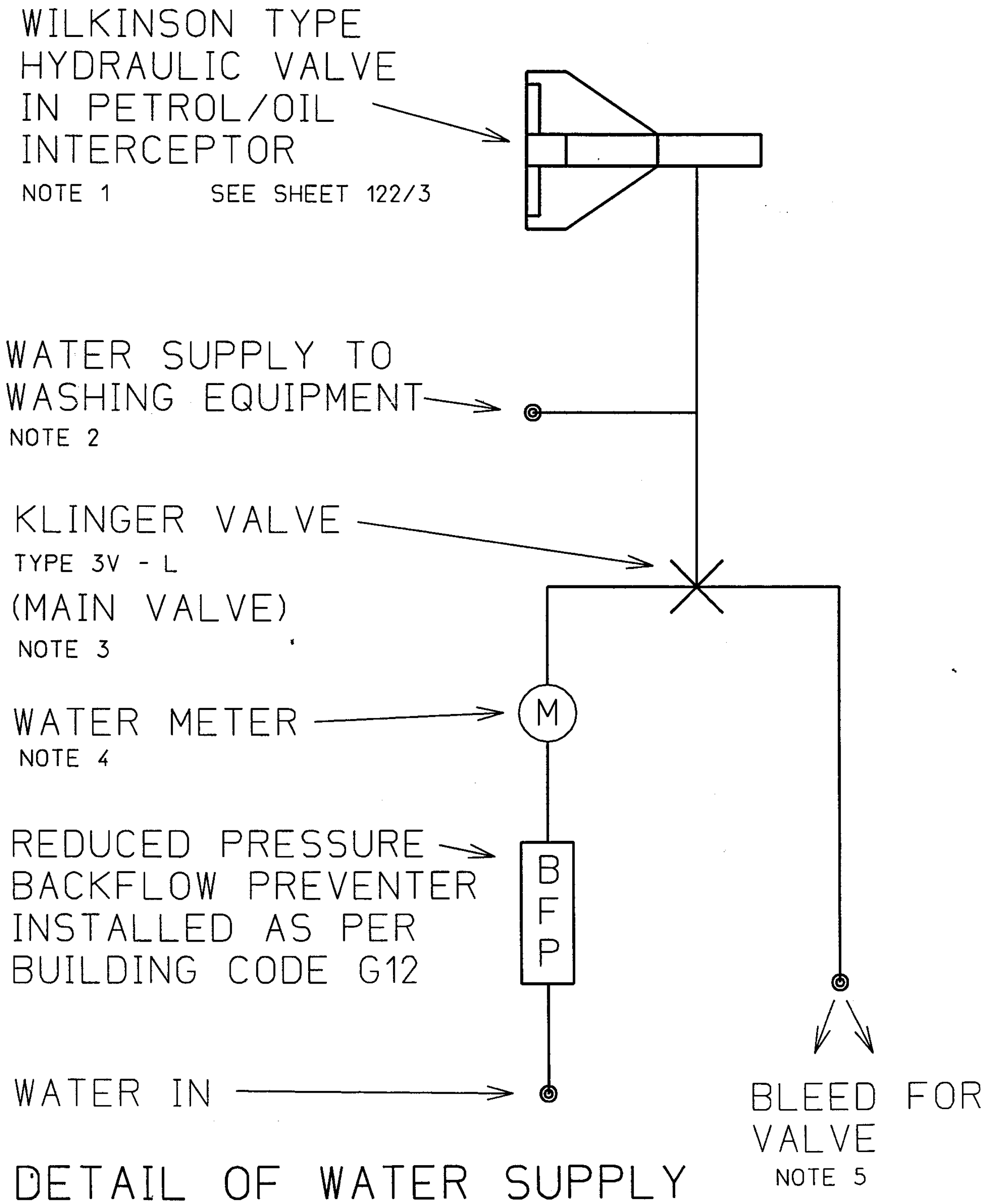
BUS / TRUCK WASH FACILITY DESIGN REQUIREMENTS	8000
	SHEET 122/4
DESIGNED C.C.C. TRADE WASTE	

PETROL/OILINT DGN



DETAIL OF WATER SUPPLY

NOTES:
SEE REVERSE OF THIS SHEET FOR ASSOCIATED NOTES

NOT TO SCALE

PRODUCED BY UTILITY MAPPING
WASTE MANAGEMENT
APRIL 1998

BUS / TRUCK WASH FACILITY DESIGN REQUIREMENTS	8000
	SHEET 122/5
DESIGNED C.C.C. TRADE WASTE	

PETROL/OILINT DGN

m:/graphics/kenctw.dgn Jun. 16, 1998 09:43:14

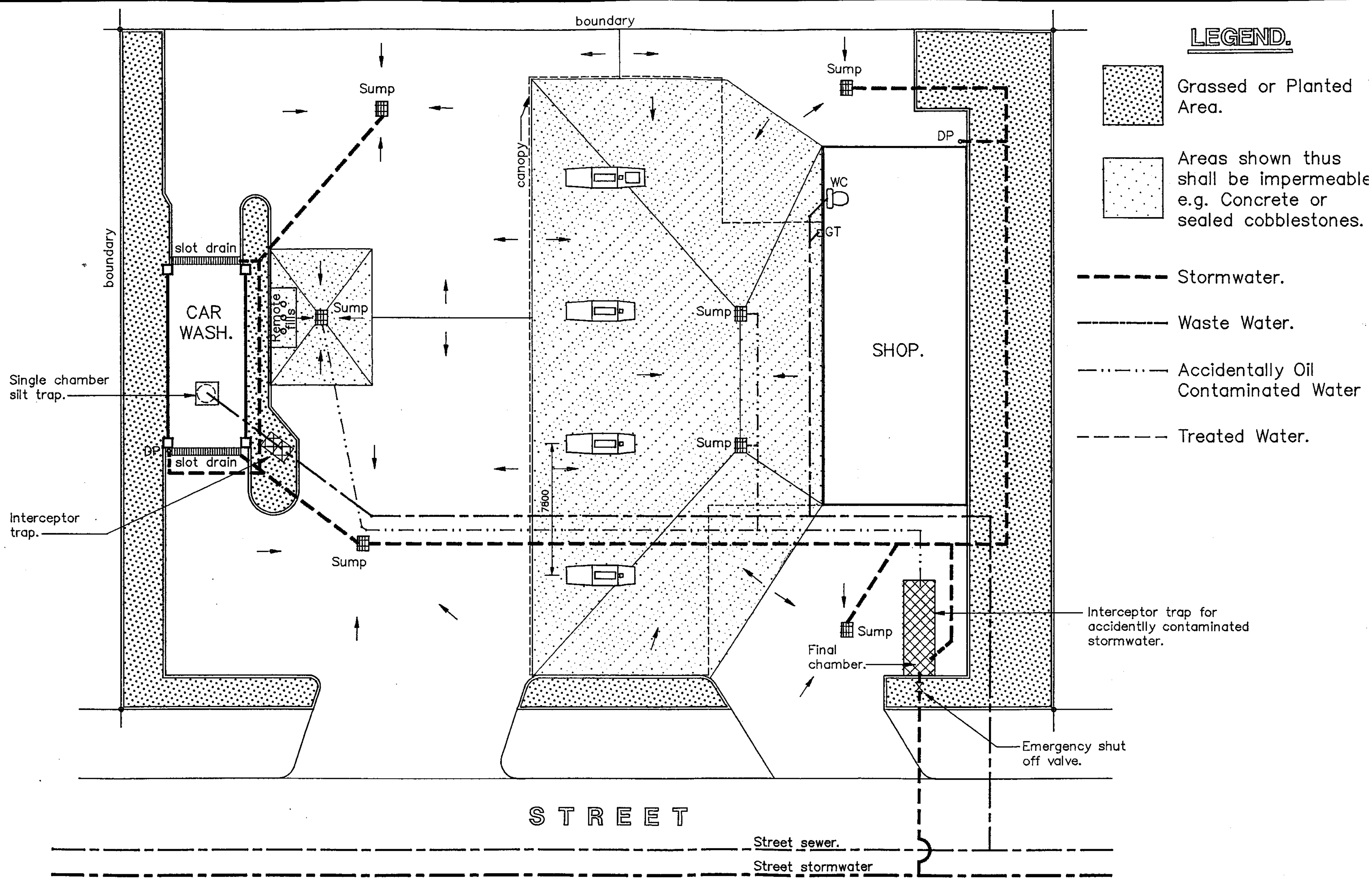
APPENDIX 8

SITE LAYOUTS

APPENDIX 8 SITE LAYOUTS

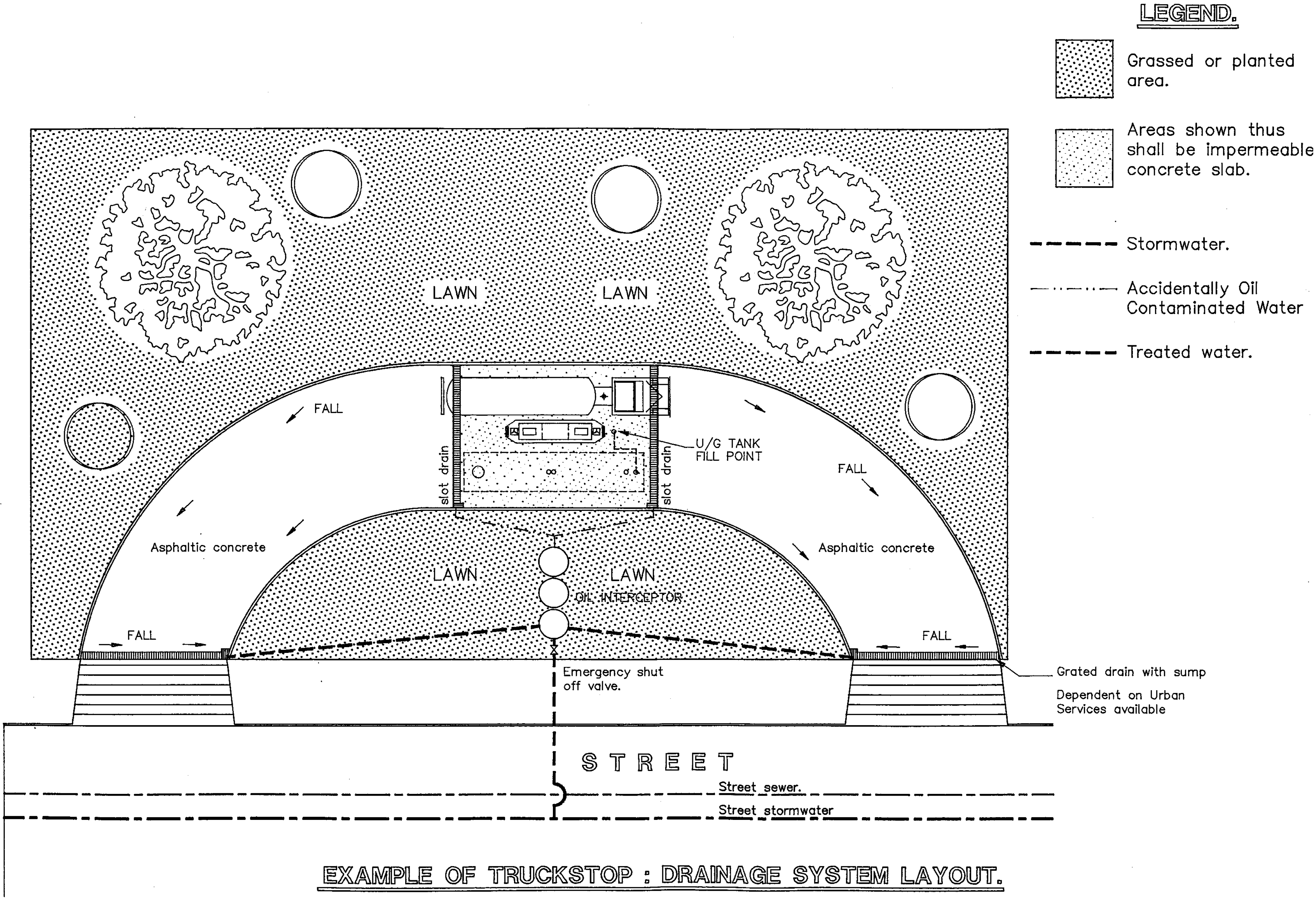
This appendix gives idealised site layouts for a service station, truck stop, storage depot, and manufacturing site. These illustrate how sites may be configured but the drawings do not necessarily reflect the preferred solutions.

Scale 1:200



EXAMPLE OF RETAIL SITE : DRAINAGE SYSTEM LAYOUT.

Scale 1=200

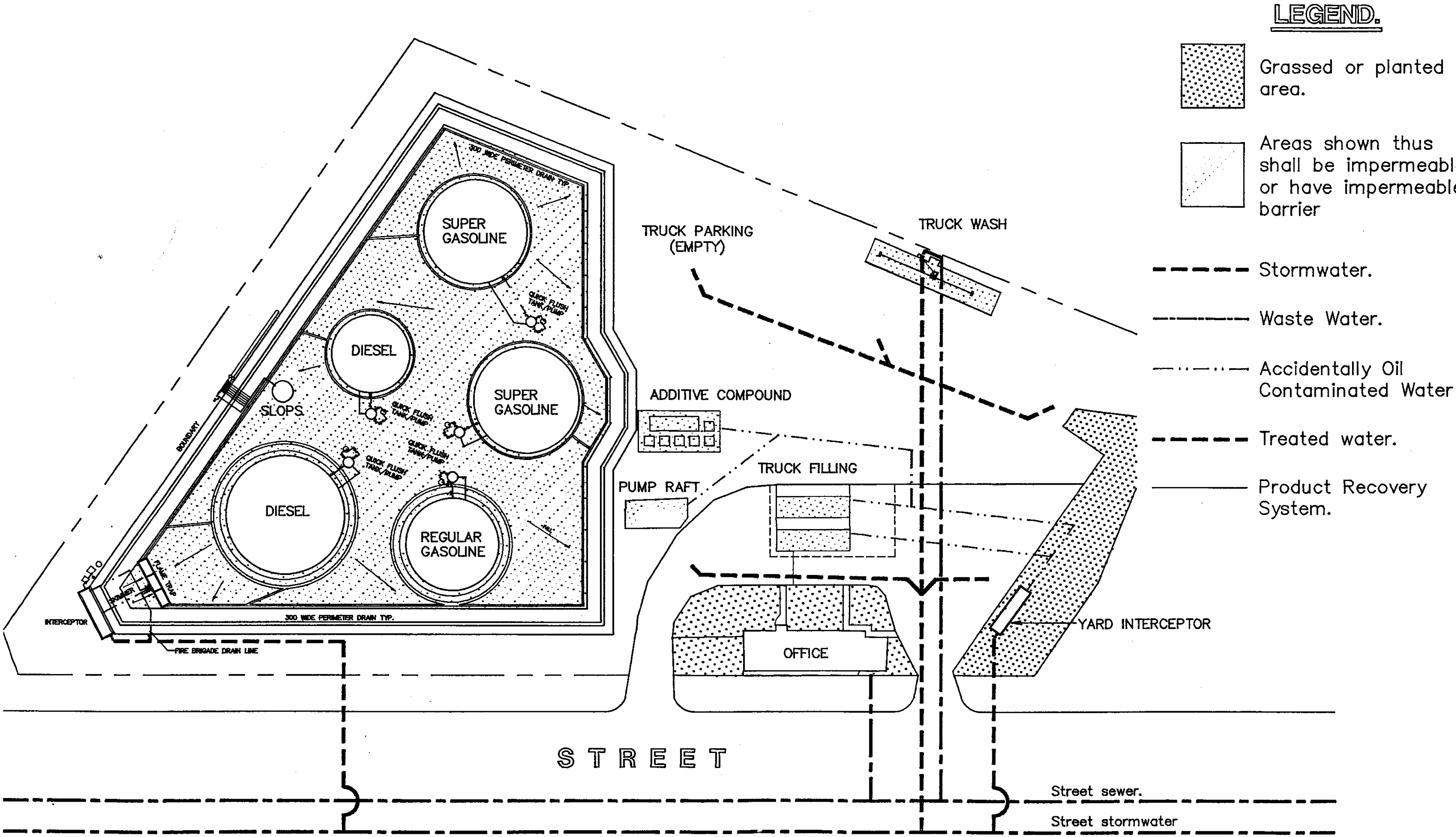


EXAMPLE OF TRUCKSTOP : DRAINAGE SYSTEM LAYOUT.

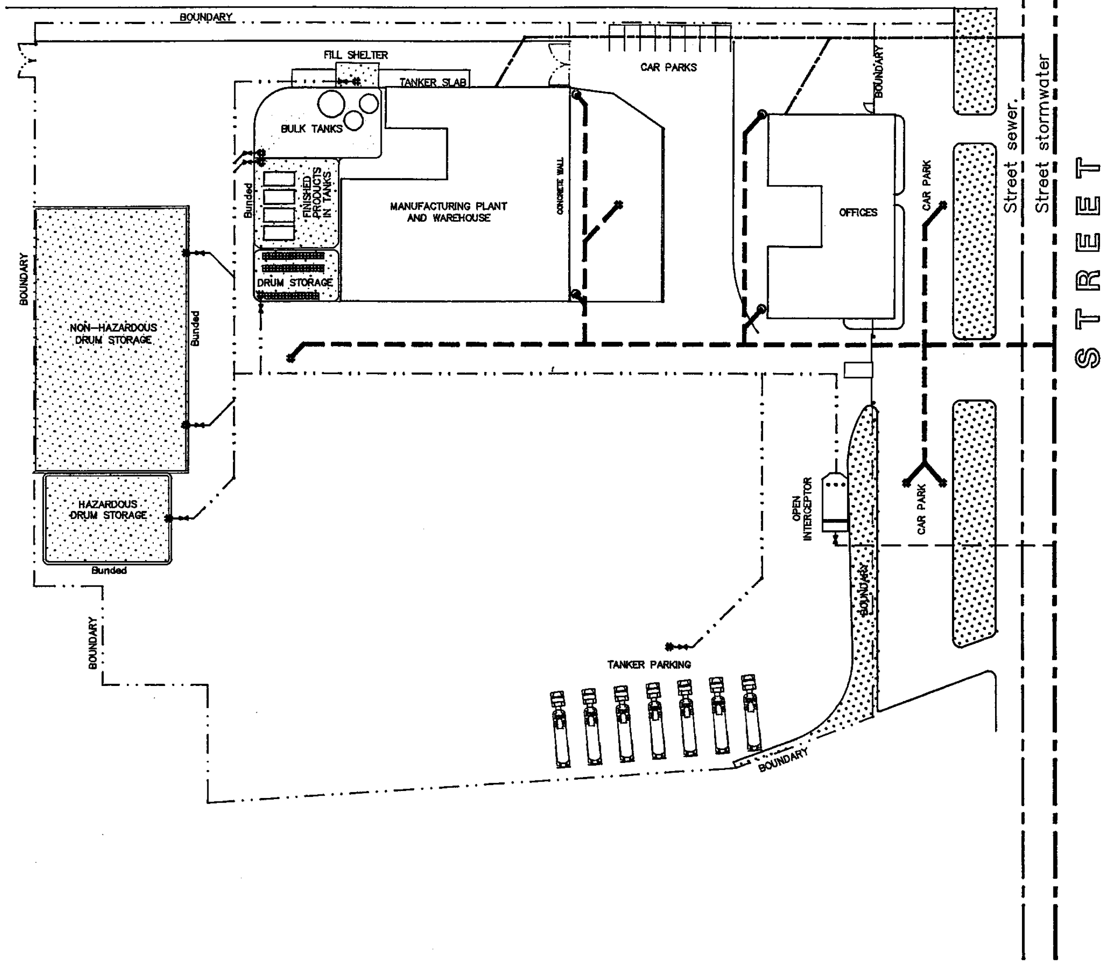
Scale 1=200

issue date 22/8/96

SK 2640/2



EXAMPLE OF BULK STORAGE SITE : DRAINAGE SYSTEM LAYOUT.



Grassed or Planted Area.

Areas shown thus shall be impermeable or have impermeable barrier beneath concrete slab.

Stormwater.

Accidentally Oil Contaminated Water

Treated Water.

Waste Water.

EXAMPLE OF MANUFACTURING SITE : DRAINAGE SYSTEM LAYOUT.