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AGC Woodward-Clyde Pty Limited
A.C.N. 000-691-690

PIONEER-BFI WASTE SERVICES

2535/1

MARCH 1993

SOUTHERN LANDFILL

SOUTH CARDUP

PUBLIC ENVIRONMENTAL REVIEW

AGC Woodward-Clyde Pty Limited
A.C.N. 000-691-690

PUBLIC ENVIRONMENTAL REVIEW
SOUTHERN LANDFILL AT SOUTH CARDUP

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

The Public Environmental Review (PER) for the proposed Southern Landfill was prepared by Pioneer-BFI Waste Services in accordance with Western Australian Government procedures. The report will be available for comment for eight (8) weeks, beginning on Monday, 15 March 1993 and finishing on Monday, 10 May 1993.

Comments from Government agencies and from the public will assist the EPA in preparing its Assessment Report in which it will make recommendations to Government.

Following receipt of submissions from Government agencies and the public, the EPA will discuss the comments made with Pioneer-BFI Waste Services and may ask for further information. The EPA will then prepare its Assessment Report which will contain recommendations to Government, taking into account issues raised in the public submissions.

Why Write a Submission

A submission is a way to provide information, express your opinion and put forward your suggested course of action including any alternative approach. It is helpful if you indicate any suggestions you have to improve the proposal.

Developing a Submission

You may agree or disagree, or comment on, the general issues discussed in the PER or with specific proposals. It helps if you give reasons for your conclusions, supported by relevant data.

You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific proposals in the PER:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to Keep in Mind

By keeping the following points in mind, you will make it easier for your submission to be analysed.

Attempt to list points so that the issues raised are clear. A summary of your submission is helpful. Refer each point to the appropriate section, chapter or recommendation in the PER. If you discuss sections of the PER keep them distinct and separate, so there is no confusion as to which section you are considering.

Attach any factual information you wish to provide and give details of the source. Make sure your information is correct.

Please indicate whether your submission can be quoted, in part or in full, by the EPA in its Assessment Report.

REMEMBER TO INCLUDE YOUR NAME, ADDRESS AND DATE.

THE CLOSING DATE FOR SUBMISSIONS IS: Monday, 10 May 1993.

SUBMISSIONS SHOULD BE ADDRESSED TO:

The Chairman
Environmental Protection Authority
Westralia Square
38 Mounts Bay Road
PERTH WA 6000

Attention: Mr Ron Van Delft

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EXECUTIVE SUMMARY

1 Background

Pioneer-BFI Waste Services recognizes the need for long-term solid waste disposal facilities in Perth for commercial and special industrial solid wastes, and proposes to establish a sanitary landfill in South Cardup, hereafter known as the Southern Landfill. The landfill will be used as a secure containment facility for disposal of putrescible, non-putrescible, inert and low level commercial and industrial wastes. Hazardous, soluble, chemical and liquid wastes will be specifically excluded from the landfill. The proposal for development of the Southern Landfill is in response to the mid to long-term shortage of secure disposal facilities for putrescible, non-putrescible and low level industrial wastes in the southern and south-eastern Perth metropolitan region.

The proposal to establish the Southern Landfill is being formally assessed by the Environmental Protection Authority (EPA) at Public Environmental Review (PER) level. The PER also serves to provide information to satisfy the Health Department's requirements for a proposal and management plan for the establishment and operations of a waste disposal facility.

The site for the Southern Landfill has been identified by the Proponent through a site selection process based on topographical, environmental and land use criteria, as well as operational requirements. The features of the chosen site include reasonable haul distances from waste sources, existence of quarries suited to rehabilitation by landfilling, and the suitability of landforms, hydrology and geology in the locality to ensure the integrity of the landfill.

A programme of consultation with the public and with Government agencies has been implemented by Pioneer-BFI Waste Services as part of the process of preparing environmental and planning documentation for the proposed Southern Landfill. This programme has included:

- Consultation with interested/concerned parties during the formative stage of the proposal, to identify issues or concerns thereby enabling their consideration during preparation of the proposal.

- A public open day at the proposed project site to provide local residents and other interested persons with an opportunity to obtain information about the proposal and identify issues of interest or concern, to enable those issues to be addressed during preparation of the proposal.

A number of concerns were raised during the public consultation process. Most centred on possible groundwater contamination by leachate, odour, noise, dust, litter and vermin. However, other issues were also raised, including: hours of

operations and their effect on adjacent land users; mistrust of regulatory authorities' willingness or ability to police the landfill operations; management of methane generation and utilization; financial costs to the local community imposed through rates; impact on surface water quality; impacts on flora and fauna within the site; compliance with undertakings given by the Proponent; and monitoring of the impact of the landfill on private bores.

Where practicable, these concerns have been addressed through the specific site planning and development strategies, and the proposed operational and post-closure management and monitoring programmes.

2 Waste Management Strategy

An integral part of the Health Department of Western Australia's current waste management strategy is the concept of regionalization, whereby a number of local authorities combine to form a regional body to develop and operate fewer, larger sanitary landfill sites. Although the principle behind the concept of regionalization is to rationalize the number of landfills operated on a municipal level, most municipalities currently operating landfills are reluctant to accept low level commercial and industrial wastes.

This has created an increasing demand for a site at which to dispose of such wastes, with the demand emanating from a range of sources within a number of metropolitan waste management zones. The proposal to develop the Southern Landfill is primarily aimed at meeting this demand, although the site will also serve as a disposal site for municipal wastes as required.

The specific objectives of Pioneer-BFI Waste Services' waste management strategy are:

- to select a waste disposal site that is conveniently accessible to the community and will facilitate management of potential adverse environmental impacts associated with waste disposal operations;
- to design a landfill facility which incorporates measures to limit potential environmental impacts, and sufficient operational flexibility to enable effective response to any problems which may arise; and
- to adopt and implement management practices that will ensure effective control over all aspects of the landfill operation.

The landfill will be operated and managed in strict accordance with accepted modern sanitary landfill practices, and in compliance with the Health Department's guidelines and Pioneer-BFI Waste Services' own environmental and landfill policies.

3 Alternative Waste Management Options

A range of technologies are now available for each waste stream component to implement an integrated waste management system. Disposal options include mechanical separation for re-processing, composting, incineration, waste derived fuels, and pyrolysis. Nevertheless, these technologies will still produce residues which are from 20-70% of the original waste stream volume, and for which landfill disposal is required. Consequently, landfill will remain a critical component of these systems.

4 Existing Environment

The proposed landfill site comprises the current Pioneer Concrete quarry operations (Lot 8), grazing land (Pt. Lot 3) and the clay shale pit (Pt. Lot 6). The quarry is bordered to the west by grazing land held by the Government for Mental Health Purposes. To the north-west and south-west is privately owned grazing land and to the east partially degraded forest (State Forest No. 22). The shale pit is bordered to the west by a motor cross track (Hendley Park Motorcross) which was previously a gravel extraction pit.

The proposed Southern Landfill site lies on the western edge of the Yilgarn Block, just east of the Darling Fault. The surface geology comprises a sequence of Quaternary aged sands, silts and clays, which is underlain by shales and sandstones in the western portion of the site, and by granitic bedrock to the east.

The easternmost portion of the site is underlain by a mesocratic rock of granite, granodiorite and adamellite composition which has been intruded by doleritic dykes. The existing Pioneer Concrete hard rock quarry lies in the Archaean rocks of the Western Gneiss Terrane, part of the Yilgarn Block. These rocks are mafic gneisses which have been intruded by multiple veins and dykes of granites.

Between the quarry and South Western Highway, Proterozoic shales and sandstones of the Cardup Group outcrop.

The Stage 1 landfill area is underlain by Archaean granites and dolerite dykes, with a narrow width (several metres) subcrop of steeply dipping sandstone (Neerigen Formation). The granitic and doleritic rocks have insignificant primary porosity and permeability and contain groundwater only where fractured. The Neerigen Formation has low primary porosity and permeability and only hosts significant groundwater where fractured. The fault which transects the Stage 1 area may provide local conduits for groundwater where fracturing has developed and remained open.

The Stage 2 landfill area is underlain by the steeply dipping Armadale Shale. The shale is weathered and is of low permeability. The near vertical orientation of the bedding planes will further reduce or prevent horizontal movement of groundwater through this unit. The effect of the fault which partially offsets this

formation north of the landfill is not known. However, the Darling Fault, located approximately 500 metres to the west, is a barrier to deep groundwater movement westwards into the Perth Basin.

Native vegetation in the proposed Stage 1 area has been cleared for pasture establishment. Scattered mature remnant *Eucalyptus calophylla* (Redgum) and *E. rudis* (Flooded Gum) trees have been retained for shade and shelter. Pasture consists predominantly of annual legumes and grasses, with some scattered wild cotton (*Gossypium sp.*), a declared noxious weed species, also present. Vegetation of this area has little conservation value due to extensive clearing and grazing.

Much of the area proposed for Stage 2 of the landfill has been cleared for shale extraction, and the surrounding areas severely degraded by quarrying activities. Scattered remnant *Eucalyptus marginata* (Jarrah) and *E. calophylla* exist on the margins of the site, with associated shrub species. Owing to the level of disturbance of the area, the conservation status of the shale pit area and surrounds is very low.

The vegetation of the existing hard rock quarry works area consists mainly of pasture grasses between scattered eucalypts, for all but the high eastern area. The eucalypts are dominantly *Eucalyptus marginata* and *E. calophylla* with scattered patches of *E. wandoo, E. rudis* and *E. patens*, with the latter two in moister sites.

5 Description of Proposal

It is proposed that the facility will be developed in three stages within the project site, as follows:

Stage 1	-	Valley fill encompassing the existing Pioneer Concrete quarry stockpile area and adjacent farmland, with an expected operational lifetime of 8-10 years;
Stage 2	-	Infill of the existing Bristile shale pit, over an expected operational period of 5-6 years; and
Stage 3	-	Infill of the Pioneer Concrete hard rock quarry over a period in excess of 15 years.

Currently, engineering design details have only been prepared for the first two stages of the facility.

Key engineering measures of site development will include the:

- Provision of stormwater diversion drains to divert runoff generated in areas outside of the active landfill cell to minimize leachate generation.

- Construction of a low permeability lining system on the base and walls of all waste disposal areas to ensure the safe containment of leachate.

- Installation of leachate collection and storage facilities to minimize leachate accumulation above the lining system.

- Construction of a composite low permeability landfill cap.

- Provision of a landfill gas control system to minimize odour generation, prevent off-site migration of gases and to protect vegetation planted on the rehabilitated landfill surface.

6 Environmental Impacts and Management

While the potential for adverse biophysical impacts associated with establishment and operation of the proposed landfill is low, a number of relevant environmental issues have been identified and addressed.

- Water Resources
  Contamination of groundwater and surface water resources can potentially occur if appropriate drainage, collection and treatment measures for landfill leachate and runoff are not implemented. Management initiatives to be implemented include sealing of cells with liners, capping of completed cells, installation of leachate collection systems, and diversion of clean surface runoff away from active landfill areas.

- Odours
  Decomposition of refuse during landfilling produces a characteristic odour. Malodours from a landfill are most likely to occur under conditions of aerobic decomposition, and result from esters, ammonia, mercaptans (thiols) and hydrogen sulphide generated during the decomposition of organic materials. Proposed management measures to reduce potential odour impacts include adequate regular compaction and covering of deposited waste, exclusion of free standing water from active landfill cells, and implementation of an off-site buffer to achieve 500 m separation between the active landfill sites and adjacent residences and amenities.

- Litter
  The loss of rubbish from vehicles accessing a landfill site, leading to an accumulation of litter along the site access routes, often extends the impact of the landfill into the surrounding environment. Wind distribution of this litter can exacerbate this impact. Wind-blown debris from the actual landfill site can also cause littering of adjoining areas. Wind blown litter fouling

boundary security fencing can also produce an undesirable visual impact in the vicinity of a landfill site. To minimize such impacts a programme of regular litter collection from the perimeter fencing and access routes within a 2 km radius of the site will be implemented.

- Noise
  Noise is another factor which could spread the effect of the proposed landfill. There is the potential for noise impacts to occur as a result of increased vehicle movements (particularly heavy truck traffic) on access routes and from machinery operating within the landfill site. To minimize such potential impacts, the hours of operation of the site will be restricted. Vehicles operating on-site will be fitted with exhaust system silencers. On-site vegetation screening will also act as a noise buffer.

- Dust
  As a result of the prior and ongoing extractive operations and agricultural activities, virtually all of the site will have been disturbed in advance of landfilling. Although restabilization of disturbed areas will be required, the potential for dust generation will remain. Dust management initiatives will include sealing of all on-site trafficked areas, dust suppression through watering, peripheral landscaping to provide windbreaks, and progressive stabilisation and revegetation of disturbed surfaces.

- Pest Species
  Due to the availability of food and suitable host conditions, both vermin and nuisance species can be attracted to a landfill. These include flies, mice, rats and feral domestic animals, particularly cats. If allowed to proliferate, these species could move off-site, to the detriment of the surrounding human and biophysical environments. Suitable host conditions will be eliminated through adequate, regular covering and compaction of refuse.

- Landfill Gas
  Landfill gas consists predominantly of methane and carbon dioxide, along with minor proportions of other gaseous hydrocarbons. The need to address Greenhouse emissions from the proposed landfill, (particularly methane) is, therefore, important. To this end, completed cells will be capped and a gas collection system will be installed and operated.

- Fire
  Due to the availability of on-site fuel (including methane, which is continuously being generated), the risk of a fire occurring at a landfill is always present. Air-borne embers from fires within the landfill site can increase fire hazard in surrounding areas,

particularly those containing bushland or grassland vegetation. Smoke (and odour) produced by fires can also pose a nuisance to nearby residences. Fire prevention measures will include maintenance of fire breaks around the site perimeter, on-site provision of a water truck for fire fighting, regular covering and compaction of waste and landfill gas management.

- Social Impacts
  A range of potential social impacts can arise in association with biophysical impacts resulting from the landfill operations. These impacts will be minimized through implementation of the site development, operation and post-closure management practices which apply to the other potential impacts described above, together with the implementation of the off-site buffer for the duration of the active landfill lifetime.

7 Environmental Management and Monitoring

The management programmes incorporated in the Southern Landfill proposal address all potential environmental impacts normally associated with solid waste disposal sites. In so doing, Pioneer-BFI Waste Services has also responded to issues raised by the community during consultation undertaken as part of the project.

The Proponent recognizes that the public and the regulatory authorities have concerns about private industry operation of regional facilities. To this end, the Proponent is committed to a policy of financial assurances, in favour of the Shire of Serpentine-Jarrahdale, to cover emergency contingencies and long term risks in a form and to an amount acceptable to the Environmental Protection Authority, Health Department of Western Australia and the Shire of Serpentine-Jarrahdale.

Pioneer-BFI Waste Services also recognizes the importance of ongoing community involvement with the project. Although adverse off-site environmental impacts as a result of the landfill are not expected, maintenance of a complaints register and submission of periodic performance reports will provide an opportunity for any grievances within the community arising from the landfill (and Pioneer-BFI Waste Services' response thereto) to be independently scrutinized. Through this mechanism, the community will be able to influence operational practices in areas of legitimate concern.

Finally, Pioneer-BFI Waste Services specifically acknowledges that its environmental management and monitoring responsibilities extend beyond the operational life of the proposed landfill. Ensuring that the site is available for redevelopment within the shortest possible time frame will, however, be in Pioneer-BFI Waste Services' (and the community's) best interests. This objective will only be achieved if Pioneer-BFI Waste Services discharges its ongoing responsibilities effectively following cessation of the landfill operation.

8 Timing

Pioneer-BFI Waste Services recognizes that the environmental impact assessment process is lengthy, and that environmental approvals for the proposed landfill, if granted, are unlikely to be finalized before the third quarter of 1993.

Assuming environmental clearance and other necessary approvals (which cannot be finalized prior to the granting of environmental approvals) are forthcoming within this time frame, construction of the landfill facility could commence in the last quarter of 1993, with commissioning expected to occur in mid 1994.

9 Commitments

The Proponent has provided a comprehensive range of commitments relating to:

- compliance with the proposal as described in the PER;
- construction, operation and management of the facility to the satisfaction of the relevant State Government agencies;
- maintenance and enhancement of refuse recycling programmes;
- design details of the proposed landfill;
- development and operational features of the proposed landfill;
- management of anticipated environmental impacts;
- environmental monitoring programmes;
- performance reporting;
- contingency planning; and
- post-closure management.

If the proposed landfill receives environmental approval, the Proponent's commitments will become statutorily enforceable requirements under the provisions of the Minister for the Environment's statement pursuant to Section 45 of the *Environmental Protection Act, 1986*.

10 Conclusion

All of the environmental issues and potential impacts associated with the proposed Southern Landfill will be addressed through design principles, and ongoing operational practices and specific management measures. The Proponent is committed to implementing responsible operational and management practices that will minimize the occurrence of adverse effects often associated with waste disposal facilities. Nevertheless, the proposed landfill will produce some environmental change that may be perceived as an undesirable impact upon the human environment.

The South Cardup locality is a rural setting, but has been subject to changed character and amenity through previous and ongoing commercial quarrying and extraction operations. Potential social impacts associated with the proposed landfill have been considered in this context. While the proposed landfill may

be seen as likely to produce adverse social impacts, the potential for such impacts is not great and will be further reduced by the management programmes proposed. Additionally, the complaints register to be maintained by Pioneer-BFI Waste Services, and the submission of periodic performance reports will ensure external scrutiny of any perceived social impacts and the Proponent's response thereto. The periodic performance reports will also be made available to the local community for scrutiny.

The potential for on-site biophysical environmental impacts associated with the proposed landfill is very low because much of the site has already been comprehensively modified through the extractive industry operations, or disturbed by the grazing activities. The potential for off-site biophysical impacts will also be low because of the management programmes intended.

On commencement of landfilling, Pioneer-BFI Waste Services will initiate a thorough monitoring programme, committed to in the PER. Monitoring results will be incorporated in reports documenting operational and management experience and records, unforeseen occurrences, proposed changes to the management programmes, and the complaints record. These reports will be produced and submitted to regulatory authorities on an annual basis.

During the preparation of the PER, Pioneer-BFI Waste Services has consulted widely with the local community and government agencies and has endeavoured to respond to concerns raised. Commitments to facilitate ongoing community involvement with the landfill operation, should it proceed, have also been provided.

While recognizing that the proposed landfill will produce some change within the local human and biophysical environment, Pioneer-BFI Waste Services believes such change has been demonstrated to be manageable and unlikely to produce any unacceptably adverse impacts. Pioneer-BFI Waste Services therefore considers that the proposed Southern Landfill should be regarded as environmentally acceptable, subject to the commitments provided.

1 INTRODUCTION

1.1 The Proposal

Browning-Ferris Industries (Australia) Pty Ltd (BFI) and Pioneer Australia Waste Management Pty Ltd (PAWM) propose to jointly establish a sanitary landfill in South Cardup, Western Australia (Figure 1), hereafter known as the Southern Landfill. The landfill will be used as a secure containment facility for disposal of putrescible, non-putrescible, inert and low level commercial and industrial wastes, employing strictly controlled sanitary landfill practices.

The landfill has not been designed for hazardous, soluble, chemical or liquid wastes and their exclusion constitutes a primary operational objective.

South Cardup has been identified as a potential location for a sanitary landfill in the area to the south-east of Perth from an extensive search for potential sites in the Perth area undertaken by BFI (Figure 2). The existing Pioneer Concrete (WA) Pty Ltd hardrock quarry site and adjacent Bristile Limited shale extraction pit have been identified as the preferred site for the three staged development of the landfill (Figure 3).

The stages for development of the landfill are as follows:

Stage 1 - Valley fill encompassing the existing Pioneer Concrete quarry stockpile area (portion of Lot 8) and farmland on Pt. Lot 3 which presently belongs to Mr P Nairn. The expected lifetime of Stage 1 is 8-10 years.

Stage 2 - Infill of the existing Bristile shale pit on Pt. Lot 6. The expected lifetime of Stage 2 is 5-6 years.

Stage 3 - Infill of the existing (and expanding) Pioneer Concrete hard rock quarry on Lot 8. This final stage has an expected lifetime exceeding 15 years.

1.2 Proponent

The proponent for the proposed Southern Landfill is Pioneer-BFI Waste Services, a general partnership between BFI and PAWM. Proponent details are:

Name: Pioneer-BFI Waste Services
Address: C/- 123 Whitehorse Road
DEEPDENE VIC 3103
Telephone: (03) 819 4220
Facsimile: (03) 817 5554

BFI is one of the world's largest publicly owned companies engaged primarily in providing waste services, and is a major operator in the Australian waste management industry. BFI's subsidiaries and affiliates collect, transport, treat and dispose of commercial, residential, municipal and industrial solid and liquid wastes. The company, which is based in Houston, USA, operates over 100 sanitary landfills world-wide.

PAWM is a recently formed subsidiary of Pioneer International Limited, a wholly Australian company operating throughout the world, and one of Australia's top twenty public companies. Pioneer operates numerous stone, sand and clay extraction sites throughout Australia, the majority of which will be rehabilitated by landfilling. PAWM has been formed to provide environmental management of closure and rehabilitation of extraction sites.

1.3 Statutory Requirements and Approval Procedures

Following an initial feasibility study to assess the suitability of the Southern Landfill site, BFI referred the proposal to the Environmental Protection Authority (EPA) to set a level of environmental impact assessment. The EPA subsequently set assessment of the project at Public Environmental Review (PER) level.

The statutory procedures under which the project will be undertaken are:

- environmental protection and management conditions contained in the Ministerial statement issued pursuant to Section 45 of the *Environmental Protection Act 1986*;
- gazettal of approval, pursuant to Section 119 of the *Health Act 1911-1984*, and any conditions associated with such approval established by the Commissioner of Health; and
- development approval (and attendant conditions) under the provisions of the *Metropolitan Region Town Planning Scheme Act 1959*.

The Health Department of Western Australia (Health Department) has a supervising role in respect of landfill sites in the State.

The primary responsibilities of the EPA include environmental impact assessment and the prevention, control and abatement of environmental pollution. The EPA has responsibility for ensuring that all wastes are disposed of in an environmentally acceptable manner. Pollution is defined by the *Environmental Protection Act 1986* as direct or indirect alteration of the environment to its detriment or degradation, or the detriment of any beneficial use (see also van Delft & Hansen 1990).

The Health Department's *Discussion Paper for a Metropolitan Waste Strategy* (Health Department of WA 1988) requires that applications for the establishment of waste disposal facilities must be supported by a proposal and management plan prepared in accordance with guidelines issued in the discussion paper. The Health Department and the EPA have worked together to produce *Guidelines for a Proposal and Management Plan for the Establishment and Operation of a Waste Disposal Facility* which enables the preparation of a single document to satisfy both agencies. This document then normally forms the basis upon which the Health Department and other State Government agencies consider the application submitted.

In the case of the proposal for the Southern Landfill, the EPA has decided that the environmental significance of the proposal is sufficient to warrant formal assessment pursuant to the provisions of Part IV of the *Environmental Protection Act*, at PER level. This PER addresses the requirements of both the EPA and the Health Department.

The EPA will assess the environmental impacts of the proposed development as outlined in the PER, and produce a report and recommendations on the proposal.

As other specific approvals required for the proposed landfill cannot be finalized until environmental clearances for the project have been obtained, the EPA's environmental impact assessment requirements effectively control the overall approval process for the landfill project. These other approvals (i.e. gazettal by the Health Department, and development approval under the Metropolitan Region Scheme) can progress in parallel with the environmental impact assessment process, but cannot be finalized until the Minister for the Environment has issued a statement pursuant to Section 45 of the *Environmental Protection Act* specifying the conditions under which the proposal can proceed.

The development of a sanitary landfill in South Cardup will require planning approval from the Shire of Serpentine-Jarrahdale, assessed under the following criteria:

- zoning/land use requirements;
- any other relevant provisions of the Town Planning Scheme;
- the maintenance of orderly and proper planning for the locality;
- the views and comments of the relevant government departments and agencies;
- the views and comments of the general public; and
- the individual merits of the proposal.

1.4 This Document

In accordance with the guidelines issued for the preparation of the PER (see Appendix A), this document provides descriptive information on:

- the proposal;
- prevailing environmental conditions;
- site suitability for waste disposal;
- anticipated environmental impacts;
- measures to protect groundwater from contamination by leachates and monitoring to ensure groundwater protection measures are effective;
- management of methane emissions caused by waste degradation in the landfill to reduce Greenhouse gas impacts;
- long-term responsibility for the site; and
- post-closure care.

On this basis, the broad outline of the PER document is as follows:

- Introduction
  - information about the Proponent, the proposed project, and the statutory requirements applying to the project.
- Overview of Solid Waste Management
  - a review of the historical and current waste management practices in the Perth metropolitan region, identification of alternatives, and discussion of the need for the proposed landfill.
- Rationale for this Proposal
  - objectives and scope of the proposal.
- Existing Environment
  - descriptive information regarding the prevailing regional and site-specific environment.
- Description of the Proposal
  - descriptive information about the project, including the site, planning context, development and operation of the landfill, and site rehabilitation.

- Environmental Impacts
  - identification of anticipated impacts and discussion of their significance and consequent management requirements.
- Environmental Management and Monitoring
  - discussion of specific management initiatives to ameliorate anticipated environmental impacts, and continuing monitoring requirements.
- Proposed Timetable
  - timing of the proposal.
- Commitments
  - consolidation of undertakings given by the Proponent.
- Conclusion
  - broad synthesis of the capacity of the receiving environment to assimilate the anticipated impacts of the proposal, including judgements about the overall acceptability of the proposal.
- References
- Glossary and Abbreviations
- Appendices

The appendices comprise the PER guidelines, supplementary details of technical studies undertaken for the landfill study and a site-specific management plan for the proposed Southern Landfill. The management plan consolidates information relating to operational practices to be implemented at the landfill.

2 SOLID WASTE MANAGEMENT

2.1 Definition of Solid Waste

Solid waste may be categorized as follows (Moore 1990):

- Domestic soft waste: household refuse collected by councils;
- Domestic hard waste: larger household refuse such as garden waste, old furniture, etc.;
- Commercial and industrial: packaging, offcuts, etc. resulting from commercial and industrial activities; non-hazardous and collected by contractors;
- Special (prescribed) industrial wastes;
- Demolition waste: demolition rubble and offcuts from building activity;
- Council waste: street sweepings, tree prunings, garden waste, etc.;
- Contaminated soils;
- Medical wastes; and
- Radioactive wastes.

The solid waste stream is considered in terms of four primary methods of waste collection and transportation:

Council Waste: All waste collected by or on behalf of local councils, including domestic garbage, clean-up waste, beach, street, parks and garden and local government engineering waste, and trade waste.

Small Vehicle Waste: Waste transported by individuals in cars, station sedans, utilities and the like.

Commercial and Industrial Waste: Non-hazardous waste collected from industry and commerce.

Demolition Waste: Hardfill type waste resulting from reconstruction projects.

Putrescible waste is defined as waste which contains food waste, offal, dead animals and the like. Domestic garbage is the main source of putrescible waste. Such waste is relatively unstable and is liable to degradation by micro-organisms with such rapidity as to cause nuisance from odours and leachate generation.

Non-putrescible waste may contain some material of an organic nature, e.g. wood, paper, tree loppings or grass cuttings. It is in a relatively stable form and its products of degradation are considerably less offensive and polluting than those from putrescible waste.

Special (prescribed) waste is defined as 'wastes that are acceptable for landfill disposal but require special handling prior to and during disposal over and above the normal environmental control measures applied' (Hubick 1991).

Special wastes by definition require more attention to their collection and disposal because they have the potential to be offensive (odorous, e.g. scallop shells) or a health risk (e.g. asbestos) if inappropriately handled. Many special wastes have some potential to leach quantities of contaminants into solution. Consequently, these wastes are preferably disposed of in containment landfills rather than in dilute and attenuate landfills.

2.2 Solid Waste Acceptance Criteria

The Health Department of WA is currently developing acceptance criteria for the disposal of solid wastes to landfill facilities in Western Australia. These criteria focus on the physicochemical characteristics of the wastes, especially the concentrations and forms of potential contaminants, and combustibility. Such characteristics determine the potential for environmental problems and health hazards arising from the disposal of the wastes.

Whilst the specific tests and acceptance criteria in Western Australia are yet to be finalized, the discussion below serves as a guide to the methods which are likely to be used in the assessment of the wastes disposed of at the Southern Landfill. This discussion is based on the assessment approach and procedures currently adopted by the regulatory authorities in other States (e.g. Victoria).

A combination of digests and leaching tests are typically employed to determine the total concentration and weakly-bound forms of potential contaminants in solid wastes. The total concentration of contaminants is generally determined using USEPA Method 3050 (USEPA 1986), and the results compared with the acceptance criteria for disposal to the landfill facility. Such criteria are usually based on the ANZECC and NHMRC (1992) guideline values for the assessment of contaminated soil and sediments.

The Toxicity Characteristic Leach Procedure (TCLP) is generally used to determine the concentration of weakly-bound contaminants in the solid wastes. The TCLP test is described in USEPA Method 1311 (1990), and involves the controlled leaching of the waste at pH 5 under zero-headspace conditions. Metals and organic compounds (including volatiles) may be leached from the wastes in the TCLP test.

Depending on both the total concentration of the contaminants, and the TCLP-test results, the particular waste-disposal method and landfill facility are determined. In certain circumstances, the solid waste may need to be stabilized (e.g. lime-dosed) to ensure that the contaminants are "fixed", and so not prone to leaching following disposal. The acceptance criteria for the Southern Landfill will conform to those currently being developed by the Health Department.

To ensure that only wastes of low combustibility will be disposed of to the Southern Landfill, specific tests will be carried out on certain waste types. Whilst the actual tests and acceptance criteria are yet to be finalized by the Health Department, the closed-cup flash-point test may be used for this purpose. Further details of waste screening procedures are described in the proposed Operations Management Plan for the Southern Landfill (see Appendix E).

The types of wastes proposed to be accepted for disposal within the Southern Landfill are as follows:

- domestic refuse;
- putrescible wastes (other than domestic refuse);
- special (prescribed) wastes as listed in Table 1;
- low level contaminated soils; and
- other wastes not specifically excluded within Table 2, subject to the written approval of the EPA and the Health Department.

The wastes specifically prohibited from disposal within the existing landfill are:

- soluble chemical wastes;
- hazardous wastes;
- liquid wastes; and
- wastes listed in Table 2.

Further details on waste acceptability criteria are presented in Appendix E.

2.3 Landfilling as a Waste Management Option

2.3.1 Introduction

Under the landfill method of disposal, solid waste is compacted to the smallest practical volume by the use of specialized compaction equipment and covered with clean soil-like material at the end of each working day.

A modern sanitary landfill is an engineered structure which usually includes a liner, leachate collection system, landfill gas extraction system and a low permeability cap to protect the local environment.

2.3.2 Historical Concerns

The standard of operation of a landfill determines to a large extent its impact on the environment. Prior to the 1970s, waste disposal sites (tips) were often operated as open dumps, utilising little if any cover material and compaction. Such standards of operation resulted in frequent fires, serious odour problems, severe leachate pollution of creeks and rivers and substantial subsequent major settling of the site.

TABLE 1

ACCEPTABLE PRESCRIBED INDUSTRIAL WASTES

- Acidic sludges*
- Adhesives (cured)
- Alkaline sludges and residues*
- Antimony and antimony compounds
- Aqueous paint sludges and residues*
- Asbestos (all chemical forms)
- Barium and barium compounds
- Boiler blowdown sludge*
- Boron and boron compounds
- Cadmium and cadmium compounds
- Caustic sludges and residues*
- Chromium compounds
- Contaminated soils (greater than low level contaminant levels)
- Copper compounds
- Cyanide sludges and residues*
- Electroplating sludges and residues*
- Filter cake sludges and residues*
- Fish processing residues
- Fly ash
- Heat treatment salts
- Immobilized waste
- Inorganic cyanides and cyanide sludges and residues*
- Inorganic sulphur containing compounds
- Lead sludges and residues*
- Lime neutralized sludges*
- Lime sludges*
- Mercury sludges and residues*
- Metal finishing residues
- Nickel compounds
- Paint residues (solid only)*
- Polymeric lattices
- Poultry processing residues
- Resins (cured)
- Scallop processing residues
- Selenium and selenium compounds
- Tannery sludges and residues*
- Tars and tarry residues*
- Timber preserving residues*
- Treatment plant sludges and residues (excluding sewage and septic tank sludges and residues)*
- Vanadium and vanadium compounds
- Wool scouring residues*
- Zinc compounds*

Note: To be acceptable for disposal at the landfill, wastes marked with an '*' must consist only of components listed in Table E1 or Table E2 (Appendix E) and be subjected to an elutriation test and not exceed the parameter maximum concentration listed in Table E3 (Appendix E).

TABLE 2

PROHIBITED WASTES

(1) Arsenic and arsenic compounds (except in low level contaminated soils up to the permissible elutriable fraction or maximum concentration).

(2) Beryllium and beryllium compounds.

(3) Biocides.

(4) Chloride sludges and residues.

(5) Chlorinated hydrocarbon wastes.

(6) Distillation residues.

(7) Explosive wastes.

(8) Grease trap and interceptor residues and sludges.

(9) Highly reactive wastes such as carbides, phosphorus sludges, alkali metals, oxidizing and reducing agents.

(10) Hydrocarbon-based solvent residues and sludges.

(11) Isocynate compounds (excluding solid inert polymeric materials).

(12) Methylacrylate compounds (excluding solid inert polymeric materials).

(13) Oils and oil interceptor sludges.

(14) Pharmaceutical substances.

(15) Pesticides.

(16) Phenolic compounds (excluding solid inert polymeric materials and low level contaminated soils up to the maximum concentration prescribed by the Health Department).

(17) Polybrominated biphenyl and related materials and equipment containing polybrominated biphenyls and related materials.

(18) Polychlorinated biphenyls and related materials and equipment containing polychlorinated biphenyls and related materials.

(19) Prescribed biomedical wastes.

(20) Radioactive wastes.

(21) Saline residues and sludges.

(22) Surfactants and detergents.

(23) Wastes containing greater than 200 grams per cubic metre of free cyanide.

(24) Wastes having a closed cup flash point less than 61 degrees Celsius.

(25) Wastes which, when subject to an approved elutriation test, produce an elutriant which exceeds the values prescribed by the Health Department.

Leachate is liquid which has percolated through or drained from waste and which contains dissolved and/or suspended materials from the waste. If not carefully controlled, leachate can cause pollution of groundwater, surface water and streams.

In addition to the environmental problems resulting from lack of compaction, inefficient use was made of the available space in the waste disposal facility.

Disposal of waste in Perth has historically been controlled at a Local Council (or equivalent) level. The traditional approach to landfill design, development and operation in the Perth metropolitan region has been to site landfills where land space is available, with little allowance for the potential for environmental problems (Sinclair Knight 1991).

2.3.3 Modern Landfill Operation

Modern landfill practice differs substantially from the land-based disposal methods common up to the early 1970s. The vast majority of wastes in Australia and elsewhere in the world are disposed of by the landfill method. It is the lowest cost method of disposal currently available and it is immensely flexible in terms of being able to cater for wide variations in waste input and waste characteristics.

Landfill Design Strategies

The effectiveness of a landfill in the containment of waste depends on a number of factors, particularly with respect to the local soil structure, water table, and movement of groundwater through the soil. Strategies for landfill design and construction which take into account the potential for dissolution of compounds in groundwater are:

- dilute and attenuate; or
- containment.

The dilute and attenuate strategy depends on the predictable action of chemical, physical, and biological processes within and surrounding the waste material in landfill. The processes need to proceed at a rate adequate to degrade compounds in leachate to harmless materials.

The containment strategy has as its goal the minimization of leachate produced by the landfill. Leachate which is produced is collected and treated. This strategy requires the use of liners inside the landfill to maximize the containment and collection of leachate. Containment within the landfill requires internal liners in the landfill site. This may include 'geomembranes' made from high density polyethylene (HDPE) in addition to clay layers. The liner is used as a barrier layer to restrict the flow of fluids and leachates. The design of the clay liner is based on determination of soil parameters, laboratory permeability testing, field permeability testing and selection of clay liner thickness. Typical soil parameters used in design include Atterberg limits (soil behaviour relative

to moisture content), particle size distribution, moisture-density relationship, permeability (hydraulic conductivity) and shrink/swell potential.

Site Management

An important aspect of modern landfill practice is a high standard of site management, especially the provision and proper use of cover material. Common problems such as wind blown paper, flies, rodents and birds can be significantly reduced by good site management. The waste material is deposited in layers and compacted with specialized landfill compactors. Each series of compacted layers is covered progressively with earth or other suitable material. A final top layer of properly compacted impervious material is then applied to the finished landfill with a slope to minimize water infiltration and hence the generation of leachate.

Leachate Control

The first step in leachate control is minimization of generation. Leachate minimization is achieved basically through effective stormwater diversion away from the filling zone as well as compaction and regular covering of the waste with earth. These measures greatly reduce the amount of water which is able to percolate through the fill, and correspondingly reduces the quantity of leachate produced and the concentration of dissolved and suspended materials.

The second aspect of leachate control is the prevention of any leachate that is generated from entering groundwater, streams and other waterways.

Landfill operations in disused quarries may produce large quantities of leachate as rainfall accumulates in the pit. Rainfall is not normally able to run off the site, especially in the early stages when filling is proceeding in the lower levels of the pit. This is controlled through the installation of extensive stormwater and leachate drainage systems, and the use of control measures such as effective compaction and frequent covering of waste.

Site Rehabilitation and Long-Term Maintenance

Landfilling has long been accepted as a method of restoring parcels of quarried or otherwise degraded land into passive and active recreation space of value to the community.

Before a landfilled site is available for the development of a planned end-use, substantial rehabilitation work is necessary. This work includes filling of the site to the required end-use contours, revegetation of filled areas and control of leachate and landfill gas production. Use of trees, shrubs and groundcovers, the control of contours and slope gradients, and the construction of effective stormwater drainage systems are adopted to minimize erosion.

Landfill Gas Control

It is necessary to undertake extensive landfill gas control measures at some filled sites. Landfill gas, generated by decomposition of organic wastes, is basically a mixture of about 60% methane and 40% carbon dioxide. Lack of control of gas generation at any filled landfill site may cause environmental problems such as malodours and injury to vegetation on filled and adjacent areas.

Landfill gas monitoring and extraction systems are installed at all landfills accepting putrescible wastes, after closure, to minimize malodours and to prevent any damage to future vegetative rehabilitation at the sites, and ensure that the sites are compatible with their planned end uses.

Landfill Gas Utilization

The recovery of methane gas generated in landfills, which can be viewed as simple anaerobic digesters, is widely practiced throughout the world and it is envisaged that this energy recovery technology will become more important in the future.

Landfill gas has a heating value of about 22 megajoules per cubic metre. Research by the Waste Management Authority of New South Wales (1990) indicates that a landfill site will produce in excess of 1 000 cubic metres per hour of landfill gas per million tonnes of waste in the fill and that gas production will continue for between 5-15 years depending on a number of factors. While not all of this gas is recoverable, it is evident that considerable potential exists for the economic extraction and utilization of the gas as an energy source.

2.4 Current and Future Needs for Waste Management in the Perth Metropolitan Region

The general tightening of environmental regulations in Western Australia, together with community expectations, will see the phasing out of existing landfills which are close to residential and other sensitive areas, or are environmentally unsatisfactory.

The outcome of recommendations presented in *Criteria for Landfill Management 1992* (Health Department of WA 1992) is that by 1 July 1994 virtually all landfills operating in the Perth metropolitan area will have to be lined, incorporate leachate and landfill gas management, and be generally designed and operated in such a way as to minimize offsite pollution and ensure thorough post-closure management.

As a result, landfills that may face closure or will be required to modify their management plans in order to comply with the new regulations include:

- City of Canning - Ranford Road site;
- Shire of Kalamunda - Brand Road (scheduled for closure 31/12/95);
- City of Melville - John Connell Reserve;
- Shire of Mundaring - Mathieson Road (scheduled to close shortly);
- City of Stirling - Yirrigan; and
- City of Rockingham - Ennis Road.

The total current capacity of landfill sites in the Perth metropolitan area is sufficient to meet the expected total demand up to the year 2007, based on present disposal methods, and projected waste streams, allowing for some redistribution of waste disposal as the sites with small capacity are closed (Sinclair Knight 1991).

The *Discussion Paper For A Metropolitan Waste Strategy* (Health Department of WA 1988) emphasizes the concept of regionalization, stating that "few, if any, landfill sites will be approved in the metropolitan area if not developed as regional sites", and identifies the need for "Host/Guest Agreements" and Regional Councils to secure the level of co-operation necessary to achieve the benefits of regionalization.

According to the Report of the Working Group on Waste Management, *Waste Management into the 21st Century* (Health Department of WA 1991):

> ". . . a readily accessible and secure site for low hazard solid waste remains an urgent requirement. The lack of suitable industrial waste disposal facilities in our waste management system can be a significant impediment to certain types of industrial development."
>
> "Perth, like most other major cities, has now identified a number of sites contaminated with oils, heavy metals and a range of other hazardous wastes. Inevitably, some material will require disposal off-site at a low hazard solid waste landfill. The present lack of a suitable landfill site hinders clean up impacting future development and beneficial use of contaminated sites.
>
> "Local governments have been reluctant to accept waste from contaminated sites even when their landfill is technically suitable for disposal of that waste."

2.5 Alternative Waste Management Options

The adoption of alternative technologies to landfill disposal could effectively reduce the demand for landfill capacity to 35% of the current waste stream. Assuming a base level demand for landfill of 35% of the current waste stream, the current level of landfill capacity would be sufficient to meet the needs of the Perth metropolitan area to beyond the year 2015 (Sinclair Knight 1991).

A range of technologies are now available for each waste stream component to implement an integrated waste management system, but landfill will remain a critical component of these systems.

Other disposal options include:

- Mechanical separation for re-processing (recycling);
- Composting;
- Incineration;
- Waste Derived Fuels (WDF); and
- Pyrolysis.

A comparative summary of estimated capital and operating costs for the range of feasible waste processing options is presented in Table 3. The costs used in the economic assessment are based upon overseas experience as none of these systems are operating in Australia.

Factors such as local environmental conditions, importation of equipment and interest rates significantly affect the capital and operating costs of the various processing options.

Accordingly, the cost estimates shown in Table 3 must be viewed with caution and should be considered indicative rather than definitive economic assessments. However they provide a useful guide to the likely relative differences between the differing processing options. It should be noted that the costs are shown in 1989 Australian dollars and take into account estimated credits for recovered materials and energy (Waste Management Authority of New South Wales 1990).

In the event that potential landfill sites within viable transfer distance from the metropolitan area do not become available, the next most feasible options for managing the waste stream is materials recovery, waste derived fuel (WDF) or composting in combined or separate plants. Nevertheless, these technologies will still produce residues ranging from 20-70% of the waste stream (Table 4). Suitable sites and areas of land to handle these residues will be required as shown in Table 5.

TABLE 3

COMPARATIVE PROCESS COSTS

Process	Capacity (tonnes/day)	Capital Cost[1] ($ million)	Net Operating Cost[2] ($ per tonne)
Landfill[3]		2	14
Transfer and Landfill	500	7	34
Composting[4]	400	18 - 25	50 - 60
Waste Derived Fuel	400	12 - 15	40 - 50
Mechanical Separation[5]	400	20 - 25	45 - 60
Incineration (with energy recovery)	1 000	120 - 150	70 - 80

[1] Capital costs cover fixed mechanical plant and civil works only. Land costs and mobile plant costs are not included.

[2] Net operating costs are equivalent to break even gate charges. Included are amortization of capital, operating costs (including full operating costs of any mobile plant, disposal of any residue by landfill and credits for income received from sale of materials or energy. Land costs are excluded.

[3] Based on a landfill with 2 000 000 tonne capacity.

[4] Garbage only; no sewage sludge.

[5] Recovers paper and cardboard, glass, compost, ferrous, some waste derived fuel.

Source: Waste Management Authority of NSW (1990).

TABLE 4

PROCESS RESIDUES REQUIRING LANDFILL (BY WEIGHT)

Incineration	20 - 30%
Materials Recovery	20 - 50%
Composting	50%
Waste Derived Fuel	65 - 70%

Source: Waste Management Authority of NSW (1990).

TABLE 5

LAND REQUIREMENTS

	Process Operating Capacity (tpd)	Site Requirements (hectares)
Transfer Station	400	2.0 - 2.5
Waste Derived Fuel	400	2.0 - 3.0
Incineration	1 000	2.5 - 3.0
Materials Recovery	400	2.0 - 4.0
Composting	400	3.5 - 4.0

Source: Waste Management Authority of NSW (1990).

Incineration generates the least residue for landfill disposal, is a well proven processing technology and is increasingly utilized in densely populated areas elsewhere in the world where there is little access to landfill sites. However it is the most expensive disposal option and its adoption would result in a sharp increase in the cost of waste disposal for the entire community (Waste Management Authority of New South Wales 1990).

The potential for future integration of materials recovery, composting or WDF processing technology into the solid waste management system is more promising, but is dependent on factors such as the identification and development of markets for recovered products, the availability of adequate suitable land for siting alternative technologies, especially in the inner city areas; and the acceptance by the community of the higher costs involved in exchange for the environmental advantages gained.

Although municipal waste management and disposal practices are becoming more sophisticated, particularly the emphasis being placed on resource recovery and recycling, landfills still represent the foundation of disposal operations. Various alternative waste disposal technologies (i.e. other than landfilling) are available, however, the establishment of waste disposal facilities utilising these technologies is generally regarded as beyond the resources of even the regional groupings of local government authorities which have been formed in Perth (Sinclair Knight 1991).

2.6 Administrative Considerations for Waste Management in the Perth Metropolitan Region

2.6.1 Government Involvement

An integral part of the Health Department of Western Australia's current waste management strategy is the concept of regionalization, whereby a number of local authorities combine to form a Regional Council (constituted under Part XXIX of the *Local Government Act*) to develop and operate fewer, larger sanitary landfill sites (Health Department of WA 1988).

Amongst the cited potential benefits of this regionalization are:

- Ensuring sufficient waste generation to justify routing to appropriate transfer stations and landfill sites;
- Providing an orderly use of land for capital works;
- Ensuring economical scale of operation;
- Allowing improved traffic management;
- Allowing more efficient utilization of plant and equipment; and
- Allowing better long-term planning.

The Perth metropolitan region has been divided into a series of waste management zones, of which the South East Zone is one. This zone consists of the City of Armadale, the City of Gosnells, the Shire of Kalamunda, the City of South Perth and, until recently, the Shire of Serpentine-Jarrahdale. They are not presently bound by a regional council (Sinclair Knight 1991). The Shire of Serpentine-Jarrahdale withdrew from the South-East Zone on 8 June 1992.

Although the principle behind the concept of regionalization is to rationalize the number of landfills operated on a municipal level, most municipalities currently operating landfills are reluctant to accept low level commercial and industrial wastes.

This has created an increasing demand for a site at which to dispose of such wastes, with the demand emanating from a range of sources crossing a number of metropolitan waste management zones.

The proposal to develop the Southern Landfill is primarily aimed at meeting this demand, although the site will also serve as a disposal site for municipal wastes from the Shire of Serpentine-Jarrahdale and other Peel Ward member councils (Shire of Waroona, Shire of Boddington, Shire of Murray, City of Mandurah) as required.

2.6.2 Private Sector Involvement

Traditionally, waste management has been controlled by local authorities. Private industry was involved only as collection and cartage contractors to local authorities. The increasing volumes of commercial and special waste collection which occurs across council boundaries has created more central control and involvement of the private sector. The private sector is now involved in the collection and disposal of industrial and commercial solid waste and other waste streams.

Data from interstate indicate that the private sector is handling approximately 50% of the total waste stream, which is attributed to the emergence of multinational companies skilled in the waste management industry, with ready access to the increased capital required to develop and operate sophisticated waste disposal facilities (Health Department of WA 1991).

In identifying future directions for waste management in Western Australia, the Health Department of Western Australia (1991) stated:

> "the structure developed for management of waste must accommodate the interests and views of private industry, and allow their development within any comprehensive plans for the state."

2.7 Conclusion

Although initiatives such as recycling and resource recovery will form an increasingly prominent part of future waste management practices, and can significantly reduce the quantity of waste requiring disposal by landfill, landfilling will continue to be an important component of waste disposal operations within the Perth metropolitan region.

There will always be a significant demand for landfill capacity to cater for process residues and waste not amenable to processing.

Nevertheless, improvements in the general selection of landfill sites, and in the planning and management of landfill facilities will be necessary.

3 RATIONALE FOR THIS PROPOSAL

3.1 Objectives

Pioneer-BFI Waste Services recognizes the need for long-term solid waste disposal facilities in Perth for commercial and special industrial solid wastes. This proposal for development of the Southern Landfill is in response to the mid to long-term shortage of secure disposal facilities, for putrescible, non-putrescible and low-level industrial wastes in the southern and south-eastern Perth metropolitan region.

The Health Department's *Discussion Paper for a Metropolitan Waste Strategy* (Health Department of WA 1988) emphasizes the importance of regionalization of municipal waste management facilities. Pioneer-BFI Waste Services recognizes the benefits of regionalization for municipal wastes, and during negotiations with the Health Department concerning establishment of a new landfill, has indicated its willingness to accommodate Local Government Authorities' requirements.

The Peel Regional Plan (Department of Planning and Urban Development 1990) recommended that:

(i) A regional strategy for the collection, transport and disposal of liquid effluent and noxious and hazardous waste be developed by local authorities in conjunction with the Health Department, EPA, Department of Minerals and Energy and other agencies.

(ii) Disposal of domestic refuse be examined on a regional basis.

The Shire of Serpentine-Jarrahdale has already indicated its willingness to utilize the Southern Landfill to dispose of some 5 000 tonnes per annum of municipal waste. Other member councils of the Peel Ward (i.e. Shire of Waroona, Shire of Boddington, Shire of Murray and City of Mandurah) are presently considering the Southern Landfill proposal as part of evaluating options for municipal waste disposal when their existing individual landfills reach capacity. The time-frame for closure of these landfills ranges from approximately 5 to 25 years.

However, the need for a long-term solid waste disposal facility for commercial and special industrial wastes extends beyond the concept of regionalization of municipal waste disposal. The identified need is for an environmentally acceptable site located within the Perth metropolitan region to be developed, as a waste disposal facility to handle commercial and special industrial wastes, by a proponent that has the financial backing and technological expertise to ensure that the facility is appropriately designed and operated.

BFI Waste Systems disposes in excess of 100 000 tonnes of commercial waste per annum in the Perth region. A large proportion of this will be directed to the Southern Landfill. It is anticipated that other commercial operators would also use the facility. In addition to commercial and special industrial waste, the Southern Landfill would provide support for disposal of municipal wastes for councils located in the southern and south-eastern areas extending to the Peel Ward municipalities.

With the development of the Southern Landfill, Pioneer-BFI Waste Services proposes to service primarily commercial and special industrial waste producers. The goal of Pioneer-BFI Waste Services' waste management strategy is to establish an alternative waste disposal facility which is both financially realistic and environmentally responsible. Achieving an environmentally responsible landfill will require minimization of the adverse influences that are often associated with such facilities. However, a number of specific objectives will need to be satisfied if this is to be achieved. These objectives relate both to the location and design of the landfill, and the operational practices to be implemented at the landfill.

On this basis, the specific objectives of Pioneer-BFI Waste Services' waste management strategy are:

- to select a waste disposal site that is conveniently accessible to the community and will facilitate management of potential adverse environmental impacts associated with waste disposal operations;

- to design a landfill facility which incorporates measures to limit potential environmental impacts, and sufficient operational flexibility to enable effective response to any problems which may arise; and

- to adopt and implement management practices that will ensure effective control over all aspects of the landfill operation with the potential to produce adverse environmental impacts.

The landfill will be operated and managed in strict accordance with accepted modern sanitary landfill practices, and in compliance with the Health Department's guidelines and Pioneer-BFI Waste Services' own environmental and landfill policies. A properly located, designed, operated and managed landfill represents an environmentally sound form of waste management.

3.2 Site Selection Process

The *Discussion Paper for a Metropolitan Waste Strategy* (Department of Health WA 1988) was released in November 1988. This document made reference to the need for provision to be made for the private industry sector to become more involved in waste management (collection, processing and disposal) in Western Australia.

Consequently, in January 1990 BFI commenced investigations into the potential for private operators to establish waste disposal facilities (landfills) to service the Perth metropolitan region. In April 1990 BFI commissioned a geological consultant to undertake a desk study of potentially suitable landfill disposal sites in the Perth metropolitan region, with a capacity of the order of five to six million cubic metres.

Potential landfill sites were identified in the study area by a process of elimination using the following topographical, environmental and land use criteria:

- location relative to centres of waste generation;
- site accessibility from major roads;
- property size;
- potential visual impact;
- site topography;
- site geology;
- site drainage - surface and probable sub-surface;
- land use and zoning;
- flooding and water catchment;
- land instability and subsidence after mining; and
- availability of sites currently or previously used for extractive industry.

A major consideration in the site selection process was the draft *Environmental Protection (Swan Coastal Plain Wetlands) Policy 1991* (EPA 1991). This Draft Policy prohibits filling, mining, pollution or changing drainage of wetlands on the Swan Coastal Plain, except where absolutely necessary.

Sites which were investigated are shown on Figure 2. On the basis of this investigation, the Darling Scarp at Byford/South Cardup was identified as a suitable location with potential to develop a sizeable landfill. The attractive features included reasonable haul distances from waste sources, existence of hard rock and clay quarries suited to rehabilitation by landfilling, and the suitability of landforms, hydrology and geology in the locality to ensure the integrity of the landfill.

Following identification of the South Cardup locality as a potentially suitable area for development of a landfill in mid 1990, BFI initiated an on-going programme of liaison with the Health Department and the EPA to discuss the concept. At the same time, BFI initiated discussions with local land owners (Bristile, Mr P Nairn and Pioneer Concrete) to address land purchase options.

As a result of these discussions, the Pioneer Concrete hard rock quarry, the adjacent Bristile shale extraction pit and a portion of Mr Nairn's neighbouring rural property were chosen in mid 1991 as the preferred site for a three-staged landfill development.

3.3 South East Zone Waste Management Audit

Independent of the site selection studies undertaken by BFI, the South East Zone Refuse Disposal Committee (then comprising representatives of the Shires of Kalamunda and Serpentine-Jarrahdale, and the Cities of Gosnells, Armadale and South Perth) commissioned Sinclair Knight Consulting Engineers (Sinclair Knight and Bowman Bishaw Gorham 1991) to undertake a study ('audit') to define the directions for waste disposal for the Zone up to the year 2025. Part of the scope of this study was to identify potential areas for locating a future regional landfill site.

After preliminary evaluation three sites were selected for detailed study:

- Readymix granite quarry in Cockram Road, Gosnells;
- Metro Brickworks shale quarry in Kiln Road, Cardup; and
- Pioneer Concrete quarry in South Cardup.

All three sites were deemed to be suitable for landfill development, although at the time of that study, Pioneer Concrete was not receptive to the use of the quarry for a stand-alone landfill site development because of their plans for future expansion of quarrying activities (Sinclair Knight and Bowman Bishaw Gorham 1991).

3.4 Consultation with Interested Parties

A specific government and public consultation programme has been implemented by Pioneer-BFI Waste Services as part of the process of preparing the required environmental and planning documentation for the proposed Southern Landfill. This programme has included:

- Consultation with interested/concerned parties during the formative stage of the proposal, to identify issues or concerns thereby enabling their consideration during preparation of the proposal. These parties included:

  - Environmental Protection Authority of WA;
  - Health Department of WA;
  - Water Authority of WA;
  - Department of Planning and Urban Development;
  - Department of Minerals and Energy, Geological Survey Division;
  - Department of State Development;
  - Hon. R J Pearce, then Minister for the Environment and Member for Armadale;
  - Hon. P G Pendal, Member for the South-East;
  - Hon. B House, Member for the South-West;
  - Mr M Thorn, Adviser to the Minister for Health;
  - South East Zone Refuse Disposal Committee;

- Shire of Serpentine-Jarrahdale Council;
- Shire of Waroona;
- Shire of Boddington;
- Shire of Murray;
- City of Mandurah; and
- Town of Kwinana.

- A public open day at the proposed project site was held on Saturday, 25 July 1992 to provide local residents and other interested persons with an opportunity to obtain information about the proposal and identify issues of interest or concern so such issues could be addressed during preparation of the proposal. Over forty local residents attended the public open day.

A number of concerns were raised during the public consultation process. The concerns expressed frequently addressed potential environmental impacts often associated with landfill proposals, including groundwater contamination by leachates, odour, noise, dust, litter and vermin. However, other issues were also raised, including:

- hours of operations and their effect on adjacent land users;
- mistrust of regulatory authorities' willingness or ability to police the landfill operations;
- management of methane generation and utilization;
- financial costs to the local community imposed through rates;
- impact on surface water quality;
- impacts on flora and fauna within the site;
- compliance with undertakings given by the Proponent; and
- monitoring of impact on private water bores.

Pioneer-BFI Waste Services recognizes the importance of public involvement during the formative stages of the proposal, as reflected by the community consultation that has occurred during the process of preparing the PER document.

In addition to the community consultation undertaken by the Pioneer-BFI Waste Services during preparation of the PER document, the Proponent is also committed to providing the opportunity for continued public involvement following establishment of the proposed landfill. Details of these commitments are provided in Section 9 of this document.

4 EXISTING ENVIRONMENT

4.1 Climate

4.1.1 Air Temperature

The study area has a Mediterranean type climate characterized by warm to hot dry summers and cool wet winters. Temperature extremes are greater on the Darling Plateau compared to the Swan Coastal Plain.

Climatic data are summarized in Table 6. The two hottest months are January and February when the average daily maxima near 30°C. Winters are cool with the average daily minima for the coldest month (July) being near 6°C. Winter minimum temperatures are higher on the plateau surface than in the dissected valleys or at the foot of the scarp where winter fogs and frosts can occur. Mean temperatures for summer and winter are 22°C and 13°C, respectively.

4.1.2 Rainfall and Evaporation

Rainfall is winter-dominant with 80% occurring in the five months from May to September. The orographic effect of the Darling Scarp results in an increase of rainfall from the west to the east across the Swan Coastal Plain. Rainfall varies from about 800 mm per annum on the coastal plain, up to about 1 200 mm per annum within the Darling Range.

Evaporation exceeds rainfall in all but the wettest four months from May to August. Low evaporation during that wet period results in usually reliable runoff to surface catchments in the Darling Scarp, and recharge to groundwater reserves in the coastal plain.

4.1.3 Wind

Seasonal variation in wind patterns in the study area result from a shift in high pressure systems. The summer pattern from September to March is predominantly easterly, producing hot, dry conditions which are generally counteracted to some extent in the afternoon by cooler south-westerly breezes from the Indian Ocean. During the winter these systems move north and the predominant winds are moderate to strong westerlies associated with low pressure systems moving west to east across the continent (AGC Woodward-Clyde 1991).

The closest wind recording station to the site is Perth Airport. In summer the prevailing winds at Perth Airport at 9.00 am are easterly approximately 57% of the time, with only 8% calm days. At 3.00 pm the winds are most commonly westerly to south-westerly (approximately 64% of the time) (Stephens 1991). Wind roses are shown on Figure 4.

TABLE 6

SUMMARY OF METEOROLOGICAL DATA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Serpentine (Karnet), Station No. 00911, Elevation 286 m													
Mean rainfall (mm)	18	23	22	73	157	238	224	193	123	84	44	19	1 218
Mean daily max. temp (°C)	30.4	30.1	27.3	22.6	18.5	16.0	15.3	15.5	17.4	20.5	23.8	27.9	22.1
Mean daily min. temp (°C)	15.3	15.6	13.9	11.3	8.8	7.3	6.2	6.2	7.2	9.0	11.2	13.5	10.5
Perth Airport, Station No. 009021, Elevation 20 m													
Mean rainfall (mm)	7	14	14	44	109	178	164	119	68	48	25	12	802
Mean Class "A" pan evaporation (mm)	308	282	310	271	310	299	309	310	271	318	330	341	3 659
Mean daily max. temp (°C)	31.5	31.6	29.4	25.1	21.4	18.7	17.7	18.3	20.0	22.4	25.4	28.5	24.2
Mean daily min. temp (°C)	16.7	17.3	15.6	12.6	10.2	9.0	8.0	7.9	8.6	10.0	12.3	14.5	11.9

Source: Bureau of Meteorology 1988.

In winter, the winds are generally lighter and the dominant direction is less distinct. At 9.00 am the wind is from the north to east quadrant approximately 57% of the time, with 26% of the days calm. At 3.00 pm the wind direction is evenly spread with a west to south direction being slightly more common (43% of the time) (Stephens 1991).

Of particular significance to this project are the strong katabatic air flows that occur on summer mornings. Katabatic winds are generated when cooler air to the east of the Darling Scarp flows west down the scarp under the influence of gravity.

On the Swan Coastal Plain, the katabatic effects are progressively reduced as distance increases from the Scarp. Katabatic winds in the Byford/South Cardup area are likely to be similar to those in other areas influenced by the Darling Scarp. In the lower Canning River valley, the katabatic winds are on average twice as strong as the winds at Perth Airport, although on some mornings they are four times stronger. At Kelmscott, the katabatic winds blow from midnight to midday with the strongest flows between 4.00 am and 6.00 am (Stephens 1991).

Air temperature inversions occur when the near-ground air is cooler than the higher layers of the atmosphere and there is insufficient wind present to mix the air layers. This occurs most commonly overnight and is broken up by surface warming of the near ground air layer by sun and increases in wind speed. Temperature inversions occur most commonly during autumn-winter-spring, when approximately 50% of the days have the necessary atmospheric conditions. In summer the sea breezes and katabatic winds mix the air, reducing the likelihood of temperature inversions.

Data from Perth Airport indicate that 90% of inversions are broken up by solar heating alone by 12.30 pm and 100% by 2.00 pm. There are occasional situations when weak temperature inversions can develop late in the afternoon: in summer when the sea breeze is weak and intrudes under a layer of warmer air, and in winter when radiational cooling begins before nightfall (Stephens 1991).

4.2 Geology and Soils

4.2.1 Regional Description

Geology

The study area spans two distinct geological provinces divided by the Darling Fault: the Archaean Yilgarn Block is located to the east, and the Palaeozoic and Mesozoic sedimentary deposits of the Perth Basin occur to the west (Figure 5). The west-facing Darling Scarp is the surface expression of the Darling Fault and has a maximum elevation of 300 m AHD with relief up to 200 m (AGC Woodward-Clyde 1991).

The Darling Plateau forms the surface of the Yilgarn Block which consists of Precambrian rocks, mainly granite, gneiss and some doleritic intrusives, mantled by Tertiary lateritic duricrust. This consists mainly of hydroxides of iron and aluminium, underlain by a pale kaolinitic clay. In isolated pods, where aluminium content is high, the laterite is mined as bauxite.

The western portion of the plateau has a relatively flat surface but is strongly incised by a number of major valleys where massive rock outcrops are common features. Crushed rock aggregate from these valleys and the scarp is used by the construction industry. To the east, the plateau's mantle becomes more dissected and the landscape is undulating with more shallow, broader valley forms.

Soils and Landforms

The gently undulating lateritic uplands of the Darling Plateau are dominated by duricrust, gravels and sands. In its western portion the plateau surface is strongly incised by major valleys. The chief soils of the upland interfluve areas (Dwellingup series) are ironstone gravels with sandy and earthy matrices, which overly duricrusts comprising re-cemented ironstone gravels, block laterite or mottled-zone or pallid-zone clays. Minor, gently concave valleys with swampy floors (Yarragil series soils) and sandy shallow depressions at the heads of drainage lines (Goonaping series soils) also occur within the upland surface. Goonaping soils are characterized by grey sands while Yarragil soils are generally more earthy (AGC Woodward-Clyde 1991). Both of these latter landforms are shallowly incised valleys beneath the laterite mantle and are distinguished from the major valleys not only be relief but also by the absence of outcrops of granitic country rock.

Hills or monadnocks which rise above the general surface of the plateau are represented by a single landform/soil association, Cooke. These areas are mainly mantled by laterite, but extensive granite outcrops also occur and the soils are usually shallow sands.

The Darling Scarp and major valley soil series (Helena and Murray) at or near the Darling Plateau's western margin, have steep gradients and massive rock outcrops as a common feature. Red and yellow duplex soils occur on the moderate to steep upper slopes, acid red gradational earths on the colluvial slope deposits, and gravelly sands on the ridge tops and spurs.

4.2.2 Project Site Description

Geology

The proposed Southern Landfill site lies on the western edge of the Yilgarn Block, just east of the Darling Fault. The surface geology comprises a sequence of Quaternary aged sands, silts and clays which extend to a depth of between 0.4 m to the east, to over 30 m in the west of the site. This veneer of sediments is underlain by shales and sandstones in the western portion of the site, and by granitic bedrock to the east (Figure 5).

The easternmost portion of the site is underlain by a fine to coarse grained, mesocratic rock of granite, granodiorite and adamellite composition which have been intruded by doleritic dykes. The existing Pioneer Concrete hard rock quarry lies in the Archaean rocks of the Western Gneiss Terrane, part of the Yilgarn Block. These rocks are mafic gneisses which have been intruded by multiple veins and dykes of granites. In other locations dating of the granites has revealed ages of between 3 100 and 2 200 million years.

The gneiss is dark with typically 20% porphyroblasts of pink albite/oligoclase feldspar in a groundmass of 40% to 60% amphibole/biotite and the remainder quartz and feldspar. The gneiss is thought to have been developed by cataclysmic deformation of pre-existing granitic rocks (Stephens 1991).

The granites are medium-grained with a composition of between 40% to 60% quartz, 40% to 60% feldspar and 5% dark mineral. Some granites are intrusive and consist solely of large quartz and pink feldspar crystals. Several series of faults and joints intersect the area (Figure 5). The faults are indicated by fractured zones. Epidote is commonly present along the joints and fractures (Stephens 1991).

Between the quarry and South Western Highway, Proterozoic shales and sandstones of the Cardup Group outcrop (Figure 5). According to the Geological Survey of Western Australia, 1:50 000 scale Environmental Geology series Serpentine map sheet (Jordan 1986), the shales are part of the steeply dipped Proterozoic Armadale Shale Formation, which corresponds to brown, green to black, silty, thinly bedded shale with interbeds of siltstone and sandstone. Abutting this to the east is the Neerigen Formation, also of Proterozoic age comprising a sandstone described as a basal conglomerate of silty sandstone and silty shale. These shales are currently being quarried for brick making clay in the Bristile Shale Pit.

Both the granitic rocks and the Cardup Group are intruded by a suite of quartz dolerite dykes which have been dated in other areas at between 750 and 450 million years ago.

Soils and Landforms

Geotechnical test pitting has been conducted over all three proposed stages of the landfill to assess the availability and suitability of clay resources in particular (Figure 7). Details of the on-site studies are presented in Appendix B.

The proposed Stage 1 of the landfill is approximately 11.5 ha in area (plus an additional 16 ha required for associated infrastructure) and occupies a small valley lying to the north and north west of the Pioneer Quarry stockpile area. The valley lies on the lower west facing slopes of the Darling Scarp and is drained by a small stream course that runs initially westwards and then north westwards through the proposed landfill area (Figure 6).

In the Stage 1 area, the clay profile, where well developed, generally consists of a variable depth of red, brown and yellow mottled clays giving way to pallid zone clay and weathered bedrock. Deeper alluvial clay profiles, often with a high proportion of cobbles and boulders, were encountered in test pits excavated along the floor of the valley and on the lower northern slopes (Appendix B). The oversize alluvial material varied in size up to 1 m in diameter and consisted of largely unweathered, durable dolerite.

The pits excavated further up the southern and northern slopes of the valley generally encountered weathered bedrock at relatively shallow depths (Appendix B). Significant variation in topsoil thickness occurred within these pits and clays are poorly developed.

The proposed Stage 2 area includes the shale pit currently owned by Bristile lying to the west of the Stage 1 area, and an area of approximately 1.7 ha lying immediately to the north of the shale pit. The area is bounded on the northern margin by the stream that flows through the Stage 1 area. The ground generally slopes northwards down towards this stream.

The soil profiles encountered to the north of the shale pit consisted largely of weathered shale and silty clay, with the clay horizon generally increasing in thickness northwards towards the stream. Alluvial clays were only encountered in the northernmost pits and generally contained a component of rounded oversize material (cobbles and occasional boulder) (Appendix B).

The Stage 3 area includes the quarry currently being operated by Pioneer Concrete and an extensive area lying to the south and south-south-east of the existing limits of the quarry.

The area is generally underlain by granitic rocks with a variable weathering profile and topsoil thickness. Much of the south-eastern section of the area is covered by a durable laterite hardcap that prevented pit excavation. Outcropping granite rocks occurred at locations across the site, particularly towards the crest of the ridge.

The pits excavated on the gentle western slope, off the crest of the ridge, generally showed a relatively thin, organic rich topsoil horizon overlying soils of various thickness representing decomposed granite (Appendix B). The residual soil matrix generally shows a distinct segregation of fines with depth from the coarse sand sized felspar and quartz fragments. The colour change is generally from a yellow to reddish yellow sandy clay, through a red and greyish white mottled zone into a pale grey to white sandy zone at the base of the profile, overlying hard granitic bedrock.

4.3 Seismicity

As part of the broader Perth region, the Cardup locality is within seismic zone A according to Australian Standard 2121-1979 (SAA 1979).

The probablistic earthquake risk maps of south-west Western Australia (Gaull & Michael-Leiba 1987) show Perth and the South Cardup area to have a comparable seismic risk with an estimated ten per cent chance that the ground motion will exceed 48 mm/s or 0.44 m/s^2 during a fifty year interval. Ground motion of this magnitude corresponds to a Modified Mercalli intensity of about MMVI. This ground motion would be expected to be generated by seismic activity in Zone 1 which (as defined by Gaull & Michael-Leiba 1987) lies to the east of the study area.

Commonly observed effects associated with an intensity VII earthquake (0.10 to 0.19 m/s), as listed in Australian Standard 2121-1979 (SAA 1979), are presented below.

Observed Effects of an Intensity VII Earthquake

- Difficulty experienced in standing.
- Noticed by drivers of motor cars.
- Trees and bushes strongly shaken.
- Large bells ring.
- Masonry D cracked and damaged (i.e. non-wooden buildings with low standard of workmanship, poor mortar or constructed of weak materials, e.g. mud brick and rammed earth).
- Few instances of damage to Masonry C (i.e. non-wooden buildings with ordinary standard of workmanship and mortar of average quality).
- Loose brickwork and tiles dislodged.
- Unbraced parapets and architectural ornaments may fall.
- Stone walls cracked.
- Weak chimneys broken.
- Domestic water tanks burst.
- Concrete irrigation ditches damaged.
- Waves on ponds and lakes.
- Induced turbidity in water bodies.
- Small slips, and caving-in of sand and gravel banks.

The proposed landfill area lies within the Darling Fault Zone. There are four main recognized episodes of movements recorded by the mylonites, the youngest of which are generally oblique, and indicate normal displacement with downthrow to the west may be associated with the formation of the Perth Basin between 430 to 130 million years before present (Ma).

The 1:50 000 Environmental Geology Series Serpentine Sheet (part sheets 2033(ii) and 2133(iii) (Jordan 1986) indicates a fault trending west-north-west/east-south-east across the proposed Stage 1 area, coincident with the main

drainage line (Figure 5). The fault has been determined by the off-setting of the Cardup Group sequence of weakly metamorphosed shale, sandstone and conglomerates, and appears to be related to a minor adjustment on the Darling Fault. The highly weathered and variable nature of the bedrock encountered in the test pits precluded a positive identification of the relative displacement of the Cardup Group rocks.

There is no evidence to suggest that the on-site fault is currently active (P Gregson, Mundaring Geophysical Observatory, pers. comm., 11 December 1992).

4.4 Hydrology

4.4.1 Regional Surface Hydrology

The major river in the region is the Serpentine River, which rises in the Darling Plateau and traverses the scarp in a deeply incised valley that provides the sites for the present water storage structures, Serpentine Reservoir and Pipehead Dam. Only those parts of the catchment which are downstream of these structures contribute flow to the lower reaches except for releases of compensation water in the summer months.

Along the western edge of the Darling Plateau, eight small streams (Wungong Brook - south branch, Beenyup, Cardup, Manjedal, Medulla, Karnet, Dirk and Myara Brooks) arise and flow westwards across the Pinjarra Plain.

Within the Darling Range a number of catchments are currently used, or proposed for use, for water supply purposes. Collins and Rosair (1978) report that the streams along the Darling Scarp (Beenyup, Cardup, Manjedal, Karnet, Dirk and Myara) have a combined average annual runoff of approximately 18 million cubic metres of good quality water.

Most of the land within the hills catchments is held under Crown ownership and almost totally covered by State Forest, although some remains in private ownership, particularly in the smaller proposed water supply catchments. These catchments (Dirk, and the Gooralong Water Reserve) are attractive for water-supply purposes because of their relatively high rainfall and the fact that they can be harnessed quite cheaply by pipehead or pumpback schemes. Collins and Rosair (1978) warn however that utilization of these sources could have a deleterious effect on the water quality of the flows in the coastal plain drainage systems. This is because less relatively fresh water would be available to dilute the nutrient enriched coastal plain drainage waters.

4.4.2 Project Site Hydrology

The project development area is located in a valley at the toe of the Darling Scarp. A stream passes through the area, flowing in a general westerly direction (Figure 6). Upstream of the Stage 1 development site, the stream drains an area

of some 240 ha. West of the site, the stream crosses under the South Western Highway and eventually dissipates in the sediments of the Swan Coastal Plain. The general site topographical setting and drainage patterns are shown in Figure 6.

The project area stream is ephemeral, flowing predominantly during the winter months. Seepages from the valley sides are reported to keep the stream just flowing into the early summer months. Some water from the stream is reportedly utilized for stock watering purposes on the downstream properties.

Within the stockpile and crushing plant area of the existing quarry, the streams have been piped through a series of sumps and 750 mm diameter concrete pipes. The pipes drain from the south and the south-east for approximately 400 m and discharge at the base of the landscape bank on the north-west boundary of the stockpile area. Discharges are then fed through a small concrete sediment catchment dam, before being released downstream. Water leaving the vehicle washdown areas of the quarry pass through fuel and oil traps before entering the pipe system.

The boundary landscape bank of the stockpile area is several metres high and constructed from waste rock obtained from quarry operations. At the time of the field studies (October 1992), a small stream issued from the toe of this rockfill bank and joined the westerly flowing stream draining the valley.

4.4.3 Regional Hydrogeology and Groundwater Quality

The occurrence of groundwater across the Darling Plateau varies considerably with geomorphology over short distances, and is relatively unpredictable. Archaean rocks of the Yilgarn Block, together with small outcrops of rocks of Proterozoic age, are generally deeply weathered, but may be partly covered by a thin veneer of Quaternary sediments. The old rocks are poor groundwater producers, but small local supplies of potable water may be found in the weathering profile of the granite or the overlying colluvium. Other small supplies occur in fractured rocks where the groundwater is stored in joints or fault zones (DCE 1980).

Wilde and Low (1978) report that small amounts of potable groundwater, generally at yields less than 15 m^3/d, are available from bores extending through the deep weathered lateritic soil profile to bedrock. Bores sited within valleys or on hillslopes may yield larger supplies, but salinity may be higher, ranging up to 3 000 mg/L TDS.

On the Swan Coastal Plain, water is drawn from wells and boreholes to supply domestic and agricultural needs as well as supplementing the public water supply system (Jandakot Public Water Supply). Nearly all of the groundwater is obtained from unconfined aquifers in the superficial deposits; some is obtained from deeper confined pressure aquifers (artesian water resources: the Leederville, Cockleshell Gully and Yarragadee Formations).

Shallow groundwater resources on the southern coastal plain include the Jandakot Mound and the Karnup area south of the Serpentine River (Figure 8). The availability of shallow groundwater is ultimately limited by the amount of rain received, the amount of runoff collected and conveyed by the rural drainage system and the soil type through which the drains flow.

Groundwater contours for the coastal plain indicate that groundwater movement in the shallow aquifers is predominantly to the west (Figure 8). Collins and Rosair (1978) suggest that significant groundwater outflow contributes to the base flow of the Serpentine River. The depth to water table varies considerably; in some areas the water table intersects the natural surface of the land to form wetlands and lakes, and in others it may be at 15 m depth or more.

The salinity of groundwater in the shallow aquifers is variable. In the northern, central and southern part of the Shire of Serpentine-Jarrahdale salinity is generally less than 1 000 mg/L TDS. In the central portion of the Shire, around Mundijong Road, and also around Serpentine River, salinities tend to be higher than 1 000 mg/L TDS, particularly in poorly drained low-lying areas. Colour, turbidity, iron and hydrogen sulphide are also present in these groundwaters (AGC Woodward-Clyde 1991).

The Water Authority is responsible, under the State's *Rights in Water Irrigation Act 1914*, for the control of all underground water in Western Australia. Within the Shire of Serpentine-Jarrahdale, the Water Authority has proclaimed the Jandakot Public Water Supply Area and the Serpentine and Perth Groundwater Areas to enable groundwater management controls to be imposed. The Serpentine Groundwater Area extends from the foothills of the Darling Scarp to the western boundary of the Shire, and from Thomas Road to the Shire's southern boundary. Perth Groundwater Area extends north of Thomas Road and is bounded to the west and east by Nicholson Road and the South West Highway respectively (Figure 8).

The proposed landfill site lies on the eastern edge of the Proclaimed Groundwater Management Area (Figure 8), providing catchment for the Jandakot Mound (Perth Urban Water Balance Study) (WAWA 1987). Existing and possible future groundwater schemes within these areas are detailed in Table 7. Within the Serpentine Groundwater Area, the Karnup and Jandakot South areas are currently proposed for proclamation for Public Water Supply (Figure 8).

4.4.4 Project Site Hydrogeology and Groundwater Quality

The Stage 1 landfill area is underlain by Archean granites and dolerite dykes, with a narrow width (several metres) subcrop of steeply dipping sandstone (Neerigen Formation). The granitic and doleritic rocks have insignificant primary porosity and permeability and contain groundwater only where fractured. The Neerigen Formation has low primary porosity and permeability and only hosts significant groundwater where fractured.

TABLE 7

EXISTING AND POSSIBLE FUTURE GROUNDWATER SCHEMES

Name	Area (km^2)	Quota (mill.cu.m/yr)	No. of Wells	Most Likely Implementation Date
Jandakot Public Water Supply Area (PWSA)				
Jandakot	104 (PWSA)	5.25	15 shallow 2 artesian	Existing
~~Jandakot Stage II~~ (Approximately 2 km buffer east and west of Jandakot)	~~104~~ (PWSA)	~~4.0~~	~~20~~ shallow 1 artesian	~~1995/96~~
Jandakot South Stage I (South of Thomas Rd)	104 (PWSA)	3.1	7 shallow 2 artesian	2007/08
Serpentine Groundwater Area (GA)				
Jandakot South Stage II (South of Thomas Rd)	427 (GA)	3.1	7 shallow 1 artesian	2007/08
Karnup	427 (GA)	7.5	20 shallow 15 artesian	Post 2012

Source: Mauger 1989.

The fault which transects the Stage 1 area may provide local conduits for groundwater where fracturing has developed and remained open.

Seepage and water in-flows into the geotechnical test pits in the Stage 1 area occurred either at the base of the gravelly topsoil horizon or at greater depth, where either the alluvial soil contained a high proportion of gravel and oversize material or within the fractured bedrock zone. The more significant in-flows occurred at depth, more commonly in those pits excavated adjacent to the stream which flows through the centre of the area, but also in a few pits located on the relatively steep southern and eastern valley slopes.

The Stage 2 landfill area is underlain by the steeply dipping Armadale Shale. The shale is weathered and is poorly permeable. The near vertical orientation of the bedding planes will further reduce or prevent horizontal movement of groundwater through this unit. The effect of the fault which partially offsets this formation north of the landfill is not known. However, the Darling Fault, located approximately 500 m to the west, is a barrier to deep groundwater movement westwards into the Perth Basin.

The west of the Stage 2 area, the Armadale Shale is overlain by shallow alluvium which forms a perched aquifer. This alluvium overlies the Darling Fault and possibly provides surficial hydraulic continuity across the fault.

Geotechnical test pit depths in the Stage 2 area ranged from 1.3 m to 3.4 m with the greatest depths generally occurring adjacent to the stream on the north eastern boundary. Water was observed seeping into the base of pits 2/3, 2/6 and 2/10 at depths below 1.3 m and into pits 2/4 and 2/13 at depths below 1.9 m (Appendix B).

Water was generally observed to enter the geotechnical test pits in the Stage 3 area through the sandy soils at the base of the soil profile.

A soak on the faulted drainage line has been deepened into a small storage dam to supply water to the quarry operation. A 100 mm diameter pipe transports water to the quarry plant area and a 50 mm diameter pipe transports water to the Pioneer-owned farmhouse.

Appendix C provides details of groundwater monitor bores which have been installed on the proposed project site to collect representative baseline water quality data from the main hydrogeological formations within the project area.

At the time of sampling (5-6 January 1993), salinity ranged from 620 mg/L (TDS) in bore SL5 (located in a dolerite dyke up-gradient of the proposed Stage 1 landfill) to 4 700 mg/L (TDS) in bore SL2 (located in granite down-gradient of the proposed Stage 1 landfill). Details of other baseline groundwater quality parameters are presented in Appendix C.

4.5 Vegetation and Flora

4.5.1 Stage 1 Area

Native vegetation in the proposed Stage 1 area has been cleared for pasture establishment. Scattered mature remnant *Eucalyptus calophylla* (Redgum) and *E. rudis* (Flooded Gum) trees have been retained for shade and shelter. Pasture consists predominantly of annual legumes and grasses, with some scattered wild cotton (*Gossypium sp.*), a declared noxious weed species, also present.

Vegetation of the site, originally forming part of the Forrestfield Complex (DCE 1980) has little conservation value due to extensive clearing and grazing.

4.5.2 Stage 2 Area

Much of the area proposed for Stage 2 of the landfill has been cleared for shale extraction, and the surrounding areas severely degraded by quarrying activities. Scattered remnant *Eucalyptus marginata* (Jarrah) and *E. calophylla* exist on the margins of the site, with associated shrub species characteristic of the Forrestfield Complex (DCE 1980). Owing to the level of disturbance of the area, the conservation status of the shale pit area and surrounds is very low.

4.5.3 Stage 3 Area

A vegetation and flora survey of existing Pioneer Concrete hard rock quarry area (and proposed extensions) was conducted in 1984 and verified by a second field reconnaissance in 1991 (Stephens 1991). Literature and ground searches were conducted for Declared Rare and Endangered Flora and for species listed on the Priority Species List. No Gazetted Rare or Endangered Flora or Reserved Flora were identified during the surveys of Lot 8.

The vegetation of the existing hard rock quarry works area consists mainly of pasture grasses between scattered eucalypts, for all but the high eastern area. The eucalypts are dominantly *Eucalyptus marginata* and *E. calophylla* with scattered patches of *E. wandoo, E. rudis* and *E. patens*, with the latter two in moister sites.

On the higher ground to the east, the vegetation is similar to Jarrah/Marri Woodland, with the introduction of the typical understorey species of *Acacia pulchella, Dryandra sessillis, Banksia grandis* and *Allocasuarina fraseriana.* In the stream line and around the soak, the vegetation is similar to Jarrah/Marri Forest, although the structure reaches a thicket of *Agonis linearifiora, Paraserianthes lophantha* and *Viminaria juncea.*

Around the works areas and screen banks of the existing quarry, a variety of *Eucalyptus, Acacia* and other species are planted. These have been selected for their rapid growth and variable growth structures.

Two predominant plant communities were identified in the area of the proposed quarry extensions: Open Jarrah/Marri Forest and Jarrah/Banksia/Sheoak Woodland.

Open Jarrah/Marri Forest

The overstorey consists of *Eucalyptus calophylla* and *E. marginata* (Marri and Jarrah) in an open forest structure. Under this canopy, there is generally a dense cover of small shrubs and ground covers such as *Macrozamia reidlei, Xanthorrhoea preissii, Leucopogon capitellatus, Acaia pulchella, Hibbertia hypericoides, Hakea lissocarpha* and *Persoonia elliptica.*

In the north and south-western corners of Lot 8, the overstorey is dominantly Marri (*Eucalyptus calophylla*).

The Open Jarrah/Marri Forest appears to be free from Jarrah dieback (*Phytophora* spp.), based on the health of the understorey species. However there appears to be a significant number of deaths and dieback of both the large Marri and Jarrah trees. The cause of this is unknown, but may be related to another factor such as reduced water availability.

Jarrah/Banksia/Sheoak Woodland

This community covers all of the eastern half of Lot 8.

The tree species are characterized by *Eucalyptus calophyla, E. marginata* (Marri and Jarrah), *Banksia grandis* and *Allocasuarina fraseriana* (Sheoak). A taller shrub layer of smaller *Banksia grandis, Dryandra sessilis* (Parrot Bush), *Persoonia longifolia* (Snottygobble) and *Hakea trifurcata* is present in this community, together with low shrubs and ground covers. Typical smaller shrubs are *Leucopogon propinquus, L. capitellatus, Adenanthos barbigerus, Baeckea camphorosmae, Hibbertia hypericoides, Xanthorrhoea preissii* and *Macrozamia reidlei.*

Jarrah Dieback

Jarrah dieback (*Phytophora* sp.) has affected the eastern part of the Jarrah/Banksia/Sheoak community. In the affected area much of the vegetation has suffered dieback of the taller trees, particularly Jarrah. *Phytophora* spp. appears to be responsible because susceptible understorey species are dying or absent; notably *Banksia grandis, Xanthorrhoea preissii* and *Macrozamia reidlei.* Some areas are badly affected whilst others appear lightly affected.

The dieback appears to have spread into Lot 8 from the forested areas to the east as, at the time of the 1991 survey, the worst affected area was along the eastern boundary. There was no apparent evidence of dieback around the existing quarry and processing plant.

4.6 Fauna

4.6.1 Stage 1 and 2 Areas

No fauna survey has been conducted in these areas. The land has been largely cleared of undergrowth and is currently used for quarry stockpiling, grazing and shale extraction, respectively. The range of fauna likely to occur in this area is therefore likely to be less diverse and populous than those identified for the Stage 3 area (described below).

4.6.2 Stage 3 Area

A fauna survey of Lot 8 was conducted in February 1984. The vegetation communities were identified and the fauna likely to occur in those communities

researched and noted. Any evidence of fauna recorded during six detailed traverses was related to the plant communities (Stephens 1991).

The faunal study conducted listed 79 species of birds, 9 species of amphibians, 31 species of reptiles and 18 native mammal species as possibly being present within or in the immediate vicinity of the proposed quarry site.

The plant communities are sufficiently similar for most faunal species to overlap through the communities. For example, the Short-Beaked Echidna (*Tachyglossus aculeatus*) and the Chuditch (*Dasyurus geoffroii*) are likely to be found in any of the plant communities. However, the ground frog (*Geocrinia leai*) will probably be restricted to the moister areas near the stream.

For Lot 8, the current status of some listed species is uncertain owing to their inherent rarity, frequent spring burning, clearing of firebreaks and access roads and the introduction of exotic fauna.

The indigenous fauna of much of the land other than Lot 8 has been severely affected by clearing and farming operations although isolated species may have benefited (e.g. Australian Magpie, *Gymnorhina tibicen*).

Rare and Endangered Fauna

No rare or endangered fauna were recorded during the faunal survey, however the following rare or endangered fauna were identified as possibly being present. They are gazetted as Rare or in need of special protection in the Government Gazette (16 November 1990):

Chuditch	*Dasyurus geoffroii*	Schedule 1
Numbat	*Myrmecobius fasciatus*	Schedule 1
Peregrine Falcon	*Falco peregrinus*	Schedule 2
Carnaby's Black Cockatoo	*Calyptorhynchus funereus latirostris*	Schedule 2
Baudin's Black Cockatoo	*Calyptorhynchus baudinii*	Schedule 2
Carpet Python	*Morelia spilota imbricata*	Schedule 2

Note: Schedule 1 - Rare fauna likely to become extinct;
Schedule 2 - Fauna that is in need of special protection.

4.7 Significant Landscape and Conservation Areas

The following regional landscapes and environments are considered important in terms of the Shire of Serpentine-Jarrahdale's rural strategy (AGC Woodward-Clyde 1991).

4.7.1 System 6 Recommended Areas

The Shire of Serpentine-Jarrahdale encompasses 14 sites affected by area-specific System 6 recommendations (Department of Conservation and Environment 1983). The sites are shown on Figure 9 and the relevant recommendations are presented in Table 8. None of these locations are in close proximity to the proposed Southern Landfill site.

4.7.2 The Darling Escarpment

The steep, widely visible Darling Escarpment and its valleys and foothills are scenically valuable landscapes which have a variety of habitats and support specialized and characteristic flora. These area are prone to bushfires and are easily degraded by land clearing and unsympathetic development. Much of the Escarpment is protected by reserves but large areas remain in private ownership and require stringent development controls (State Planning Commission 1987).

The Shire of Serpentine-Jarrahdale has such controls in its current Town Planning Scheme No. 2 which contains a landscape protection policy stating that:

- subdivision will generally not be supported;
- buildings will not be permitted on ridges or where slopes are greater than 25%;
- other buildings require consent and are to be built on sites such as to limit visual intrusion;
- overall tree cover to be increased by tree retention and additional planting; and
- landholders are to prevent stock damage to trees.

The general area of landscape value along the Escarpment is 9 368 ha, within which the visually prominent areas (1 829 ha) are shown on Figure 9. These areas are encompassed within proposals to extend and consolidate the Parks and Recreation reservations in the Metropolitan Region Scheme into a system of metropolitan parks (State Planning Commission 1987).

4.8 Human Environment

4.8.1 Shire of Serpentine-Jarrahdale

Serpentine-Jarrahdale Shire has a peripheral urban location and has been growing constantly since 1966. In the five years from 1966 to 1971, the population of the Shire grew by 14.6%. From 1971 to 1976, the growth rate had fallen to 6.9%, paralleling a general decline in the local economy (Croft 1991).

Over the three statistically comparable population survey periods, the Shire has grown on average by 3.3% every year. At this rate the population will double every 22 years. If the trend was to continue the Shire would have 12 800 residents in the year 2009 and 25 600 by the year 2030 (Croft 1991).

TABLE 8

SYSTEM 6 RECOMMENDATIONS

M83 *Reserve C2457 Mundijong*
It was recommended that the purpose of the reserve be amended to Conservation and Flora and Fauna and vested appropriately. This has been implemented.

M84 *Gooralong Management Priority Area (MPA 8.4)*
M86 *Karnet Management Priority Area (MPA 3.8), and*
M87 *Serpentine Management Priority Area (MPA 8.7)*
These areas are contiguous and were the subject of the Reserves Review Committee recommendation that the entire Gooralong MPA, including both core and buffer, be designated as a conservation reserve. Amendments were recommended for the boundaries of the Karnet and Serpentine MPAs.

The recommendations have been implemented through the gazettal of Reserve A39825, which is for the purpose of National Park. However, this area excludes Reserves 988 and 990 which, in the System 6 recommendation, were intended to be added to the former MPA (now National Park). Reserve 988 is adjacent to the eastern boundary of the Millbrook Special Rural zone, and Reserve 990 is then located 1.5 km to the south-east. Although the intent to incorporate these reserves into the national park remains, no specific time-frame has been established by Government (F Keating, EPA, personal communication).

M85 *Serpentine National Park*
It was recommended that various reserves, freehold land held by the Crown, and part of the State Forest within Gooralong MPA be added to Reserve A28862 (Serpentine National Park). The recommendations still stand.

M88 *Land north of Keysbrook*
It was recommended that means of providing protection and to increase the umbers of salmon white gums in the area be sought. Part of this area is within the 'Tallagandra' Special Rural zone and specific tree protection provisions apply (Western Australian Government Printer 1989).

M89 *Woodland east of Keysbrook*
This area has significant landscape value and contains a very early jarrah logging trail. It was recommended that part of the State Forest be managed by CALM for conservation of scientific and historic aspects, and education of the public, and that ways and means of protecting the remainder were sought. Area now occurs within the designated landscape protection area of the Shire's planning scheme (Western Australian Government Printer 1989).

M99 *Reserve A25886*
M100 *Reserve C28167*
It was recommended that the existing purpose and vesting of these reserves is endorsed (Conservation of Flora and Fauna, vested in the Western Australian Wildlife Authority).

M105 *'Lowlands' Property, west of Serpentine*
It was recommended that the Government recognize the conservation value of the uncleared woodland of the property and, in consultation with the landowner, investigate ways and means of protecting it. The area is recognized as a significant area of remnant vegetation and is listed within the Shire's planning scheme (Western Australian Government Printer 1989) as a place of natural beauty of historical or scientific interest where clearing of land or removal of trees shall not proceed without the approval of Council.

M108 *Geogrup Lakes*
Only a small portion of this area occurs within the Shire. It was recommended that general planning and management recommendations for Regional Parks be applied here.

C37, C39 Albany Highway and Windsor Management Priority Area
Margins to the Albany Highway constitute open space of regional significance because of their value for conservation, for roadside display and for scientific study. The Windsor Management Priority Area contributes to open space of regional significance because of its high scenic, conservation and recreation values. It was recommended that general planning and management recommendations for Regional parks be applied here.

Source: Department of Conservation and Land Management (1983).

From 1981-1986, the real increase in settlers into the Shire was probably 25-30% of the population as traditional broadacre farming came under increasing pressure to subdivide large properties into smaller ones (Croft 1991).

It is likely that this trend will continue as more people move into the area, and as the ecological and economic constraints make conventional farming a less viable enterprise. The growth of intensive horticulture and orchards in the area, which has shown some increase over the last 30 years, is likely to continue once techniques of organic agriculture and low fertilizer applications and nutrient load management are implemented to comply with Government initiatives to reduce surface and groundwater eutrophication problems.

Over the course of the two decades since the late 1960s, the agricultural sector had been able to maintain itself, albeit in a reduced fashion, as the economic base of the community. The future of farming in the Shire will depend upon the economic incentives available to it. If farmers can make more money from quick returns as land developers, they are likely, given the present rewards of our economy, to take this route (Croft 1991).

4.8.2 Existing Land Use Adjacent to the Project Site

The proposed landfill site comprises the current Pioneer Concrete quarry operations (Lot 8), grazing land (Pt. Lot 3) and the clay shale pit (Pt. Lot 6). The quarry is bordered to the west by grazing land held by the Government for Mental Health Purposes. To the north-west and south-west is privately owned grazing land and to the east partially degraded forest (State Forest No. 22). The shale pit is bordered to the west by a motor cross track (Hendley Park Motorcross) which was previously a gravel extraction pit (Figure 10).

Part of State Forest 22 was mined to within 2.5 km of the proposed landfill between 1978-80, and there are active mineral claims for heavy mineral sand to the west from South Western Highway, 2.5 km from the proposed extension of the hard rock quarry. To the north, 2.5 km away, is a claypit and associated brick manufacturing plant which belongs to Metro Brick (Bristile Ltd) (Figure 10).

Approximately 1 km to the south-west is an entertainment complex and Deer Park. Across South Western Highway, 2 km to the north-west, is an operational saw mill. The Manjedal Scouting Centre is located 1.1 km south-west from the proposed extension to the hard rock quarry (Figure 10).

Scattered farmhouses are located on nearby properties. The closest are the quarry caretaker's house located approximately 400 m south-west from the hard rock quarry operations, a private dwelling 900 m north from the quarry crushing plant, and a private dwelling 800 m south-west from the current quarry and crushing plant (Figure 10).

Hardrock Quarry

Pioneer Concrete has extracted hard rock from the Byford Quarry since 1976. Prior to that time the quarry had been worked on a smaller scale, but was disused when Pioneer took over the operation and commenced excavation.

Access to the existing quarry is via South West Highway. From the Highway a sealed bitumen access road runs east up the hill and then deviates round the slope to the weighbridge. The road is 1.2 km long and is fenced for its length. A lockable gate is located at the end of the straight section, 900 m from South West Highway. This gate is locked at all times outside normal working hours.

The quarry presently operates from 7.00 am to 4.00 pm Monday to Friday. Types of equipment currently in use (Stephens 1991) are:

- primary, secondary and tertiary crushers with related screens and conveyor belts;
- 35 tonne off-road dump trucks for internal transport of rock from the pit to the crusher;
- rubber-wheeled loaders, e.g. Caterpillar 988;
- track-mounted percussion drill and compressor (Gardner Denver 750 Airtrack);
- 20 tonne water truck for dust suppression; and
- 33 tonne total capacity truck and trailer combinations for transporting hard rock products from the quarry.

Currently, there are usually 40-45 laden truck movements per working day.

Shale Pit

Bristile is recovering clay from the shale pit to a depth of about 10 m from the original ground surface. The company has future plans for a northern extension to the existing shale pit to win additional suitable clay materials.

4.8.3 Heritage Places

Shire of Serpentine-Jarrahdale

Heritage places are important to the Shire's identity, culture and history, as well as to tourism. Places considered by the Shire Council to be of historic, architectural, scientific, scenic or other value and which should be retained in their present state or restored, are listed in Appendix 13 of Town Planning Scheme No. 2. In general, the Scheme provisions prevent any development or

alteration to these areas (including clearing of land or removal of trees) without Council approval.

Various historic sites exist within the Shire. The locations of Aboriginal sites protected under the *Aboriginal Heritage Act (1972-1980)* are generally not publicized. The Bibbulmun Track bushwalking trail traverses the State Forest area from north to south, west of Serpentine Dam, and passes through many scenic areas. The Track is now a registered heritage trail (AGC Woodward-Clyde 1991).

Various historic sites recorded since European settlement reflect the development patterns of the agricultural and timber industries, some of which are listed in Appendix 13 of Town Planning Scheme No. 2.

Project Site

An archaeological and ethnographic study of Lot 8 (Stage 3 landfill area) was conducted in 1985 (Stephens 1991).

Lot 8 has been subjected to logging, numerous bushfires and the construction of firebreaks and access tracks. The resulting disturbance of the surface and the removal of large trees will have rendered valueless anything less than a large and extensive archaeological site (Stephens 1991).

A systematic site survey failed to find any artefacts of "lithic waste" materials, nor any indication of early Aboriginal occupation of the area (Stephens 1991).

An examination of the available literature failed to find any references to the proposed quarry site or the surrounding area, and the Department of Aboriginal Sites of the Western Australian Museum has no records of significant sites in the area (including Stages 1, 2 and 3 of the proposed southern landfill).

No archaeological or ethnographic study has been conducted in the areas proposed for Stage 1 and Stage 2 of the Southern Landfill. As discussed in Sections 4.5.1 and 4.5.2, the areas have previously been subject to extensive clearing and disturbance associated with pastoral grazing and quarrying/shale extraction operations.

4.8.4 Land Use Planning and Management

4.8.4.1 Regional Zoning and Development

The South East Corridor Plan (Metropolitan Region Planning Authority 1978) is the current regional plan for the area. The Plan recognizes the importance of the clay, shale and hard rock reserves of the area east of South Western Highway and the need to prevent sterilization of the resources by urban development. In addition the Darling Scarp was recognized for its aesthetic value and it was recommended that the Scarp should continue to be reserved for parks and recreation. The South East Corridor Plan foresaw the need for urban

expansion in the area and proposed that a corridor of urban development, 3 km wide, be planned for the area between South Western Highway and Hopkinson Road, encompassing Byford and Mundijong (AGC Woodward-Clyde 1991).

Currently, there is a plan being considered by the Department of Planning and Urban Development (DPUD) for the creation of more urban land in Byford, north of Nettleton and Mead Roads. The remainder of the Byford-Serpentine area to the west of South Western Highway is classed as Future Urban Area Category B (suitable, but currently constrained; which may become available within 30 years). The only effect the proposed landfill is likely to have on any additional urbanization would be the transport of refuse through the expanded urban area.

The area east of South Western Highway (including the proposed landfill site) is zoned Rural (Figure 11) and is presently used for this purpose, with the exception of the Special Use and State Forest areas (Figure 11). The South East Corridor Plan recommended that the area continue to be rural with lot sizes of greater than 20 ha.

4.8.4.2 Water Resource Management

The protection and conservation of water resources are issues of major importance not only for local purposes but also in terms of their potential to contribute as a source for Perth's water supply. Demand for use of water resources within the Shire of Serpentine-Jarrahdale will continue to grow with the major consumers being urban uses (including Perth), industry and agriculture. Although "export" of water outside the Shire is objected to by some residents, it is consistent with the concept that the State's water resources, regardless of location, are of value to the community as a whole (AGC Woodward-Clyde 1991).

Some land uses can result in changes in local hydrology, the pollution of surface and groundwater resources or excessive water abstraction. These can lead to reduced water and increased costs for public and private water supply, wetlands drying up, overfilling or becoming eutrophic, and salinization of groundwater. There is therefore a need to manage water resources in order to:

- conserve public water supply
- control flood waters
- protect flora and fauna
- provide fire protection
- avoid erosion and pollution; and
- maintain recreation resources.

There are several existing government policies and guidelines relating to water resource management which are of particular relevance to the current project:

Environmental Protection Authority/Department of Agriculture

- Zero off-site nutrient export is the objective for general industry, intensive animal industry and horticulture.

Water Authority

- Groundwater usage within the areas proclaimed as Public Water Supply Area or a Groundwater Area is controlled by the issuing of licences by the Water Authority. For any type of water usage, a licence is required prior to drawing water from an existing bore, installing a new bore, or altering an existing bore.

- Within or adjacent to public water supply areas, rural irrigation will be in competition with public water supplies for available groundwater. As a general guide, the proportion of land that can be irrigated within the limits of sustained availability is 1 ha in every 10 averaged across the area. However, factors such as existing groundwater usage, water availability and land management practices will vary greatly.

Department of Planning and Urban Development

- Rezoning of land or subdivision applications will not be supported where it is considered that water resources (groundwater or surface water) are likely to be polluted and/or diminished to the detriment of public water supply systems

4.8.4.3 Vegetation Protection

The need to protect vegetation, particularly remnant vegetation, is now widely recognized at both government and public level. Remnant vegetation may be considered as areas of native vegetation which are not used for grazing and where the understorey is largely or completely intact.

4.8.4.4 Soil Erosion

Department of Agriculture/Shire of Serpentine-Jarrahdale

- Under the *Soil and Land Conservation Act (1945-82)*, if the Commission of Soil Conservation considers that particular land management practices are resulting in, or likely to result in land degradation, he may serve notice on the owner or occupier of the land to alter his management to minimize land degradation.

- Any owner or occupier of land shall be responsible for appropriate measures to prevent dust pollution and soil erosion. Council may require remedial action where, in its opinion, a use or activity is likely to contribute, or is contributing, to dust pollution or soil erosion.

Environmental Protection Authority

- Adequate buffers of indigenous native vegetation should be retained/planted along margins of watercourses to maintain stability of banks.

4.8.4.5 Bush Fire Abatement

Shire of Serpentine-Jarrahdale

In bushfire-prone areas, the Shire of Serpentine-Jarrahdale (following advice from Bush Fires Board of CALM) may specify that:

- subdivider may be required to provide a 92 000 L tank for fire fighting purposes;

- 'strategic' firebreaks shall be cleared to a width of twice the normally specified firebreak width; and

- additional access/exit routes be provided.

5 DESCRIPTION OF THE PROPOSAL

5.1 Proposed Site

5.1.1 Location

The proposed Southern Landfill site is located in a small valley of the Darling Scarp, 1 km east from the South Western Highway, 45 km south-east of Perth City centre, 5 km south from Byford and 4 km north-east from Mundijong (Figure 1). The site comprises an existing hard rock quarry and proposed area of extension, a clay shale pit, and a valley which is presently farmland.

The existing valley area required for Stage 1 of the filling operations is about 11.5 ha, with an additional 16 ha to be used for the necessary site facilities including workshops, truck parking, garden waste composting area, weighbridge, site manager's office and amenities building (Figure 12).

The proposed Stage 2 area includes the Bristile Shale Pit and an area of approximately 1.7 ha lying immediately to the north of the shale pit (Figures 2 and 12).

The Stage 3 area includes the hard rock quarry currently being operated by Pioneer Concrete and an extensive area lying to the south and south-south-east of the existing limits of the quarry which will be used for quarrying prior to establishment of the Stage 3 landfill (Figure 7).

Access to the site is currently via a sealed road which joins South Western Highway 0.9 km south of its junction with Norman Road (Figure 10).

5.1.2 Zoning and Land Use

Under Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2, the land encompassed within the proposed project site is currently zoned as follows (see Figure 11):

- Lot 8 Cockburn Sound Locations 214, 1051, 2779 and portion of Cockburn Sound Locations 326 and 422 - Special Use, with permitted use being extraction and processing of hard rock and clay.

- Lot 6 of Cockburn Sound Loc. 22 - Special Use, with permitted use being extraction and storage of shale and clay.

- Portion of Lot 3 Cockburn Sound Location 22 - Rural.

- The Special Use zoning permits only the specified uses (as listed in Appendix 2 of Town Planning Scheme No. 2) to be conducted on land with that zoning category. Activities which can be conducted on rural land are less specific. Under the Metropolitan Region Scheme, landfilling and associated activities are not deemed to be incompatible with the existing rural zoning of the subject land.

- For the purposes of the proposed Southern Landfill development, the Shire of Serpentine-Jarrahdale has stated a preference for the land encompassed by the project site to be rezoned/amended to Special Use to enable the Shire to have administrative control over all activities that are undertaken on the site. In addition to existing permitted uses as defined in Appendix 2 of Town Planning Scheme No. 2, application has been made by Pioneer-BFI Waste Services to have the project area zoning amended to permit use for "waste disposal and associated activities, and composting activities".

5.1.3 Ownership

Pioneer Concrete (WA) Pty Ltd owns all Lots occupied by the existing hard rock quarry (Lots 214, 1051, 326, 2779, 422 and Pt. 499) (Figure 3). Bristile owns Lot 6. Mr P Nairn owns Lot 3 (Figure 3). Subdivision applications have been lodged with the Department of Planning and Urban Development to subdivide Pt. Lot 3 and Lot 6 to form Pt. Lot 3 (to be amalgamated with Lot 8) and Pt. Lot 6 which will be purchased from the current owners.

5.2 Planning

5.2.1 Staging

It is proposed that the Southern Landfill will be developed in three stages commencing with a valley landfill, then progressing to the clay shale pit, and then to a third and final stage in the hard rock quarry. Each stage will comprise a number of individual waste disposal cells.

The existing vegetation, which must be removed as part of site development for each stage, will be cleared progressively as required.

Following vegetation clearance from each of the first and second waste disposal cells, the walls and floor of the first cell will be shaped during which excess material suitable for the daily covering of refuse will be stockpiled in a convenient location on the second cell. The base of the cell will then be lined and graded to the leachate collection sump located at the lowest point of the landfill (see Figures 13 and 15).

When each cell is completely filled it will be capped with an engineered barrier system (Figure 19). The final surface of the completed cell will be revegetated with grass to minimize erosion of the landfill cap system to blend into the surrounding landscape (Figures 14 and 16).

The estimated operating lives of Stages 1 and 2 are 8-10 years and 5-6 years, respectively. The third stage has a potential operating life in excess of 15 years if the proposed additional quarrying is undertaken by Pioneer Concrete.

5.2.2 Waste Streams and Waste Generation

The landfill will accept non-putrescible and putrescible solid waste only from domestic, commercial and industrial sources. Radioactive, hazardous, soluble chemical waste and liquid wastes will not be permitted. Details of waste acceptance criteria and screening are presented in Appendix E.

5.3 Proposed Method of Operation

5.3.1 Development Concept and Design Philosophy

Facilities for detailed screening of wastes will be provided at the entrance to the site to ensure the suitability of incoming wastes of industrial origin. As a further security measure, detailed logs of transactions will be maintained, identifying source and ownership of the waste.

Entry to the site will be strictly controlled and granted only to private contracted transporters and municipal waste collection vehicles.

Restricted access to the landfill not only significantly reduces traffic to and from the site, but permits a smaller tipping face to be maintained with the resultant benefits of reduced odour, litter and leachate generation.

As a result of recent changes relating to public access to tipping faces after December 1995, Pioneer-BFI Waste Services anticipates that waste transfer stations will be established in generation areas throughout the south-eastern region of Perth. The South East Zone Waste Management Audit (Sinclair Knight & Partners and Bowman Bishaw Gorham 1991) made recommendations for Community Transfer Stations to be constructed at the Kelvin Road, Hopkinson, Roleystone and Mundijong landfill sites.

Pioneer-BFI Waste Services is committed to providing a contribution of $20 000 towards the provision of a transfer station at the Mundijong landfill site to obviate the need for direct public access to the tipping face of the Southern Landfill.

Waste from transfer stations will be hauled to the Southern Landfill in specially designed transfer vehicles.

5.3.2 Design Features

The proposal for the Southern Landfill incorporates specific design features that are important in terms of satisfying the principles reviewed above. It is intended that the site will be fully developed in accordance with these design features from the outset. The initial development plan is presented on Figure 12.

Key engineering measures of site development will include the:

- Provision of stormwater diversion drains to divert runoff generated in areas outside of the active landfill cell to minimize leachate generation (Figure 12).
- Construction of a low permeability lining system on the base and walls of all waste disposal areas to ensure the safe containment of leachate (Figure 19).
- Installation of leachate collection and storage facilities to minimize leachate accumulation above the lining system (Figure 20).
- Construction of a composite low permeability landfill cap (Figure 19).
- Provision of a landfill gas control system to minimize odour generation, prevent off-site migration of gases and to protect vegetation planted on the rehabilitated landfill surface (Figure 22).

Further details on site development are contained in Appendix E.

(i) Stormwater Control

The proposed Southern Landfill site is located in a valley at the toe of the Darling Scarp. The proposed development will block the existing creek line and hence will require stormwater diversion drains to direct flow from further up the valley around the landfill perimeter (Figure 12). The existing creekline conveys stormwater and seepages from the ridges on either side of the valley before meandering out across the Swan Coastal Plain.

The stormwater management system proposed for the site will consist of two components. An external network of contour drains will be constructed up-gradient of the development to ensure that discharges generated on the higher areas of the catchment are diverted around the landfill (Figure 12). An internal system of drains will be provided to capture stormwater runoff generated within the site, other than that which has come in contact with the active waste disposal area (Figure 21). These discharges will be diverted to a sedimentation pond, where sediment loading of the water will be reduced prior to release to the natural drainage system (Figure 20).

(ii) Leachate Control

Leachate is the liquor produced when water percolates through refuse. During the time of contact the soluble components of refuse are taken up by the liquor, causing contamination and potential for pollution.

The landfill will be operated in such a manner as to minimize the production of leachate. This includes the provision of perimeter diversion drains to prevent the inflow of surface runoff from areas external to the site, and the controlled development of the landfill whereby the site is filled in a series of cells, with each cell being capped following its completion to reduce the infiltration of stormwater flows.

A leachate collection system consisting of slotted agricultural pipe, sand and filter cloth will be installed (Figure 20). Collected leachate will gravitate to a central sump from which it will be pumped to a leachate holding tank for storage and recirculation back through the fill or transferred to tanker trucks for off-site disposal (Figures 13 and 15).

The construction of a low permeability liner on the base and walls of the waste disposal areas together with a formal leachate collection system will ensure that leachate is effectively contained within the site and that contamination of the ground and surface water systems does not occur.

(iii) Liner

The lining system proposed is a multilayer design comprised of the following components (Figure 19):

- a 1 m thick compacted clay liner having a permeability not exceeding 1 x 10^{-9} m/s and a gypsum content of less than 1%; and
- a 300 mm sand or gravel drainage blanket to be placed above the liner to provide protection against cracking of the clay material resulting in desiccation.

(iv) Low Permeability Cap

When each cell is completely filled, it will be capped with an engineered barrier system to prevent rainfall infiltration into the landfill (Figure 14).

(v) Landfill Gas Control

Landfill gas is formed as a result of the anaerobic decomposition of organic matter present in waste. The gas comprises principally methane and carbon dioxide. Uncontrolled emissions of this gas can, under particular circumstances, give rise to odours and present an explosion risk. If not controlled in unlined sites, the gas can migrate through the soil and appear some distance from the site.

To ensure that landfill gas does not cause detriment to vegetation near the landfill, a gas extraction system comprising a series of recovery wells will be installed following completion of each stage of landfill development (Figure 22).

Seismic Stability

As part of the broader Perth region, the Cardup locality is within seismic zone A according to Australian Standard 2121-1979 (SAA 1979). Section C3.3(a) states: "Zone A covers those areas where the shaking expected should be satisfactorily withstood by reasonably ductile buildings without specific design for lateral forces due to earthquakes".

The conservative design of the landfill with shallow slopes, fully compacted refuse and containment bunds and relatively flexible clay liners should provide more than adequate resistance to any seismic event that could reasonably be expected in the Cardup locality.

5.3.3 Development and Operational Features

In addition to the preceding design features, the landfill proposal also incorporates a number of development and operational features which will facilitate realization of the principles discussed in Section 5.3.1. These development and operational features are discussed below.

Site Preparation

Site preparation for Stage 1 of the landfill will involve progressive clearance of vegetation, removal and stockpiling of topsoil and excavation and grading of subsoil to form a base for the liner which has a continuous fall (Figure 17). The existing stream which passes through the Stage 1 site will be diverted to flow around the perimeter of the landfill.

Excavation will be completed in areas required for Stages 2 and 3 of landfill development prior to cell construction. The specific condition in which excavated areas are to be left following completion of the quarrying operation will be established through consultation between Pioneer-BFI Waste Services and the extractive industry operator (Bristile and Pioneer Concrete), and through conditions attached to the Extractive Industry Licence applying to the operations.

On completion of the extraction and quarrying operations, preparation of the site by Pioneer-BFI Waste Services to facilitate establishment of the landfill will entail the following.

Preparatory to installation of the compacted clay seal, the residual layer left by the extractive industry operators will be partially removed to provide sufficient quantities of stable inert fill for later use as construction and cover materials in the landfill. As part of this process, the final surface of the excavated area will be graded to allow gravity drainage across each of the landfill cells (see Figure 17).

Pit walls constructed during the quarrying operations will be modified by Pioneer-BFI Waste Services if required to provide a safer slope and to aid run-off control.

Cell Formation

The landfill will be developed progressively as a series of sealed cells within which refuse will be deposited, compacted and covered. The first cell of Stage 1 will be sized to accommodate two years' refuse, subsequent cells will be sized to accommodate approximately one year's refuse, thereby allowing closure and capping before the deposited material reaches field capacity and generates leachate (Figure 13).

The landfill cells will be progressively constructed over the 12 month period of their use, by regularly raising the perimeter embankments and interposing layers of refuse with clean fill material. The frequent placement of cover material will reduce exposure of the refuse to pest species and minimize wind blown litter and odours. Additionally, the cellular approach will facilitate progressive rehabilitation of the overall site, and will maintain operational flexibility (i.e. in terms of modifying practices in response to experience).

Cell Sealing

Two options for sealing the landfill cells have been considered, these being compacted clay and a composite of clay and a synthetic barrier membrane. A clay liner is the preferred option if sufficient quantities of clay are available at an economical price.

Testwork undertaken indicates that clay with suitable geotechnical and geochemical qualities for lining of the landfill cells should be available from local sources (see Appendix B). The clay ultimately used for the liner will be required to meet the specifications indicated in Section 5.3.1.

Further geotechnical testwork will also be undertaken before placement of the liner, to ensure the workability of the clay. This will include construction of field trial pads to proposed specification and sampling for permeability testing, to establish that permeabilities achieved in the laboratory are in fact achievable during construction of the liner.

Both the excavation of the clay for the liner and the construction of the clay liner will be supervised to ensure only materials that have been tested and found suitable are utilized. The clay will be compacted in thin layers (no more than 300 mm loose thickness) and density and moisture content will be controlled by continuous compaction testing. A Quality Assurance/Quality Control assessment report will be prepared by independent geotechnical consultants for each section of liner constructed.

A clay starter embankment of 2 m height will be constructed around the perimeter of the liner to prevent leachate and stormwater leaving the active cell. The starter embankment will be constructed in a similar manner to the clay liner.

On completion of the clay basal liner and starter embankment, a 300 mm drainage blanket of permeable material (gravel or sand) will be installed on the upper surface of the basal liner (Figures 19 and 20). This will form part of the leachate collection system.

Any area of clay liner or embankment constructed substantially in advance of the landfill operation (2 to 6 months depending on seasonal conditions) from clays susceptible to cracking will be watered as necessary to control variation in moisture content.

If adequate supplies of clay suitable for construction of the 1 m thick basal liner cannot be located, a composite clay/synthetic barrier membrane liner would be utilized as the landfill basal seal. An alternative lining system is high density polyethylene (HDPE) membrane and a clay composite.

Two millimetre HDPE membrane could be used in conjunction with a 600 mm thick compacted clay foundation layer (permeability of 10^{-8} m/s) to provide additional containment and attenuation capacity (Figure 19). In this event, the surface of the clay would be graded and all irregularities that could puncture the HDPE removed. A 300 mm thick protective layer of coarse sand would be placed over the HDPE membrane to protect it from puncture. Where required, a geotextile fabric layer would be laid beneath the clay layer.

In the event that a suitable clay source is not readily available and a barrier membrane liner is to be used, a further report specifying the liner system to be installed would be submitted to the EPA and Health Department for endorsement prior to commencement of construction of the landfill cell(s) within which the alternative lining system was to be installed. This report would also explain the leachate collection system to be installed in conjunction with the barrier membrane liner.

Leachate Collection and Disposal

Low levels of leachate production are anticipated because the active life of each of the landfill cells would be limited to about twelve months. Information about leachate generation is provided in Appendix D. A leachate drainage collection system will be installed in conjunction with construction of the clay liner, with the liner being graded to ensure that leachate will flow to the collection drains. This will comprise a 300 mm deep drainage blanket (e.g. coarse sand) immediately above the basal clay liner and a series of drains consisting of high strength, 150 mm diameter, drain coil pipe will be installed in this layer (Figure 20).

The clay liner will also be graded to promote gravity drainage of leachate to a double-lined sump located on the perimeter of the currently active landfill stage.

The sump will be constructed at the same time as the clay liner, thereby ensuring that all run-off would accumulate in the sump. The design storage volume of the pump will be determined by suitable modelling during the detailed design phase. A HDPE liner will be installed in the sump and covered with gravel screenings (Figure 20).

The Proponent will initially construct a permanent leachate storage tank(s) to service all landfill cells within Stages 1 and 2. A second permanent leachate storage tank will be constructed for Stage 3. The tanks will be covered and bunded appropriately. The leachate storage tank(s) will be sized according to the results of leachate volume estimation modelling.

Leachate collected in the tank will be recycled by pumping through an irrigation system into and onto the active landfill cell. This will increase the stability of the waste by inducing further settlement and reduce the quantity of leachate requiring disposal. The irrigation system will involve pumping the leachate into slotted pipes (Corflo) to effect trickle irrigation. There will be no spray irrigation and therefore wind dispersion of leachate is not expected to occur.

Sediments will need to be periodically removed from the leachate tank and, because of their elevated salinity, disposed of in a secure landfill or other form of secure disposal facility. While landfilling continues, these sediments will be disposed of on-site (to the active landfill cell). However, upon closure of the site, alternative arrangements for the disposal of the sediments will be necessary. Pioneer-BFI Waste Services recognizes this as an ongoing requirement following closure of the site.

Placement and Compaction of Refuse

Refuse will be progressively placed and compacted into thin layers of approximately 0.3 m compacted depth in lifts of 2 m in height. Compacting in thin layers will ensure the maximum refuse density (in the vicinity of 850 kg/m^3 using a dedicated refuse compacting machine) is obtained thereby minimizing potential subsidence of the rehabilitated site, and maximizing the storage volume available and strength of the completed cell against shear failure of the outer slopes. Voids which could harbour pest species will also be eliminated.

Cover material will be placed daily over the compacted refuse, to minimize refuse exposure and associated environmental problems such as wind blow litter, odours and availability of food for scavenging animals. The depth of cover material placed will be not less than 150 mm in the case of soil.

Intermediate cover will be applied to the top of active landfill area, and to surfaces which will be exposed to the environment for periods greater than six weeks, in layers of not less than 300 mm thickness (Figure 19).

Cover material will be sourced from on-site overburden stockpiles remaining from quarrying operations and the preparatory site earthworks.

Cell Completion

As indicated, the landfill will be constructed as a series of cells. Once filled, each cell will be decommissioned and will not require further attention except for routine rehabilitation maintenance and monitoring of landfill gas.

Each cell (with the exception of the first cell) will be filled to completed height over a period of approximately twelve months. Once filled, the refuse surface will be covered as follows (Figure 19):

- 300 mm minimum layer of low permeability clay over the intermediate cover;
- 300 mm layer of sub-soil; and
- 100 mm minimum layer of topsoil suitable for vegetation establishment.

The final layer of refuse and the composite covering layers will be designed to achieve a predetermined crossfall to enhance surface drainage and safeguard against erosion (Figure 17).

Finished contours will not constrain future use of the site for the long-term end use to be identified for that area. Cells will be progressively rehabilitated following closure, capping and covering. Shallow rooted native vegetation (species selection being based on advice from the Department of Conservation and Land Management) will be established on the individual cells as soon as practicable following closure.

Composting Facility

Garden waste accounts for almost 10% of the waste stream currently being disposed to landfill by weight and an even greater percentage by volume.

To conserve valuable landfill space and assist in the community goal of waste minimization, Pioneer-BFI Waste Services proposes to establish an on-site facility for composting garden wastes and other suitable vegetation. To ensure that the facility does not result in the generation of offensive odours, highly putrescible matter such as food processing wastes will not be composted.

Specially designed windrows can biologically decompose vegetation under controlled conditions to a valuable product which can be used as a soil ameliorant and conditioner.

It is intended to utilize compost produced on-site for landscaping the rehabilitated areas and as the final top soil for the filled and capped areas.

Establishment of the composting facility will be subject to demand as dictated by the nature of the wastes which are supplied to the Southern Landfill for disposal. Consequently, design details for the composting facility have not yet been formulated. Should the volume of garden and vegetation wastes being supplied to the landfill justify the establishment of the composting facility, the Proponent will submit detailed design and a management plan to the EPA and Health Department of WA for approval, prior to construction of the facility.

Surface Water Runoff Disposal

All surface water runoff from within an active cell will be treated as leachate. Perimeter embankments will prevent run-off from other areas entering the active landfill cell.

Runoff from the landfill area beyond the active cell, including the capped landfill cells and the outer slopes of the active and completed cells, will not contact refuse and will, therefore, be uncontaminated. This runoff will be directed to the natural drainage system via the sedimentation basin (Figure 12).

Gas Collection

The rate of gas production will be maximized by recirculating collected leachate through a slotted pipe trickle irrigation system. Cells will be capped with an engineered barrier system upon completion, and the site drainage system will direct any uncontaminated runoff away from the landfill cells.

The Proponent will prepare and implement a methane gas management plan to the satisfaction of the EPA and the Health Department, and will liaise with the relevant authorities regarding beneficial uses of landfill gas over the operating and post-closure life of the landfill.

Buffer Zones

Buffer zones to minimise the risk to health and safety of the community and adverse impacts on the environment will comprise two levels:

(i) An on-site buffer zone which includes all non-operational areas within the boundaries of the project site. This zone will be administered and managed by the Proponent for the lifetime of the entire landfill operation and post-closure management period;

(ii) An off-site buffer which complies with the Health Department of WA requirements for a minimum separation distance between an active landfill and residential development. This zone will in fact consist of three areas which extend from the perimeter of each landfill stage. Only one buffer area will be in place at any one time, according to which landfill stage is active. These areas will necessarily extend over neighbouring properties. Land use of the off-site buffer zone will be subject to the provisions of the Metropolitan Regional Planning Scheme,

the Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2 and the Shire of Serpentine-Jarrahdale Rural Strategy.

On-Site Buffer Zone

The on-site buffer zone will be vegetated, although it will be necessary to construct a firebreak/access track around the entire site. This will be constructed immediately adjacent to the perimeter fence (Figure 12).

The natural vegetation will be retained within the buffer wherever practical, thereby providing additional screening of the site. Additional vegetation will be established within the buffer as required to provide further screening of the site.

The Proponent will prepare a landscaping plan which will be developed to achieve the following objectives:

(i) That initial planting is undertaken between the landfill and neighbouring properties in the planting season before or immediately following the start of the site development earthworks, whichever is the earlier; and

(ii) To allow integration with the longer-term Post-Closure Plan.

The landscaping plans will be submitted within six months of the granting of all the necessary approvals to commence landfilling operations.

All initial plantings will be maintained at all times, and any losses replaced immediately, to the satisfaction of the Shire of Serpentine-Jarrahdale.

Off-Site Buffer Zone

Figures 23, 24 and 25 show the proposed areas of the off-site buffer, for zones extending 200 m and 500 m respectively from the perimeter of each landfill stage. The 200 m zone is that considered by the Victorian EPA to be adequate for a properly designed and managed landfill, and the 500 m zone is that proposed by the Health Department of W.A (1992) draft criteria for landfill management. The buffer area for each stage will only exist for the duration of the active landfill period, i.e. the Stage 1 buffer will have an approximate lifetime of 8-10 years; stage 2 has an approximate lifetime of 5-6 years, and stage 3 has an approximate lifetime of 15 years or more. The objective of the off-site buffer is to create a temporary area in which no residential development or other sensitive development (e.g. hospitals, schools) should be located (Health Department of WA 1992).

The establishment of this zone is compatible with the existing land use and zoning of the subject area. Under the provisions of the State Government's Basic Raw Materials Policy, a 2 km buffer zone has been designated around the existing Pioneer Quarry operations, which in effect encompasses the off-site buffer areas for the proposed landfill, as shown in Figures 23, 24 and 25. On a regional basis, the Perth Metropolitan Region Scheme has the subject land

zoned for rural use. On a local level, the zoning of the subject land under the Shire of Serpentine-Jarrahdale's Town Planning Scheme No. 2, is Special Use, Rural, Public Purposes (conservation) and State Forest, respectively (Figure 11). In addition, within the maximum buffer zone (500 m), the Shire of Serpentine-Jarrahdale's Draft Rural Strategy (Shire of Serpentine-Jarrahdale 1992) designates the rural land to the north and south-west of the landfill as an Agricultural Protection Policy Area, while the rural land west of South-West Highway (within the Stage 2 buffer area) is designated "Rural Wedge" "to maintain rural character". The area zoned Special Use is designated as a Raw Materials Extraction Policy Area.

Collectively these planning policies and schemes specifically preclude residential development in the areas that will be encompassed by temporary off-site buffer zones of either 200 m or 500 m width. Consequently, no additional land use zoning restrictions are required for this specific project.

Site Security

Site security is important in several contexts, including:

- public safety;
- safeguarding against vandalism and theft; and
- preventing illegal dumping within or adjacent to the site.

A 1.8 m high wire mesh fence will be erected along the boundaries of the site adjacent to the landfill facilities. Lockable gates will be installed at all points of access to the site including the quarry access.

The presence of site operating personnel at the landfill during operating hours will ensure site security during those hours. The landfill will be subjected to after hours surveillance.

Road Construction and Maintenance

As part of the development of the site, the following access road improvements will be undertaken by the Proponent:

- a 7 m wide sealed pavement will be extended from Pioneer Concrete's access road to the gatehouse;
- an upgrade of the intersection of South Western Highway and the site access road including acceleration and deceleration lanes; and
- sign posting along South Western Highway.

Wheel Cleaning Facilities

To prevent the tracking of debris and sediment from the unsealed portion of the site, a wheel cleaning drive-through will be installed on site. This will comprise a concrete trough with 300 mm depth of water to dislodge any debris from tyres. Solid material collecting in the trough will be regularly removed and disposed of in the active landfill cell. Contaminated water within the drive-through will be treated as leachate. The length of the trough will be sufficient to accommodate the largest vehicle likely to use the landfill.

Water Supply

All requirements of the Water Authority of Western Australia regarding the siting, construction and licensing of the required groundwater production bores will be complied with.

Odour Control

Uncovered putrescible matter at the working face can emit odours, particularly when the waste is moist or during hot, humid conditions. To ensure that odours associated with the operation of the landfill are effectively minimized on-site, the following safeguards are proposed:

- use of daily cover;
- maintaining a high standard of site management to minimize the creation of odours. This will include the effective compaction and covering of all deposited waste;
- sealing of cracks on previously covered areas;
- capping of filled cells; and
- provision of a positive leachate and landfill gas extraction system.

The Proponent will ensure that particularly odorous refuse will only be accepted at the landfill by prior arrangement and that any such material will be covered immediately.

Dust Control

Dust arising from the landfill operation will be minimized by the progressive revegetation of filled areas as soon as practicable after completion and the regular light watering of internal access roads and trafficked areas. A water tanker will be permanently stationed on the site and employed as required.

As part of normal operations, the active tipping area will be dampened to lay dust, and overburden and cover material stockpiles will be stabilized with temporary cover vegetation, mulching, water and other suitable techniques to suppress dust generation.

Litter Control

The perimeter fence surrounding the waste disposal areas will minimize the spread of windblown litter from the site. Collection of paper from all fencing would be undertaken on a regular basis.

The provision of a movable litter control screen immediately adjacent to the active tipping face, the continuous covering of waste as it is deposited in the landfill and the effective use of cell bunds will also serve to control litter on the site.

Noise Control

Noise generated on the site will mainly be due to vehicles accessing the active tipping face and the operation of landfill plant for waste compaction and covering operations.

The impact of noise arising from landfill operations will be slight due to the buffer distances to the surrounding residences, but will be further minimized by:

- ensuring that all vehicles and machines operating at the landfill site, which are under the Proponent's control, will be fitted with effective exhaust system silencers;

- limiting daily hours of operation of the landfill to between 0600 and 1800 hours Monday to Saturday and 1000 and 1600 hours on Sunday; and

- ensuring all personnel are aware of the need to minimize noise generation on-site.

Post-Closure Management

Following closure of the landfill, the Proponent proposes to maintain the site for a minimum period of 15 years to ensure that the long-term effects of leachate and landfill gas do not affect the environment or the nearby community.

Post-closure maintenance will typically include the following:

- regular inspection of the rehabilitated surface to ensure integrity of landfill capping system;

- continued collection, treatment and disposal of leachate and landfill gas;

- continued monitoring of groundwater cells;
- regular inspection of the stormwater drainage system to ensure unrestricted flow of water; and
- regular cleaning of leachate collection underdrainage system to remove any obstructions.

An after use concept plan will be prepared for the site by the Proponent to ensure that it provides maximum benefit to local community upon completion of landfilling activities and rehabilitation.

6 ENVIRONMENTAL IMPACTS

6.1 Introduction

Under the agreements being negotiated between Pioneer-BFI Waste Services and Bristile, Mr Peter Nairn and Pioneer Concrete concerning the purchase of the project lands, Pioneer-BFI Waste Services will gain staged access for landfilling. Pioneer Concrete will retain control over the in situ basic raw materials. Pioneer Concrete's objective is to ensure that the available hard rock raw material will be removed prior to landfilling.

Some areas that will be used for landfilling have been or will be excavated, while much of the remainder of the site to be developed (i.e. the Stage 1 valley fill, the composting area and facilities area) has been disturbed as a result of rural activities. Therefore, the adverse impact of the landfill proposal within the site on landscape and biological resources of the site will be minimal.

The existing Pioneer Concrete hard rock quarry is not visible from South West Highway at any location as it is obscured behind natural screening hillside or constructed landscape banks. However the top of the crushing plant at the quarry is visible from South West Highway from a point north-west from the crusher.

While the potential for adverse biophysical impacts associated with establishing the proposed landfill is not significant, the proposal needs to address a number of environmental issues, some of which have also been raised during consultation with the local community.

These issues, and the significance of potential impacts associated with the proposed landfill, are discussed hereunder.

6.2 Environmental Issues

6.2.1 Water Resources

The only surface water features within the proposed project area are an ephemeral stream that drains from the Scarp (Figure 6) and a soak containing seepage from a local spring. The latter is located east of the existing hard rock quarry and is used by Pioneer Concrete.

The stream conveys stormwater and seepages from the ridges on either side of the valley before meandering out across the Swan Coastal Plain.

The proposed landfill development (particularly Stage 1) will block the existing stream line, so stormwater diversion drains will be constructed to direct upstream flow around the perimeter of the landfill, before resuming flow out across the

Plain. On-site runoff will be captured in a drainage network which will include a sedimentation pond to reduce sediment loading of the surface water before it is discharged downstream of the landfill.

Any surface runoff which comes into contact with the active landfill cell will be collected in the leachate drainage system and treated as leachate.

The system of surface water diversion drains and collection systems will minimize the likelihood of any contaminated surface water moving off-site into downstream water courses.

On-site groundwater resources are essentially confined to the crystalline granitic rock where weathering or fracturing has resulted in secondary porosity and permeability. Groundwater forming the local water table only occurs within these rocks where there are open fractures. Temporary flows of groundwater occur after wet periods along the contact of the irregular soil horizon with the underlying crystalline rocks.

The proposed system of clay liners and leachate collection systems for the landfill stages will minimize the release of any contaminated water to the on-site groundwater aquifers. Off-site movement of groundwater is also restricted by the Armadale shale formation (underlying Stage 2 of the proposed landfill), which will create a barrier to deep groundwater movement from the landfill areas to the Swan Coastal Plain to the west.

6.2.2 Odours

Decomposition of refuse during landfilling produces a characteristic odour. Malodours from a landfill are most likely to occur under conditions of aerobic decomposition, and result from esters, ammonia, mercaptans (thiols) and hydrogen sulphide generated during the decomposition of organic materials.

The extent to which odours will migrate from a landfill depends on the prevailing climatic conditions and landforms, while the magnitude of their impact will depend on the proximity of the site to populated areas.

At present, the comparative isolation of the proposed site would decrease the potential for odour impacts from the proposed landfill. However, increasing residential development is projected to occur to the west of the Southern landfill and, accordingly, the significance of malodours as a potential impact associated with the proposed landfill could increase.

6.2.3 Litter

The loss of rubbish from vehicles accessing a landfill site, leading to an accumulation of litter along the site access routes, often extends the impact of the landfill into the surrounding environment. Wind distribution of this litter can exacerbate this impact.

Wind-blown debris from the actual landfill site can also cause littering of adjoining areas. Wind blown litter fouling boundary security fencing can also produce an undesirable visual impact in the vicinity of a landfill site.

Litter can generally be regarded as a visual pollutant. Although certain types of litter can be hazardous to wildlife (particularly if consumed), litter is essentially an impact on the human environment. As such, the comparative isolation of the proposed site will help diminish this potential impact, although the occurrence of litter along routes servicing the landfill site would be considered a significant issue by residents. Increasing residential development in the general area would, obviously, heighten the potential for adverse impact from litter.

6.2.4 Noise

Noise is another factor which could spread the effect of the proposed landfill. There is the potential for noise impacts to occur as a result of increased vehicle movements (particularly heavy truck traffic) on access routes and from machinery operating within the landfill site.

Noise also represents a potential impact upon the human environment. The present comparative isolation of the proposed site reduces the potential significance of noise impact, although future residential development will increase the prominence of noise as an issue.

Noise currently generated during quarrying and processing operations is reduced by the high quarry walls and the location of the crushing/screening plant in a valley.

The rural area surrounding the quarry is considered to fall into Category B1 of the Assigned Outdoor Neighbourhood Noise Levels, on the basis of the medium density traffic level of South West Highway and the nearby motorcross circuit, auditorium, shale pit, timber mill and provision of land for Mental Health Purposes (Stephens 1991).

Measurements of the operating noise from the existing Pioneer Concrete quarry were reported in Stephens (1991). Sound levels were recorded at the closest corners of the two nearby properties (Horner & Radford). The Sunday afternoon background noise levels on both properties were above 40 dBA due to farm and traffic noise. At both locations, noise levels increased between 5.00 am and 7.00 am and did not begin to decrease until between 7.00 pm and 10.00 pm. The elevated noise levels outside the quarry operating hours of 7.00 am to 4.00 pm were due to traffic, farm noises and 'noises of nature' (Stephens 1991).

At the Horner property, the noise level between 7.00 am and 5.00 pm averaged 47 dBA and on the Radford property the average was 44 dBA.

Trucks used in the transport of hard rock from the quarry make between 40-45 laden trips per day. The nature of the access roads assist in noise reduction. When laden, the trucks roll down hill to South West Highway and on return, when empty, climb the hill to the quarry site.

The most recent (1988) traffic count figures from the Main Roads Department show that at that time 5 500 vehicles used South West Highway (south of Kiln Road) daily. In February 1991 traffic counts were taken in Byford at Clifton Street, north of the major intersection of Nettleton Road. Total vehicle movements between 7.00 am and 7.00 pm for South West Highway was 7 463, 14% of which were heavy vehicles. Using these figures, traffic noise of at least 64 dBA was predicted by Stephens (1991) for South West Highway near the Pioneer Concrete quarry.

Noise generated by the operation of the landfill is unlikely to significantly increase existing noise levels in the area generated by heavy traffic on South West Highway and the operations of the quarry.

6.2.5 Dust

As a result of the prior and ongoing extractive operations and agricultural activities, virtually all of the site will have been disturbed in advance of landfilling. Although restabilization of disturbed areas will be required, the potential for dust generation will remain.

Establishment of the landfill will necessitate further disturbance of previously excavated areas, both during the initial construction phase and ongoing operation of the facility. Examples would include:

- establishment of the composting facilities and ancillary facilities, construction of the perimeter bunds, and preparatory earthworks and installation of the clay liner for the initial refuse cell; and

- ongoing covering of deposited refuse (both daily and final cover requirements), construction of lifter embankments within the active refuse cell, and progressive construction of future cells and perimeter bunding.

These activities will produce both temporary and permanent unconsolidated soil surfaces and, therefore, the potential for dust generation. The movement of vehicles and machines throughout unsealed portions of the site will also produce dust.

Dust generation will be greatest when weather conditions are dry, while the potential for adverse impacts from dust beyond the landfill will depend on the strength and direction of the prevailing winds. Dust is unlikely to pose a threat to surrounding vegetation unless sufficiently dense to smother the foliage.

The significance of dust as a potential impact is not high at present, because of the comparative isolation of the proposed site. However, again because of future residential development in the general locality, the significance of dust as a potential impact could increase in the future.

6.2.6 Pest Species

Due to the availability of food and suitable host conditions, both vermin and nuisance species can be attracted to a landfill. These include flies, mice, rats and feral domestic animals, particularly cats. If allowed to proliferate, these species could move off-site, to the detriment of the surrounding human and biophysical environments. The most probable pest species that will need to be addressed will be the Australian Silver Gull (*Larus nouvaehollandiae*).

Consistent with recent national and international trends, gull numbers have increased markedly in the Perth Metropolitan Region. The growth in gull numbers is generally attributed to the increased availability of food as a result of urban development. Municipal waste disposal contributes in this regard and the Australian Silver Gull is present in large numbers at a number of metropolitan landfill sites.

Silver Gulls also pose problems in the broader community, for example because of their aggressive food scavenging activities and by fouling public places and damaging property and crops. They are also often cited as a vector in the transmission of human enteric bacteria, including *Salmonella*, by faecal contamination of wetlands and other water bodies.

The attraction of pest species (particularly Silver Gulls) to the landfill and environs represents a significant potential impact arising from the proposed landfill applying to both the biophysical and human environments.

6.2.7 Landfill Gas

Landfill gas consists predominantly of methane and carbon dioxide, along with minor proportions of other gaseous hydrocarbons. The proportions of methane and carbon dioxide present are determined by site conditions such as moisture content within the landfill, age of refuse, refuse composition and oxygen levels within the decomposing mass. Commonly the ratio of methane to carbon dioxide is approximately 1:1.

Carbon dioxide and methane are major contributors to the greenhouse effect, the respective relative contributions having been estimated to be 44% and 19% (Australian and New Zealand Environment Council 1990). In terms of the overall amount of carbon dioxide and methane emitted to the atmosphere and, therefore, relative contribution to the greenhouse effect, landfills do not represent a major source of greenhouse gases. In the above cited publication, the specific carbon dioxide contribution from landfills is not quantified. However, landfills in Australia are cited as contributing 1.5 million tonnes of methane to the

atmosphere per annum, which equates to a relative contribution to the overall greenhouse effect of 4%.

Strategies to manage the greenhouse effect are intended to foster a community based approach towards both major and lesser sources of contributing gases. The need to address greenhouse emissions from the proposed landfill, particularly methane (because it is considerably more radiatively active than carbon dioxide and as it is also a valuable energy source) is, therefore, important.

6.2.8 Fire

The use of fire to reduce the volume of vegetative material, and to reduce the occurrence of vermin and pest species, is a widespread practice at refuse disposal sites. Fires at landfills can be hazardous (either on and/or off-site) and a nuisance (off-site).

Due to the availability of fuel (much of the solid waste stream is combustible) including methane (which is continuously being generated), and the difficulty in accessing the seat of the fire, it is extremely difficult to extinguish fires burning within a landfill. Air-borne embers from fires within the landfill site can increase fire hazard in surrounding areas, particularly those containing bushland or grassland vegetation. Smoke (and odour) produced by fires can also pose a nuisance in surrounding areas, particularly if developed for residential purposes.

Most fires at landfill sites are intentionally lit, either as a routine management practice or as an act of vandalism. However, under certain circumstances (e.g. during the fermentative and aerobic phases of decomposition and conditions of high biological oxygen demand), spontaneous combustion can occur. Spontaneous combustion, as a potential cause of fire and the attendant consequences (as discussed above), therefore needs to be addressed and was, in fact, an issue raised during consultation of the local community.

Any increase in fire risk within surrounding areas attributable to the proposed landfill would have to be regarded as a significant potential impact, particularly with the extent of bushland (State Forest) adjacent to the site (meaning that fire starting at the site could rapidly gain a stronghold).

6.2.9 Social Impacts

The proposed landfill will produce benefits for the broader community, in the form of an improved waste disposal site. However, people inevitably perceive a landfill as something undesirable close to where they live. It does need to be acknowledged that many of the potential effects discussed could, if occurring, detract from public amenity within surrounding areas. Such would represent a form of social impact, although difficult to quantify.

The spillover effects of traffic moving to and from a landfill can also detract from amenity within surrounding areas and, therefore, also need to be considered as a potential source of social impact.

The appearance of the proposed site will change as a result of the proposed landfilling operation. Establishment of the facility will require the erection of buildings and other structures and the progressive construction of a peripheral earth bund approximately 2 m in height. The actual landfilling operation will also result in changed landform throughout the site, the envisaged finished contours within areas used for the placement of refuse being generally more uniform and higher than natural contours.

The change in physical appearance of the site would detract from its present contribution to landscape amenity and, as such, could constitute a social impact. However, as discussed in Section 6.1, comprehensive modification of the site will occur because of the ongoing extractive operations.

6.3 Synthesis

All potential impacts associated with the proposed landfill can be addressed either through the design of the facility or ongoing operational and management practices. The landfilling operation will not, in itself, modify the intrinsic values of the proposed site. Such will, however, occur as a result of the extractive operation which has been occurring since 1976 and will continue until the in situ basic raw materials are exhausted. In essence, therefore, the proposed landfill will represent a gainful reuse of a site following an activity (extractive industry) which has frequently resulted in land dereliction.

The broader environs within which the proposed site is set therefore contains environmental features of particular significance. However, because of existing pressures, these features are already under stress and their resilience to further change will already have been diminished. The need to avoid further pressures upon them is, therefore, emphasized.

Most potential impacts associated with the proposed landfill are likely to affect the human environment rather than the biophysical environment. The present significance of these potential impacts is generally low because of the relative isolation of the site. Additionally, the effects on the character and amenity of the locality that these potential impacts could produce need to be seen in both the present and future contexts.

A number of factors already influence the character and amenity of the general environs. These are the motorcross track, the adjacent brick making facilities, and the existing hard rock and shale extraction operations. Land use proposals for the environs include another hard rock quarry which will produce further changes to the predominantly rural character of the area.

The area is, therefore, in a state of change and, although the landfill proposal will further change, its overall significance in this context is difficult to estimate. However, of greatest significance in this regard is the juxtaposition of the proposed site to future residential development areas.

7 ENVIRONMENTAL MANAGEMENT AND MONITORING

7.1 General Philosophy

As discussed in Chapter 5, the philosophy underlying the proposal for the Southern Landfill is to minimize potential environmental impacts by appropriate design, development strategies, and operational and management practices. Good landfill design and planning must protect the beneficial uses around the landfill site, ensure levels of pollutants do not exceed the assimilative capacity of the environment, and ensure future management costs are identified and expenditures are effective. The specific measures that will ensure that the potential impacts discussed in the preceding section will be minimized are discussed in the following sections.

The proposed Operations Management Plan for the Southern Landfill is presented in Appendix E.

7.2 Water Resources

7.2.1 Predicted Impacts and Management

There are natural surface water features within or immediately adjacent to Stage 1 of the landfill which will be diverted away from the landfill by engineering works. Surface water from the active landfill area will not be allowed off-site, but will percolate through the fill material. The most significant potential threat to water resources will, therefore, stem from the movement of contaminants from the proposed landfill to the water table and their subsequent transportation in the direction of the groundwater flow.

Safeguards against groundwater contamination incorporated in the landfill proposal are:

- sealing the base of each landfill cell with a clay liner of 1 m compacted thickness;
- installation of a leachate collection drainage system within each landfill cell which will discharge to a sealed sump, from which liquor would be recycled by trickle irrigation into the waste mass and over the active landfill cell and lost by evaporation;
- installation of a site drainage system that will divert clean runoff water away from areas receiving refuse for disposal;
- capping of the landfill cells upon completion of refuse deposition;

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- installation of a site drainage system that will divert clean runoff water away from areas receiving refuse for disposal;
- capping of the landfill cells upon completion of refuse deposition;

- sizing landfill cells to enable completion (i.e. filling, capping and covering) within approximately one year;

- excluding hazardous wastes; and

- using a thin layer landfilling operation (compacted layers of refuse approximately 0.3 m thick) in lifts of 2 m high and regular covering of deposited refuse with soil to reduce opportunity for aerobic fermentative decomposition of the waste.

The approach proposed will minimize leachate generation and maximize containment of any leachate generated. It will also produce methanogenic conditions within the deposited refuse. Such are beneficial in terms of the characteristics of any leachate generated and, accordingly, in terms of the pollution potential associated with the landfill.

Appendix D presents the results of the preliminary conceptual modelling of leachate generated from Stages 1 and 2 of the landfill. This modelling indicates that leachate generation will commence one year after the initiation of the landfill operation. Collection of leachate is not expected to occur until some four years after commencement of operation, reflecting the time required for the compacted waste to reach field capacity.

7.2.2 Monitoring

Dedicated monitoring bores within the site boundary will be employed to detect any groundwater contamination arising from leachate seepage through the clay liner of the landfill cells. Taking the width of the buffer zone adjacent to the site boundary, and expected dispersion of potential leachate contaminants from a point source within the aquifer into account, monitoring bores need to be constructed at intervals of about 100 m along sections of the site boundary down hydraulic gradient of the landfill. Installation of the bores will be undertaken progressively as the area of the site used for landfilling increases.

Monitoring bores will be constructed to specifications acceptable to the EPA and the Water Authority of Western Australia. Most bores will tap the uppermost few metres of groundwater, as most potential leachate contaminants are unlikely to penetrate deep into the aquifer. A few bores will tap deeper sections of the aquifer to detect the presence of any contaminants which, due to density differentials or preferred flow paths, may tend to travel at the base of the aquifer.

The frequency of monitor bore sampling will be determined by the expected rates of groundwater flow within the aquifer, the distance between the monitoring bores and landfill cells, and the timing of landfill operations. It is envisaged that sampling would be undertaken initially on a quarterly basis. Depending on the results obtained during the on-going monitoring programme, the groundwater sampling frequency will be modified, as appropriate.

In order to obtain valid groundwater quality data, it is essential that the monitoring bores are sampled, and the borewater samples preserved, in accord with recognized procedures. Prior to collecting borewater samples for analysis, the monitoring bores will be purged to ensure that the samples taken are "representative" of the groundwater tapped by the bores. Experience with municipal landfills indicates that borewater samples are best collected following the attainment of approximately constant values for the major water quality parameters (e.g. pH, electrical conductivity, redox potential, dissolved oxygen) during purging. Due to the "reducing" nature of leachate (Appendix D), the on-site determination of redox potential is required to ensure that an acceptable degree of bore purging has been reached.

Monitoring-bore purging and borewater sample collection will be carried out using equipment and methods which result in minimal "carry-over" of potential contaminants between samples. The sampling equipment would consist of teflon and stainless-steel components which can be readily decontaminated in the field.

The borewater samples will be preserved in accordance with recognized procedures for the specific water quality parameters to be determined (APHA 1985; SAA 1986). These procedures will be generally similar to those employed for the ground water quality determinations undertaken during preparation of the PER document. For water quality parameters which have short holding times (e.g. five-day biochemical oxygen demand, BOD_5), prior arrangement with the analytical laboratory will be made so that the determinations can commence immediately following the arrival of the borewater samples at the laboratory. The analytical laboratory employed will be NATA registered for the water quality determinations to be undertaken.

Prior to the commissioning of the landfill, the monitoring bores will be sampled for the determination of a wide range of water quality parameters. The water quality parameters will include pH, salinity (as total dissolved solids, TDS), redox potential, major ions, nutrients (especially inorganic and organic forms of nitrogen), total organic carbon, BOD_5 and heavy metals. The majority of these parameters were determined as part of the groundwater quality investigation undertaken for the preparation of this document.

Following the commissioning of the landfill, a less extensive suite of water quality parameters will be determined on an approximately quarterly basis, at least initially as discussed above. These parameters will include the key 'gross' parameters typical of acetogenic-stage and methanogenic-stage landfill leachates. Should groundwater contamination be indicated by the determination of such parameters, more extensive water quality determinations will be undertaken in consultation with and to the satisfaction of the EPA and Water Authority.

In addition to the monitoring bores located within the site, the monitoring programme will include water quality determinations for domestic and irrigation bores on adjacent properties. It is initially expected that this would be undertaken on an annual or biennial basis. Further, any complaint about deterioration in groundwater quality attributable to the landfill operation will be

immediately investigated in consultation with and to the satisfaction of the EPA and Water Authority.

7.3 Odours

7.3.1 Predicted Impacts and Management

The impact of odours is very difficult to quantify because human sensitivity is subjective. Nevertheless, stringent operational practices are clearly necessary at the proposed landfill to avoid odour production.

The primary strategies for controlling odour impacts from a landfill will focus on:

- achieving an acceptable separation (off-site buffer zone) between the site and areas of human settlement (taking prevailing winds into account); and
- minimizing the occurrence of odours.

The buffer distance from residential areas identified by the Victorian Environment Protection Authority as a guide for the siting of a landfill, such as proposed for the site, is a minimum 200 m (Environmental Protection Authority of Victoria 1989). In Western Australia, the preferred distance is 500 m (Health Department of WA 1992). The nearest existing individual residence to the Southern Landfill is some 300 m (from the Stage 3 landfill, the existing hard rock quarry) and the separation between the site and existing and future residential areas is substantially greater. Provision of off-site buffers is discussed in Section 5.3.3.

The occurrence of malodours from a landfill can be minimized by (Department of Environment 1986):

- avoiding deposition of waste into standing water;
- achieving good compaction and provision of adequate cover; and
- ensuring immediate deposition of wastes.

These requirements will be satisfied at the proposed Southern Landfill, as indicated below.

There will be no standing water within the landfill cells. The EPA and Health Department specify a minimum vertical separation between the base of a landfill and the water table of 3 m. This requirement will be satisfied through the use of the liner system, thereby obviating contact between refuse and groundwater. Further, although the landfill cells will be sealed, water will not accumulate therein because of the leachate collection underdrainage system.

Using the thin layer landfilling technique, and a dedicated refuse compacter machine, average compaction rates of 800 kg/m^3 or more can be achieved. In addition, routine operational practices will include regular covering of deposited material. Any particularly odorous material (e.g. partially decomposed wastes) will be received only by prior arrangement and will be covered immediately.

7.3.2 Monitoring

As stated above, human reaction to odours is difficult to quantify due to the subjective nature of the human response. Monitoring of odour generation is, therefore, not practicable. Nevertheless, some mechanism to enable the identification of any off-site odour impacts (or other adverse social impacts) is necessary. To this end, Pioneer-BFI Waste Services will maintain a complaints register. This register will also be available to residents in the vicinity of the landfill site. Appropriate changes to landfilling operations will be made if this record indicates a significant odour problem (e.g. increased frequency of covering of deposited refuse).

7.4 Litter

7.4.1 Predicted Impacts and Management

Minimization of litter as a potential impact will require initiatives in the following directions:

- loss of debris from vehicles accessing the landfill and the removal of any such debris; and
- control of wind blown material at the tipping face, including the accumulation of debris along the peripheral security fence.

Under the proposal for the site, the following measures will be implemented as a routine part of the ongoing operational and management programmes.

Loss of Debris

Pioneer-BFI Waste Services will undertake the following:

- maintain a programme to educate users of the facility of obligations under the *Litter Act*;
- monitor traffic accessing the landfill to determine the routes being used and whether debris loss is occurring during transit;
- in the event that littering along the access routes is identified as a problem (either as a result of monitoring or complaints from the public), offenders will be prosecuted under the provisions of the *Litter Act*; and

- ensure that any debris along the access routes within a 2 km radius of the site is removed.

Tipping Face Control

- Loss of material from the tipping face will be minimized through the frequent compaction and covering of deposited refuse;
- portable litter control screens will be used to intercept any material blown from the tipping face;
- the site security fence (where practicable, situated on top of the peripheral bund), supplemented by natural and planted vegetation, will act as a barrier to the off-site movement of any material that might bypass the litter control screens; and
- any material blown from the tipping face and intercepted by the security fence and on-site vegetation will be routinely collected and returned to the tipping face.

7.4.2 Monitoring

Access routes to the landfill will be monitored through regular inspection by Pioneer-BFI Waste Services' staff to determine whether littering is occurring, and any public complaints received concerning littering will receive prompt response. Any material accumulating along the access routes within 2 km will be removed. Peripheral areas of the landfill site will be under constant review as part of normal operational practices. Any material accumulating therein will be removed.

7.5 Noise

7.5.1 Potential Impacts and Management

In addressing potential impacts from noise associated with the proposed landfill, both off-site and on-site noise sources need to be considered.

Off-site Noise

The principal source of off-site noise will be traffic moving to and from the landfill site.

Existing traffic accessing the hard rock quarry comprises some 45 truck movements per day.

Traffic accessing the proposed landfill will do so from the west via South West Highway. South West Highway is an established regional route (designated under the Metropolitan Region Scheme as "Major Highway"). It carries

substantial traffic (about 5 500 vehicles per day in the vicinity of Kiln Road, based on 1988 Main Roads Department traffic counts). Accordingly, the additional traffic that would be attracted to South West Highway because of the proposed landfill would be unlikely to have a material effect in terms of increased noise impact along the route.

The existing access road to the Pioneer quarry will carry all landfill-related traffic. The road is sealed, although the Proponent will extend the seal from the access road to the landfill gatehouse.

Establishment of the landfill at the proposed site will lead to a consistent increase in traffic using the South West Highway and the existing quarry access road and, therefore, in noise levels along the route. However, at present, there is only one residence on the access road (the quarry caretaker's house at the eastern extremity) and, under the project planning proposals for the locality, this could become project land. Accordingly, although traffic and noise on the site access road will increase, the extent of impact will be limited.

On-site Noise

Machinery working within the active landfill cell will represent the principal source of on-site noise. Vehicle movements within the site will also contribute to the overall noise environment.

Machines operating at the site could be expected to generate noise levels of up to 80 dB(A) at a distance of 20 m. Estimates for the attenuation of noise with distance vary. In theory, a 6 dB reduction occurs with each doubling of distance from the source (Noise and Vibration Control Council 1980). However, in practice, the degree of reduction will be affected by a range of factors (ground conditions between the noise source and receival point, wind direction and strength). The reference cited suggests that a reduction of 4 to 5 dB for each doubling of distance is more likely.

Using these figures, machine noise of 80 dB(A) would attenuate to between 56 and 64 dB(A) at a distance of 320 m from the source.

The nearest existing house is approximately 300 m east of the existing quarry, although it is shielded from the site by an elevated landform. Separation between this house and the initial stages of the landfill significantly greater than 300 m. Other existing and future residential areas are at least 500 m from the nearest boundary of the site and are also screened by landform and vegetation. Accordingly, the degree of noise attenuation afforded by the physical separation between the site, existing residences, and existing and future residential areas would at worst be likely to be towards the higher end of the above range.

Pioneer Concrete has not received noise related complaints associated with the existing quarrying operation; suggesting that noise transmissions from machinery operating within the landfill cells are unlikely to be a problem (i.e. they are likely to be even less than suggested above). In practice, much of the landfill

operation will be below natural ground level, and the buffer zone, plus site revegetation, will further assist in the attenuation of noise from the landfill operation.

In assessing the likely significance of additional noise that would occur as a result of the proposed landfill, the existing and future noise environment, as well as the actual noise levels associated with the facility, have been considered.

Although the area is ostensibly a quiet, sparsely populated, rural locality, it already experiences some industrial related noise influence, from the Pioneer Concrete hard rock quarrying operation. Land use proposals for the general area will further influence its amenity, with the immediate environs of the site assuming an increasingly urban character. Based on this change in character, and the Assigned Outdoor Neighbourhood Noise Levels scheduled under the Noise Abatement Regulations 1979 (Noise and Vibration Control Council 1980), the potential noise impact of the proposed landfill in the future is likely to be less than would currently be the case.

To reduce the potential for noise impacts associated with the proposed landfill, the hours of site operation will be limited to those times of the day during which highest noise levels are permissible under Assigned Outdoor Neighbourhood Noise Levels (i.e. between the hours 0700 and 1900). In practical terms, however, site operating hours will be even more limited, being restricted to between 0600 and 1800 hours Monday to Saturday and 1000 and 1600 hours on Sunday.

In addition, the landfill proposal will incorporate a number of other measures to lessen its contribution to the overall noise environment:

- landscaping the peripheral areas of the site, including the buffer, which will help dissipate noise emissions; and
- ensuring that all operator-controlled vehicles and machines operating at the site are fitted with effective exhaust system silencers.

7.5.2 Monitoring

No formal monitoring of noise will be undertaken. However, as with odours, the complaints register to be maintained by Pioneer-BFI Waste Services will provide a mechanism by which any adverse off-site noise impacts can be identified.

7.6 Dust

7.6.1 Predicted Impacts and Management

The comparative isolation of the site reduces the likelihood of dust from the proposed landfill becoming a nuisance at existing residences, and existing and

future residential areas. The potential for dust nuisance associated with the proposed landfill has already been diminished with sealing of the access road. Other measures incorporated in the landfill proposal which will ameliorate dust generation are:

Site Development

- Peripheral landscaping which will provide a wind break effect and reduce wind blown dust and grit;
- restabilization with vegetation or other means (e.g. mulching etc.) of already disturbed areas not immediately needed for the landfilling operation, and of areas disturbed during site development but not needed for ongoing operations;
- sealing of all access/egress roads and other trafficked areas within the facilities area; and
- installation of a wheel cleaning drive-through at the egress from the landfill cell area to avoid the tracking of material that could generate dust onto the sealed, publicly accessible areas.

Ongoing Operations

- For much of the time, the active tipping area will be below natural ground level and, therefore, shielded from prevailing winds;
- the limited extent of the landfill cells will mean that the extent of unstabilized cover material at any given time will also be limited;
- the tipping area will be watered as necessary to lay dust;
- each landfill cell will be revegetated upon completion of filling, capping and covering operations (i.e. the entire site will be progressively revegetated in accordance with the after-use plan);
- overburden, cover material etc. stockpiled for future use will be stabilized with temporary vegetation cover, mulching, watering or other techniques; and
- where a landfill cell has been constructed ahead of use and a cover layer has been installed to protect the clay liner, the cover material will be stabilized with a temporary cover crop, watering or some other technique.

7.6.2 Monitoring

The possibility that the proposed landfill would generate dust in sufficient quantities to produce adverse off-site impacts is regarded as low. For this reason, and as dust sources within the site would be readily manageable, no formal monitoring will be undertaken. Again, however, the complaints register will enable any dust related impacts to be identified.

7.7 Pests

7.7.1 Predicted Impacts and Management

The emphasis of measures to control pests should be to eliminate suitable host conditions and food sources. However, supplementary measures to deter pests may also be required.

Normal management practices at the tipping face will minimize host conditions and food for pests as discussed below:

- continuous compaction of deposited refuse and frequent covering will eliminate voids which could harbour pest species and the exposure of food sources;

- any large appliances (such would normally be recovered for recycling before reaching the tipping face), crates etc. will be specifically crushed before covering with refuse and cover material; and

- any tyres dumped will be spread out and carefully covered.

Various other measures to deter pests would be implemented on an "as required" basis. Such measures could include the capture and removal, or humane destruction, of feral domestic animals, and baiting and spraying programmes for rats and flies. Particular initiatives may also be needed to deter Silver Gulls from the site.

Information from an International Ornithological Congress held in Christchurch, New Zealand, which included a session on the superabundance of gulls and the attendant problems, suggests that rapid covering of refuse is the most effective way of controlling gulls at landfills. Normal practices at the tipping face will achieve this objective. Nevertheless, the view that physical deterrence is the best method of controlling gulls, particularly through the use of overhead banks of monofilament wires, also exists. Other techniques for discouraging gulls are also available, including:

- noise generators to frighten the birds;
- recorded distress calls to both frighten and confuse the birds; and
- direct culling.

Pioneer-BFI Waste Services recognizes that supplementary measures to control Silver Gulls and other pests at the proposed landfill may be necessary.

7.7.2 Monitoring

Monitoring of gull activity at the landfill will entail direct observations and subjective estimates of the numbers involved. Pioneer-BFI Waste Services will co-operate with the Department of Conservation and Land Management in any monitoring programme initiated by the Department, and will consult with the Department in structuring and implementing its own gull monitoring programme.

7.8 Landfill Gas

7.8.1 Predicted Impacts and Management

As each landfill cell is to be capped with a low permeability barrier system, the opportunity for active collection of the landfill gas exists, thereby avoiding its uncontrolled release to the atmosphere. A methane gas management plan will be designed and implemented to the satisfaction of the EPA and the Health Department.

Pioneer-BFI Waste Services supports the notion of beneficial use of landfill gas. However, it is envisaged that, initially, collected gas will simply be flared. This would require installation of a system of header pipes to collect the gas and deliver it to a flaring station for burning. The collection system would need to incorporate a water trap to remove water condensate from the emergent gas and all pipework would need be resistant to corrosion from the carbon dioxide and hydrogen sulphide component of the gas. The flaring station would need to incorporate a motor/blower assembly, flare relight fuel supply, electrical control panel and burner assembly, and would need to be enclosed in a secure compound (for both safety and security reasons).

Pioneer-BFI Waste Services is willing to participate in the investigation of options for beneficial use of landfill gas, and is also willing to assist in investigations into the stimulation of methane production through the recirculation of leachate directly into the waste mass via a system of buried, slotted pipes.

7.8.2 Monitoring

Landfill gas monitoring bores will be installed within each landfill cell as completed, with gas flow rates being measured at six monthly intervals thereafter. Decisions concerning implementation of further gas management initiatives (e.g. flaring or collection for alternative use) will be taken in conjunction with the relevant State Government authorities.

7.9 Fire

7.9.1 Predicted Impacts and Management

Other than for the flaring of collected landfill gas, fire will not form part of the management programme for the proposed landfill.

Ongoing management practices (effective compaction and regular covering) combined with site security will minimize the risk of deliberately lit fires. Further, conditions within the body of the deposited refuse that will result under the intended management regime (including collection of landfill gas) will safeguard against spontaneous combustion.

Nevertheless, should a fire occur within the site (either within a refuse cell or elsewhere), manpower and machinery resources to combat it will be immediately available. A water truck will be stationed on site at all times.

7.9.2 Monitoring

The site will be under constant scrutiny by operational staff during working hours, and will be subject to after hours surveillance, thereby ensuring detection of any on-site fires.

7.10 Social Impacts

7.10.1 Predicted Impacts and Management

All management measures discussed above will help reduce the effect of the proposed landfill on the character and amenity of the South Cardup locality and will, therefore, help ameliorate social impacts associated with the facility. However, public perceptions are likely to be that establishment of the landfill will produce changes that will be considered adverse. Accordingly, it will inevitably be regarded as having an undesirable social impact.

In assessing the significance of this impact, it is necessary to examine both the present and future land use context in which the project will be set. As previously indicated, industrial activities and influences are already established within the locality and, under government planning proposals for the immediate environs, will continue.

7.10.2 Monitoring

The complaints register to be maintained by Pioneer-BFI Waste Services will represent the principal mechanism for monitoring any social impacts associated with the proposed landfill. As any complaints lodged, and Pioneer-BFI Waste Services' response to them, will need to be incorporated in the periodic performance reports to the regulatory authorities, the complaints register will ensure scrutiny of any perceived social impacts from the proposed landfill by

those authorities. Additionally, the periodic performance reports will be made available to the local community, thereby enabling those most affected by the landfill operation to also scrutinize Pioneer-BFI Waste Services' response to any complaints received.

7.11 Performance Reporting

While Pioneer-BFI Waste Services believes that the Southern Landfill proposal satisfactorily addresses all potential environmental impacts associated with the project, the submission of periodic reports documenting project performance for review by the relevant regulatory authorities is regarded as an essential component of the overall environmental impact management process. These periodic reports would need to address such matters as:

- the stage reached in the various operational and management programmes being implemented;
- results from monitoring programmes instituted, including the complaints register and the response to any complaints received; and
- modifications to the various programmes that have been implemented in response to monitoring results.

In the initial period of operation (e.g. the duration of the initial approval, perhaps three to five years), annual performance reports, outlining the year's progress on environmental and management matters, will be submitted to the EPA and Health Department. These reports will be submitted by Pioneer-BFI Waste Services within three months following the anniversary date of commencement of landfilling operations. Pioneer-BFI Waste Services will respond (through an interactive process with these agencies) to any issues they may raise following receipt of the performance report.

The final report submitted during the initial operational reporting period will provide a detailed review of performance over the entire period, and of any modifications to operational/management practices intended.

Any unforeseen or extraordinary event that adversely affected off-site environmental quality and the response to that event will be immediately reported by Pioneer-BFI Waste Services to the regulatory authorities, but would also be included in the next periodic report.

Periodic reports submitted to the regulatory authorities will also be made available to local community groups with an interest in the landfilling operation, thereby providing such groups with an opportunity to maintain an ongoing association with operation and management of the site.

7.12 Contingency Planning

The proposal for the Southern Landfill contains comprehensive safeguards against a range of potential environmental impacts that are normally associated with a landfill operation. Additionally, however, the proposal also contains safeguards that will enable an effective response to unforeseen events.

For instance, the monitoring programmes intended will enable early identification of any unanticipated problems, while the cellular approach intended combined with the limited extent of the individual cells, will facilitate the modification of operational practices (e.g. in terms of the lining system used, installation of bores to intercept contaminated groundwater etc.).

Pioneer-BFI Waste Services also recognizes that continued operation of the site (assuming initial approval) will depend on satisfactory performance, and has provided an undertaking to submit periodic performance reports for scrutiny by the regulatory authorities. This commitment extends to the immediate reporting of any unforeseen events that produce adverse off-site environmental impacts, and periodic reporting of public complaints and Pioneer-BFI Waste Services' response thereto.

Pioneer-BFI Waste Services is the responsible body in the event that future site remediation (i.e. following decommissioning of the landfill operation) is required.

While adverse environmental impacts from the proposed landfill are not anticipated, because of the design, operational and management features incorporated in the proposal, Pioneer-BFI Waste Services acknowledges that it will need to provide an undertaking to respond to any unforeseen events to the satisfaction of the relevant authorities.

The Proponent will submit for approval from the Shire of Serpentine-Jarrahdale a contingency plan for emergency situations after consultation with the Shire of Serpentine-Jarrahdale, Environment Protection Authority, Health Department of Western Australia, Bush Fires Board of Western Australia, Water Authority of Western Australia and the Department of Conservation and Land Management.

The Proponent will respond to any unforeseen contingency associated with the landfill and which is producing a demonstrable and unacceptable off-site impact in consultation with the EPA, Health Department, the Shire of Serpentine-Jarrahdale and to the satisfaction of the Minister for the Environment as appropriate.

7.13 Management Following Closure

Pioneer-BFI Waste Services recognizes that its management responsibilities will continue following closure of the landfill site. Active management input will continue to be required for a minimum of 15 years to address the following:

- site rehabilitation;
- leachate collection and disposal (including evaporation pond sediments); and
- methane collection, and flaring or utilization.

The Proponent shall be responsible for construction, operation, decommissioning and post-closure management of the site until such time as the waste has fully degraded, to the satisfaction of the Environment Protection Authority.

Within two years of the date of commencement of construction, the Proponent shall prepare a draft decommissioning and post-closure management plan, to the satisfaction of the Environment Protection Authority.

At least two years prior to closure, the Proponent shall prepare the final decommissioning and post-closure management plan, to the satisfaction of the Environment Protection Authority.

The Proponent will implement this final decommissioning and post-closure management plan to the satisfaction of the EPA.

7.14 Financial Assurances

The Proponent recognizes that the public and regulatory authorities have concerns about private industry operation of regional facilities. To this end, the Proponent is committed to a policy of financial assurances as outlined below.

7.14.1 Potential Problems Requiring Rectification

As problems may arise during the operational and post-operational phases of the landfill, resulting in environmental impacts, financial assurances will be put in place by Pioneer-BFI Waste Services prior to the commencement of filling. At this time, the probability of events occurring has not been quantified, nor has the cost of repair of the landfill, and any rectification of the consequences of each of the problems, been estimated.

7.14.2 Implementation of Financial Assurances

Within six months of commencement of landfilling operations, the Proponent will establish financial assurances in favour of the Shire of Serpentine-Jarrahdale to cover emergency contingencies and long-term risks to be assessed by risk assessment consultants in a form and to an amount acceptable to the Environment Protection Authority, Health Department of Western Australia and the Shire of Serpentine-Jarrahdale.

The amount of the financial assurances shall be reviewed every five years by the Environment Protection Authority in consultation with the Shire of Serpentine-Jarrahdale and the Health Department of Western Australia.

Company guarantees, if offered by the Proponent, shall be supported by annual audited accounts from each guaranteeing entity.

The preparation of the legal agreement relating to the financial assurances shall be executed by the Proponent's solicitors at the Proponent's expense.

7.15 Conclusions

The management programmes incorporated in the Southern Landfill proposal address all potential environmental impacts normally associated with solid waste disposal sites. In so doing, Pioneer-BFI Waste Services has also responded to issues raised by the community during consultation undertaken as part of the project.

Pioneer-BFI Waste Services recognizes the importance of ongoing community involvement with the project. Although adverse off-site environmental impacts as a result of the landfill are not expected, maintenance of a complaints register and submission of periodic performance reports as intended, will provide an opportunity for any grievances within the community arising from the landfill (and Pioneer-BFI Waste Services' response thereto) to be independently scrutinized. Through the mechanism, the community will be able to influence operational practices in areas of legitimate concern.

Necessarily, however, there will be a lengthy lag between completion of landfilling operations and the availability of the site for future redevelopment. Within two years after commissioning of the landfill, Pioneer-BFI Waste Services will prepare a draft after-use concept plan for the site. Vegetation planting programmes undertaken during site establishment and operation, and progressive rehabilitation of the completed landfill cells will be consistent with the after-use concept plan.

Finally, Pioneer-BFI Waste Services specifically acknowledges that its environmental management and monitoring responsibilities extend beyond the operational life of the proposed landfill. Ensuring that the site is available for redevelopment within the shortest possible time frame will, however, be in Pioneer-BFI Waste Services' (and the community's) best interests. This objective will only be achieved if Pioneer-BFI Waste Services discharges its ongoing responsibilities effectively following cessation of the landfill operation.

8 TIMING

The region's requirement for the Southern Landfill is imminent as a result of the scheduled closure of many other smaller landfills in the Perth Metropolitan region.

Pioneer-BFI Waste Services recognizes that the environmental impact assessment process is lengthy, and that the environmental and planning clearance for the proposed landfill, if granted, are unlikely to be finalized before the third quarter of 1993.

Assuming environmental clearance and other necessary approvals (which cannot be finalized prior to the granting of environmental clearance) are forthcoming within this time frame, construction of the landfill facility could commence in the last quarter of 1993, with commissioning expected to occur in mid 1994.

9 COMMITMENTS

The Proponent, Pioneer-BFI Waste Services, provides the following commitments concerning the construction, operation and management of the proposed sanitary landfill on Lot 8 and Part Lots 6 and 3 South Cardup.

9.1 General Commitments

(1) The Proponent will adhere to the proposal as described in the Public Environmental Review (PER) and as assessed by the Environmental Protection Authority (EPA), and will fulfil the commitments made therein and summarized below.

(2) The Proponent will develop, operate and manage the proposed sanitary landfill to the satisfaction of all relevant Government agencies including the following:

- EPA;
- Health Department;
- Water Authority;
- Department of Conservation and Land Management; and
- Shire of Serpentine-Jarrahdale.

(3) The Proponent is committed to waste minimization, reuse and recycling. The introduction of a garden waste composting facility at a landfill to recover and reuse a valuable resource which would otherwise be buried forms part of the partnership's philosophy on integrated approach to waste management.

(4) As the proposed landfill is intended as a secure facility for the disposal of municipal, commercial and industrial waste only, the Proponent will ensure that hazardous, liquid and soluble chemical waste or other forms of intractable wastes will be excluded from the site.

(5) The Proponent will provide a contribution of $20 000 towards the provision of a transfer station at the existing Mundijong landfill to obviate the need for direct public access to the tipping face of the Southern Landfill.

9.2 Industrial Waste

(6) The Proponent will submit an assessment procedure that determines the acceptability (or otherwise) of various classes and types of industrial waste at this facility for approval by the Health Department of Western Australia and the Environmental Protection Authority. Only industrial

waste that meets the acceptability requirements will be disposed of at the landfill. Forming part of the screening program will be elutriation and flash point testing and the installation of radiation detection equipment.

9.3 Design Features

(7) The Proponent will progressively develop the landfill as a series of cells. The first cell will be sized to accommodate two years' refuse, followed by cells sized to accommodate one year's refuse, in accordance with the staging plan included in the PER.

(8) The Proponent will maintain a vegetated buffer zone with a minimum of 50 m in width around the perimeter of the landfill site.

The buffer zone will be comprehensively landscaped and will contain a perimeter fence and a firebreak track.

(9) The Proponent shall prepare a landscaping plan which shall be developed to achieve the following objectives:

(i) that initial planting is undertaken between the landfill and neighbouring properties in the planting season before or immediately following the commencement of site development earthworks, whichever is the earlier; and

(ii) to allow integration with the longer term Post-Closure Plan.

The landscaping plans will be submitted within six months of the granting of all the necessary approvals to commence landfilling operations.

All initial planting will be maintained at all times. Failed plantings will be replaced immediately to the satisfaction of the Shire of Serpentine-Jarrahdale.

(10) The Proponent will implement site security measures to control vandalism, theft and illegal dumping, including the construction of a 1.8 m high wire mesh with lockable gates around the landfill facilities.

9.4 Development and Operational Features

Site Preparation

(11) The Proponent will ensure that prior to the commencement of construction of the landfill cells, the final excavated surface is graded to allow gravity drainage across each of the landfill cells.

Cell Sealing

(12) During the development of landfill cells, the Proponent will ensure that a 1 m thick compacted clay liner will be constructed over the excavated surface. A 300 mm drainage blanket will be installed on the upper surface of the clay liner as part of the process of constructing the liner (refer to Commitment 18).

(13) The Proponent will ensure that clay sources used in construction of the landfill cells will meet the following specifications, under laboratory conditions:

- in situ permeability of 1×10^{-9} m/s or less when clay is placed and compacted; and
- gypsum content of less than 1%.

(14) The Proponent will engage specialist geotechnical consulting engineers to perform Quality Assurance/Quality Control (QA/QC) in the selection of clay and construction of the clay liner. A QA/QC report will be prepared for the clay liner of each cell for submission to the EPA and Health Department of Western Australia which certifies that the liner has been constructed to meet the permeability requirements with materials that have been tested and found suitable.

(15) The Proponent will ensure that, during development of the landfill cells, the liner will be constructed and compacted in thin layers (no more than 300 mm loose thickness) and density and moisture content will be controlled by continuous compaction testing.

(16) The Proponent will ensure that, prior to deposition of refuse within a landfill cell, a starter embankment of 2 m in height will be constructed around the perimeter of the liner to prevent leachate and stormwater from leaving the active cell. Construction techniques and controls for the starter embankment will be similar to those applying to the clay liner.

(17) The Proponent will ensure that, on completion of the clay liner and starter embankment, a 300 mm thick sand or gravel cover (the drainage blanket) will be placed to provide protection against cracking of the clay material resulting in desiccation.

(18) In the event that a suitable clay source for construction of the basal liner of a landfill cell or cells and the starter embankment, is not accessible, the Proponent will utilize a synthetic barrier membrane to seal the landfill cell or cells. In this event, the Proponent will submit a supplementary report to the EPA and Health Department specifying the liner system to be used and explaining the leachate collection system to be installed. This report would be submitted to the EPA and Health Department prior to commencement of construction of the cell or cells in which the alternative lining system was to be installed, and construction of the cell

or cells will not commence until the EPA and Health Department are satisfied that the systems proposed are acceptable.

The Proponent will endeavour to place a layer of refuse over the completed drainage blanket at the earliest opportunity to provide additional protection against dehydration of the clay liner.

Leachate Collection

(19) The Proponent will ensure that a leachate collection system comprising a 300 mm deep permeable (permeability rating of 1 x 10^{-1} cm/s or more) drainage blanket is placed immediately above the basal clay liner. A series of drains consisting of high strength drain coil pipe will be installed in this layer.

(20) The Proponent will ensure that leachate collection drains will gravity feed to a sump (lined with HDPE and filled with 20 mm gravel screenings) located within each stage of the landfill constructed integrally with the clay liner. The design storage volume of the sump will be determined by suitable modelling.

(21) The Proponent will ensure that leachate will be recirculated through the refuse through a series of slotted pipes buried during landfilling, or by trickle irrigation of the internal surfaces of the active landfill cell.

(22) The Proponent will ensure that prior to depositing refuse in a newly constructed cell the leachate collection pipes are connected into the existing leachate collection system serving the completed cells allowing flow to the leachate sump within each Stage of the landfill.

(23) The Proponent will initially construct a permanent leachate treatment tank(s) to service all landfill cells within Stages 1 and 2. A second permanent leachate treatment tank will be constructed for Stage 3. The leachate treatment tank(s) will be covered and bunded appropriately. The leachate treatment tank(s) will be sized according to the results of the computer modelling to estimate leachate generation.

(24) As part of the normal site operational practice, the Proponent will pump leachate from the leachate sump of each Stage as required to the leachate treatment tank, or recirculate the leachate through the landfill as described earlier. Leachate within the treatment tank may be returned to the active landfill cell during dry periods for disposal through recirculation, or transferred to tanker trucks for off-site disposal.

Placement and Compaction of Refuse

(25) During operation of the site, the Proponent will ensure that refuse will be progressively placed and compacted into thin layers to maximize the compacted refuse density.

(26) During operation of the site, the Proponent will ensure 'Daily' cover (clean soil or other suitable material) is applied over the exposed surfaces at the active landfill area in layers (not less than 150 mm in the case of soil) so that there will be no exposed garbage at the end of the day. The Proponent will apply 'Intermediate' cover to the top of the active landfill area and to surfaces which will be exposed to the environment for periods greater than six weeks in layers of not less than 300 mm.

Cell Completion

(27) The Proponent will ensure that, upon completion of refuse deposition, landfill cells will be covered with a 300 mm layer of low permeability clay over the Intermediate cover. A further 300 mm layer of sub-soil and a final 100 mm layer of soil suitable for vegetation establishment will be placed over the low permeability clay layer.

(28) The Proponent will ensure that, as part of on-going operational practice, the final landfill surface will be constructed to a predetermined crossfall to enhance surface runoff while safeguarding against erosion and to ensure that final contours of the site will blend into the surrounding environment.

(29) The Proponent will ensure that, on completion of each landfill cell, shallow rooted native vegetation (in accordance with advice from the Department of Conservation and Land Management and the Shire of Serpentine-Jarrahdale) will be established and maintained.

Surface Water Runoff

(30) During the active operation of a landfill cell, all surface water runoff from within the active cell will be treated as leachate and the Proponent will ensure that it will be collected and disposed of through the leachate drainage system.

(31) The Proponent will ensure that a site drainage system will direct runoff water from areas outside the landfill boundary, undeveloped areas within the landfill boundary and from the rehabilitated surfaces of completed landfill cells, away from the active tipping areas. Water from this system will not have contacted refuse, and therefore it will be uncontaminated and may directly discharge into the stream.

Road Construction and Maintenance

(32) The Proponent will ensure that, from the outset of the landfill operation, all roads to be used by visitors to the site will be sealed (up to the gatehouse).

(33) The Proponent will ensure that surface runoff from internal roads within the landfill site will not contact refuse and will be directed to the on-site sedimentation pond.

(34) The Proponent will ensure that a water tanker will be permanently on-site and available for dust suppression on all unsealed trafficked areas during dry periods or as required.

Wheel Cleaning Facilities

(35) As part of the initial site development, the Proponent will ensure that a wheel cleaning drive through is installed on the egress from the landfill cell area to dislodge debris and sediment from vehicle wheels. Debris collected in the sump will be regularly removed and disposed of within the active landfill cell. Contaminated water within the drive-through will be treated as leachate.

Water Supply

(36) The Proponent will comply with all requirements of the Water Authority regarding the siting, construction and licensing of on-site production bores.

9.5 Management of Environmental Impacts

Water Resources

Commitments regarding Cell Sealing and Leachate Collection also pertain.

(37) The Proponent will ensure that an underdrain is constructed beneath the low permeability liner where required to collect and divert water egressing from the fractured granite to the sedimentation pond.

Odours

Commitments regarding Cell Sealing, Leachate Collection and Water resources also pertain.

(38) The Proponent will ensure that particularly odorous refuse will only be accepted at the landfill by prior arrangement and that any such material received will be covered immediately.

Litter

Commitments regarding Placement and Compaction of Refuse also pertain.

(39) In the event that littering along access routes to the landfill site becomes a problem, the Proponent will pursue prosecution of offenders under the provisions of the *Litter Act* as rigorously as possible.

(40) The Proponent will ensure that any landfill related litter along the site access routes within a 2 km radius of the site is regularly removed.

(41) The Proponent will ensure that, as part of normal operational practices, portable litter control screens will be placed in the vicinity of the active tipping face to intercept any material blown from the tipping face.

(42) The Proponent will ensure that, as part of normal operational practices, any litter blown from the tipping face and intercepted by the portable screens, the site security fence or perimeter vegetation will be routinely collected and returned to the tipping face.

Noise

Commitments regarding Design Features (perimeter buffers and earth bunds) also pertain.

(43) The Proponent will ensure that all vehicles and machines operating at the landfill site and which are under its control will be fitted with effective exhaust system silencers.

(44) The Proponent will limit the daily hours of operation of the landfill between 0600 and 1800 hours Monday to Saturday and 1000 and 1600 hours on Sundays.

Dust

Commitments regarding Design Features (perimeter buffers and earth bund), Road Construction and Maintenance, and Wheel Cleaning Facilities also pertain.

(45) The Proponent will, during initial site development and as part of normal operational practices, ensure the stabilization by vegetation or other means of disturbed areas not immediately needed for landfill operations.

(46) As part of normal operational practices, the Proponent will ensure that any unsealed trafficked areas are watered as necessary to lay dust.

(47) As part of normal operational practices, the Proponent will ensure that:

- active tipping area will be dampened (either by leachate irrigation or water application) as necessary to lay dust; and

- overburden, cover material stockpiles will be stabilized with temporary cover vegetation, mulching, watering or other technique to suppress dust generation.

Pests

Commitments regarding Placement and Compaction of Refuse also pertain.

(48) The Proponent will ensure that, as part of normal operational practices, any large appliances, crates etc, placed in the active tipping area will be specifically crushed before covering with refuse and cover material, and that any tyres dumped, unless shredded or split, will be spread out and carefully covered.

(49) The Proponent will implement supplementary control measures directed towards specific pest species on an as required basis in conjunction with and to the satisfaction of the EPA, Water Authority, Department of Conservation and Land Management, Shire of Serpentine-Jarrahdale or other regulatory authority.

Landfill Gas Management

(50) Prior to the commencement of tipping operations, the Proponent shall prepare a methane gas management plan which addresses monitoring, collection, disposal and potential beneficial uses of landfill gas to the satisfaction of the Environmental Protection Authority and the Health Department of Western Australia.

(51) Initially, gas will be disposed of by flaring. When monitoring results indicate that action to manage landfill gas emissions is warranted, the Proponent will implement the methane gas management plan to the satisfaction of the Environmental Protection Authority on advice of the Health Department of Western Australia. The Proponent will liaise with the relevant authorities regarding beneficial uses of landfill gas over the operating and post-closure life of the landfill.

(52) The Proponent will co-operate with Government agencies wishing to undertake investigations into the stimulation of methane generation at landfills.

Fire

Commitments regarding Placement and Compaction of Refuse, Landfill Gas Collection, and Landfill Gas also pertain.

(53) The Proponent will ensure that, from the outset of the landfill operation, site operational and management practices will not include utilization of fire except for the controlled flaring of landfill gas.

(54) The Proponent will ensure that from the outset of the landfill operation, adequate manpower and machinery resources to combat any fires which may occur within the landfill site will be maintained on-site during operating hours.

(55) The Proponent will make the water tanker truck available to the Shire of Serpentine-Jarrahdale or the Bush Fires Board to assist in fighting fires subject to the proximity of the problem and the Proponents needs at that time.

Social Impacts

Effectively all Commitments given pertain directly or indirectly to the amelioration of social impacts.

9.6 Environmental Monitoring

Water Resources

(56) The Proponent will progressively construct a series of dedicated groundwater monitoring bores to specifications acceptable to the EPA and Water Authority. It is anticipated that monitor bores will need to be installed at about 100 m intervals along sections of the site boundary down hydraulic gradient from areas used for landfilling.

(57) On commissioning of each monitor bore and prior to the commencement of tipping, groundwater will be sampled and analysed for a range of potential contaminants to provide background information on groundwater quality. Parameters determined will include pH, salinity (as TDS), redox potential, major ions, nutrients, total organic carbon, and heavy metals to the satisfaction of the Environmental Protection Authority on advice from the Chemistry Centre and the Water Authority of Western Australia.

(58) The Proponent will implement a programme of regular sampling from the monitor bores. This programme will be determined by the site hydrogeological conditions although initially, sampling on a three-monthly basis is envisaged. Water samples collected will be analysed for a select range of parameters. These will include pH, salinity (as TDS),

zinc, total organic carbon, five-day biochemical oxygen demand, ammonia-nitrogen, and total alkalinity to the satisfaction of the Environmental Protection Authority on advice from the Chemistry Centre and the Water Authority of Western Australia.

(59) The Proponent will sample privately owned bores on selected properties in the vicinity of the landfill, initially on an annual basis, and analyse samples for a select range of parameters. These will include pH, salinity (as TDS), and ammonia-nitrogen to the satisfaction of the Environmental Protection Authority on advice from the Chemistry Centre and the Water Authority of Western Australia.

(60) Groundwater samples will be collected and analysed in accordance with recognized standard procedures, and to the satisfaction of the EPA and the Water Authority of Western Australia.

(61) If monitoring indicates that groundwater quality is being effected to an unacceptable degree, as determined by the Environmental Protection Authority, the Proponent shall prepare a strategy for clean-up of groundwater contamination, to the satisfaction of the Environmental Protection Authority on advice of the Water Authority of Western Australia.

(62) The Proponent shall implement the strategy for clean-up of groundwater contamination required by Commitment 61 (above) to the satisfaction of the Environmental Protection Authority on advice from the Water Authority of Western Australia.

(63) Should groundwater analyses indicate contamination by landfill leachate, the Proponent will immediately undertake further sampling and analysis for a more extensive range of parameters in consultation with, and to the satisfaction of, the EPA and the Water Authority of Western Australia.

(64) Any complaint about a deterioration in groundwater quality reasonably attributable to the landfill operation will be immediately investigated by the Proponent in consultation with, and to the satisfaction of, the EPA and the Water Authority of Western Australia.

(65) The Proponent will implement a programme of regular water sampling of the sedimentation pond, into which groundwater collected by the landfill underdrain flows. Water samples collected will be analysed for the same parameters as for samples taken from the groundwater monitoring wells to the satisfaction of the Environmental Protection Authority on advice from the Chemistry Centre and the Water Authority of Western Australia.

(66) As soon as leachate is detected in the leachate collection sump, and thereafter in conjunction with the groundwater monitoring programme, samples will be collected and analysed for comparison with anticipated

leachate chemistry. Continuing sampling and analysis will be co-ordinated with the groundwater monitoring programme, and analytical results will be included in the periodic performance reports.

Other Environmental Monitoring

(67) From the outset of the landfill operation, the Proponent will maintain a complaints register in which details of any complaints from local residents, within the Serpentine-Jarrahdale municipality about the landfill operation will be recorded.

(68) The Proponent will monitor the activity of Silver Gulls at the landfill site, from the outset of landfilling operations, in consultation with, and to the satisfaction of, the Department of Conservation and Land Management.

(69) Following the installation of the landfill gas extraction system, the Proponent will measure landfill gas flow rates at six-monthly intervals. Results will be forwarded directly to the EPA and will also be incorporated into the periodic performance reports.

9.7 Performance Reporting

(70) The Proponent will submit annual performance reports to the EPA, Health Department and the Shire of Serpentine-Jarrahdale within three months following each anniversary of the commencement of the landfilling operation. These reports will address such matters as:

- the stage reached in the various operational and management programmes being implemented;
- results from monitoring programmes instituted, including the complaints register, and the response to any complaints received;
- modifications to the various programmes that have been implemented in response to monitoring results; and
- any unforeseen or extraordinary event associated with the landfill that has adversely affected off-site environmental quality (and the Proponent's response to that event) occurring during the preceding twelve months.

The final report submitted during a reporting period will provide a detailed review of performance over the entire period and of any modifications to operational and management programmes intended.

(71) The Proponent will respond, through an interactive process with the EPA, Health Department and the Shire of Serpentine-Jarrahdale, to any issues those agencies may raise following receipt of the performance reports.

(72) At the same time that periodic performance reports are submitted to the EPA, Health Department and Shire of Serpentine-Jarrahdale, the Proponent will make the reports available to relevant community organizations within the Shire of Serpentine-Jarrahdale

(73) Any unforeseen or extraordinary events associated with the landfill that adversely affected off-site environmental quality, and the Proponent's response to any such event will be reported immediately (by the Proponent) to the EPA, Health Department, and Shire of Serpentine-Jarrahdale.

9.8 Contingency Planning

(74) The Proponent will submit for approval from the Shire of Serpentine-Jarrahdale a contingency plan for emergency situations after consultation with the Shire of Serpentine-Jarrahdale, Environmental Protection Authority, Health Department of Western Australia, Bush Fires Board, Water Authority of Western Australia and the Department of Conservation and Land Management.

(75) The Proponent will respond to any unforeseen contingency associated with the landfill and which is producing a demonstrable and unacceptable off-site impact in consultation with the EPA, Health Department of Western Australia, the Shire of Serpentine-Jarrahdale, and to the satisfaction of the Minister for the Environment as appropriate.

9.9 Management Following Closure

(76) The Proponent recognizes that certain management responsibilities will continue following closure of the landfill site and will ensure that such responsibilities will be discharged in consultation with the relevant regulatory authorities (presently the EPA and the Health Department of Western Australia).

(77) The Proponent shall be responsible for construction, operation, decommissioning and post-closure management of the site until such time as the waste has fully degraded, to the satisfaction of the Environmental Protection Authority.

(78) Within two years after the date of commencement of construction, the Proponent shall prepare a draft decommissioning and post-closure management plan, to the satisfaction of the Environmental Protection Authority.

(79) At least two years prior to closure, the Proponent shall prepare the final decommissioning and post-closure management plan, to the satisfaction of the Environmental Protection Authority.

(80) The Proponent shall implement the final decommissioning and post-closure management plan required by Commitment 79, to the satisfaction of the Environmental Protection Authority.

9.10 Financial Assurances

(81) Within six months of commencement of landfilling operations, the Proponent will establish financial assurances in favour of the Shire of Serpentine-Jarrahdale to cover emergency contingencies and long-term risks in a form and to an amount acceptable to the Environmental Protection Authority, Health Department of Western Australia and the Shire of Serpentine-Jarrahdale.

(82) The amount of the financial assurances shall be reviewed every five years by the Environmental Protection Authority in consultation with the Shire of Serpentine-Jarrahdale and the Health Department of Western Australia.

(83) Company guarantees, if offered by the Proponent, shall be supported by annual audited accounts from each guaranteeing entity.

(84) The preparation of the legal agreement relating to the financial assurances shall be executed by the Proponent's solicitors at the Proponent's expense.

10 CONCLUSION

All of the environmental issues and potential impacts associated with the proposed Southern Landfill can be addressed by design principles, and ongoing operational practices and specific management measures. Pioneer-BFI Waste Services is committed to implementing operational and management practices that will minimize the occurrence of adverse effects frequently associated with refuse disposal facilities. Nevertheless, the proposed landfill will produce some environmental change which, inevitably, will be perceived to have an undesirable impact upon the human environment.

However, when assessing the significance of this change, both present and future conditions within the surrounding environment need to be considered. While the South Cardup locality is, ostensibly, a rural setting, established land uses (e.g. quarrying) indicate that the character and amenity of the locality is already experiencing change. Land use developments proposed for the area will reinforce this change. Accordingly, the context in which the implications of the proposed landfill need to be assessed is not a static rural setting, but a dynamic one in which non-rural activities will be increasingly prominent.

Potential social impacts associated with the proposed landfill therefore need to be considered in this context. While the proposed landfill may be seen as likely to produce adverse social impacts, the potential for such impacts is not great and will be further reduced by the management programmes proposed. Additionally, the complaints register to be maintained by Pioneer-BFI Waste Services, and the submission of periodic performance reports will ensure external scrutiny of any perceived social impacts and Pioneer-BFI Waste Services' response thereto. The periodic performance reports will also be made available to the local community for scrutiny.

The potential for on-site biophysical environmental impacts associated with the proposed landfill is very low because much of the site has already been comprehensively modified through the extractive industry operations or disturbed by grazing activities. The potential for off-site biophysical impacts will also be low because of the management programmes intended.

Groundwater contamination, and the effects of pests, including Silver Gulls attracted to the site, represent the greatest potential impacts upon the biophysical environment that could result from the proposed landfill operations.

The risk of groundwater contamination will be virtually eliminated by sealing of the refuse disposal cells, and collection of any leachate generated, initially for recycling over the active landfill cells, and ultimately for disposal off-site. Leachate production will be minimal because of the thin layer landfilling practices intended, and as each refuse cell will be capped when filling is completed. There will, however, be some movement of leachate through the clay seal of the landfill cells, although the implications for the broader

environment are effectively negligible. Any such movement is expected to be slow and the volume small, owing to the low permeability of the clay liner (10^{-9} m/s), and therefore will not pose a significant threat of pollution to the off-site environment.

The landfill cells will be progressively constructed over the twelve month period of their use, by regularly raising the perimeter embankments and interposing layers of refuse with clean fill material. The frequent placement of cover material will reduce exposure of the refuse to pest species and minimize windblown litter and odours. Nevertheless, Pioneer-BFI Waste Services recognizes that supplementary pest control measures may be needed. Pioneer-BFI Waste Services is, therefore, committed to implementing all realistic undertakings that can be provided in respect of pest control.

Undoubtedly, the proposed landfill will produce some changes within the surrounding environment, although it is considered that these changes would not exceed the assimilative capacity of the receiving environment. Pioneer-BFI Waste Services also recognizes that the proposed landfill will be regarded by some as both socially and environmentally undesirable, but is endeavouring to provide its waste management and disposal services in a fully responsible manner.

On commencement of landfilling, Pioneer-BFI Waste Services will initiate a thorough monitoring programme as committed to in Section 9 of this PER. Monitoring results will be incorporated in reports documenting operational and management experience and records, unforeseen occurrences, proposed changes to the management programmes, and the complaints record. These reports will be produced and submitted to regulatory authorities on an annual basis.

During the preparation of this proposal, Pioneer-BFI Waste Services has consulted widely with the local community and government agencies and has endeavoured to respond to any concerns raised. Commitments to facilitate ongoing community involvement with the landfill operation have also been provided.

While recognizing that the proposed landfill will produce some change within the local human and biophysical environment, the Pioneer-BFI Waste Services believes such change has been demonstrated to be manageable and unlikely to produce any unacceptably adverse impacts. Pioneer-BFI Waste Services therefore considers that the proposed Southern Landfill should be regarded as environmentally acceptable, subject to the commitments provided.

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ABBREVIATIONS AND GLOSSARY

Abbreviations

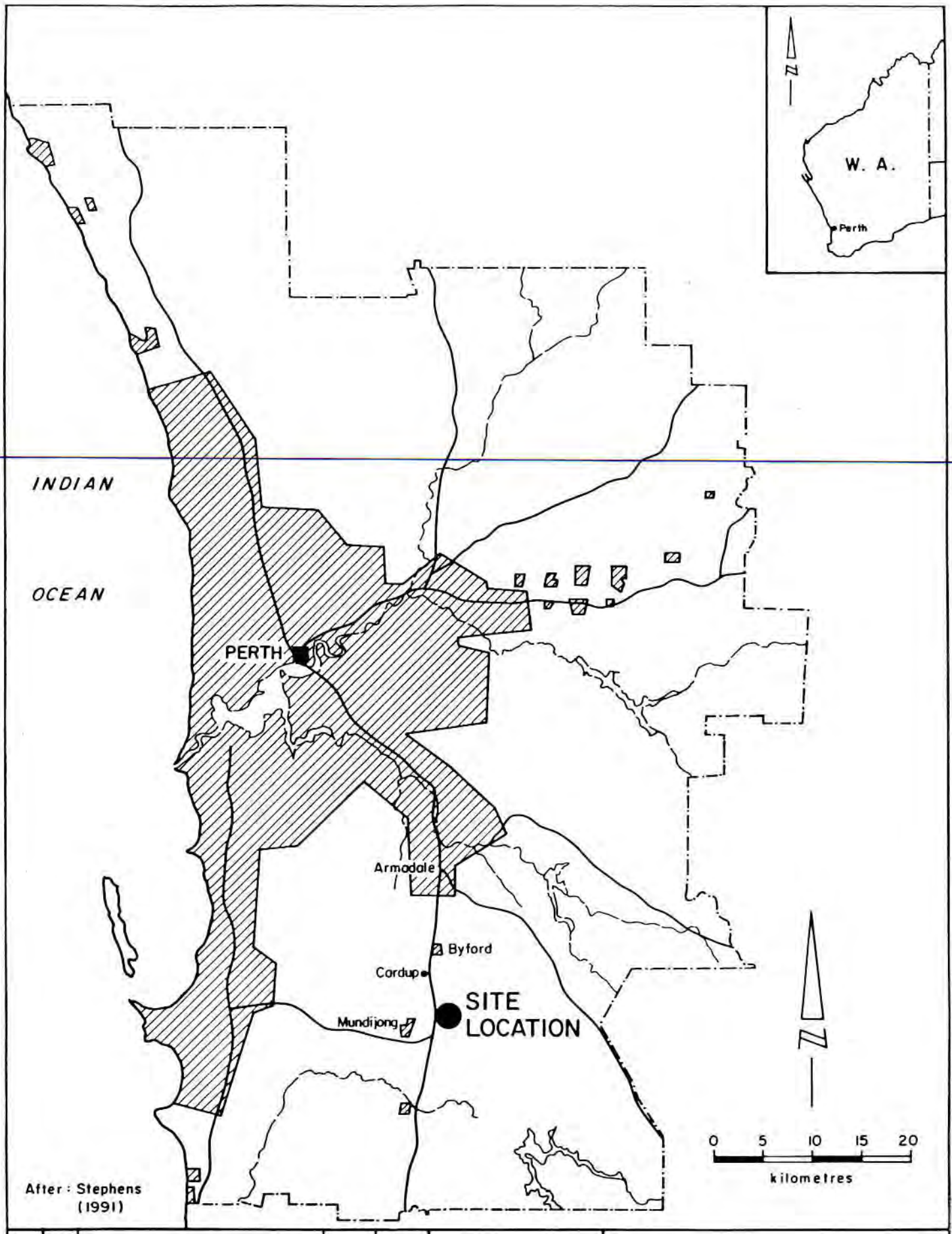
AHD	-	Australian Height Datum
ANZECC	-	Australian and New Zealand Environment and Conservation Council
BFI	-	Browning-Ferris Industries (Australia) Pty Ltd
BOD	-	Biochemical oxygen demand
CALM	-	Department of Conservation and Land Management of Western Australia
CER	-	Consultative Environmental Review
cm/s	-	centimetres per second
DCE	-	Department of Conservation and Environment of Western Australia
EPA	-	Environmental Protection Authority of Western Australia
EPAV	-	Environmental Protection Authority of Victoria
ha	-	hectare
HDPE	-	high density polyethylene
kL	-	kilolitre
km	-	kilometre
m	-	metre
m^2	-	square metres
m/s	-	metres per second
Ma	-	million years before present
mg/L	-	milligrams per litre
mm	-	millimetre
mm/s	-	millimetres per second
NATA	-	National Association of Testing Authorities
NHMRC	-	National Health and Medical Research Council
PAWM	-	Pioneer Australia Waste Management Pty Ltd
PER	-	Public Environmental Review
PVC	-	polyvinylchloride
TCLP	-	Toxicity Characteristic Leach Procedure
TDS	-	total dissolved solids
USEPA	-	United States Environmental Protection Agency
WAWA	-	Water Authority of Western Australia
<	-	less than
°C	-	degrees Celsius

Glossary

Aquifer	-	a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to bores and springs.
Aquifer throughflow	-	the volume of groundwater moving through a particular aquifer cross section during a particular time period.
Aquifer transmissivity	-	the rate at which water at the prevailing viscosity can be transmitted through a unit strip of aquifer under a unit gradient.
BOD_5	-	five day biochemical oxygen demand; a measure of the content of organic materials in a water or soil which can be readily degraded by aerobic microbes.
Calcareous	-	materials, particularly soils and rocks, containing significant amounts of calcium carbonate.
Colluvial	-	consisting of alluvium in part and also containing angular fragments of the original rocks.
Duricrust	-	a firmly cemented material often occurring below the soil surface, but sometimes as outcrops. Primarily composed of oxides of iron and aluminium, but sometimes includes soils and weathered rocks.
Effective porosity	-	the measure of the water yielding capacity of the aquifer material, expressed quantitatively as the percentage of the total volume of the material occupied by the ultimate volume of water released from or added to storage in a water table per unit horizontal area of aquifer and per unit decline or rise of the water table.
Gross alpha activity	-	the total activity of all radionuclides which emit alpha - type radiation.
Gross beta activity	-	the total activity of all radionuclides which emit beta - type radiation.
Groundwater gradient	-	the change in static head or hydraulic potential within an aquifer, per unit distance within a given direction.
Ion	-	an atom or group of atoms which carries either a positive or negative electric charge.
Katabatic wind	-	downslope flow of cold air which displaces warm, lighter air.
Leachate	-	liquid which has percolated through or drained from waste and which contains dissolved and/or suspended materials from the waste.

Monadnock	-	an upstanding rock, hill or 'mountain of circumdenudation' of resistant rock rising above the general level of a peneplain in a temperate climate.
Mylonite	-	a very fine, lithified fault breccia, commonly found in major fault thrusts and produced by shearing and rolling during fault movement.
Permeability	-	the characteristics of material which govern the rate at which water (or other liquid) will move through it.
pH	-	a measure of the acidity or alkalinity of water or soil; on the pH scale, pH 7 is neutral, pH less than 7 is acidic, and pH greater than 7 is alkaline.
Proponent	-	Pioneer-BFI Waste Services.
Redox potential (Eh)	-	a measure of the aeration status of a water or soil; a high redox potential indicates moderate to high levels of oxygen, while a low redox potential indicates low levels of oxygen; low redox potentials are generally characterized by anaerobic metabolism.
Salinity	-	a measure of the content of soluble
Solution channels	-	preferred flow paths which may develop in calcareous formations and, if extensively interconnected, may permit rapid movement of water either downwards to an aquifer or laterally within the aquifer.
Surficial aquifer	-	an aquifer containing a water table where the groundwater is not subjected to any other than atmospheric pressures.
Total dissolved solids (TDS)	-	mineral salts in water or soil; for waters, salinity corresponds to the content of total dissolved solids as determined by evaporative drying.
Total organic carbon (TOC)	-	the total content of carbon from organic compounds comprising natural and/or man made materials.
90 percentile wet year	-	a one in ten probability that annual rainfall will exceed this value.

FIGURES

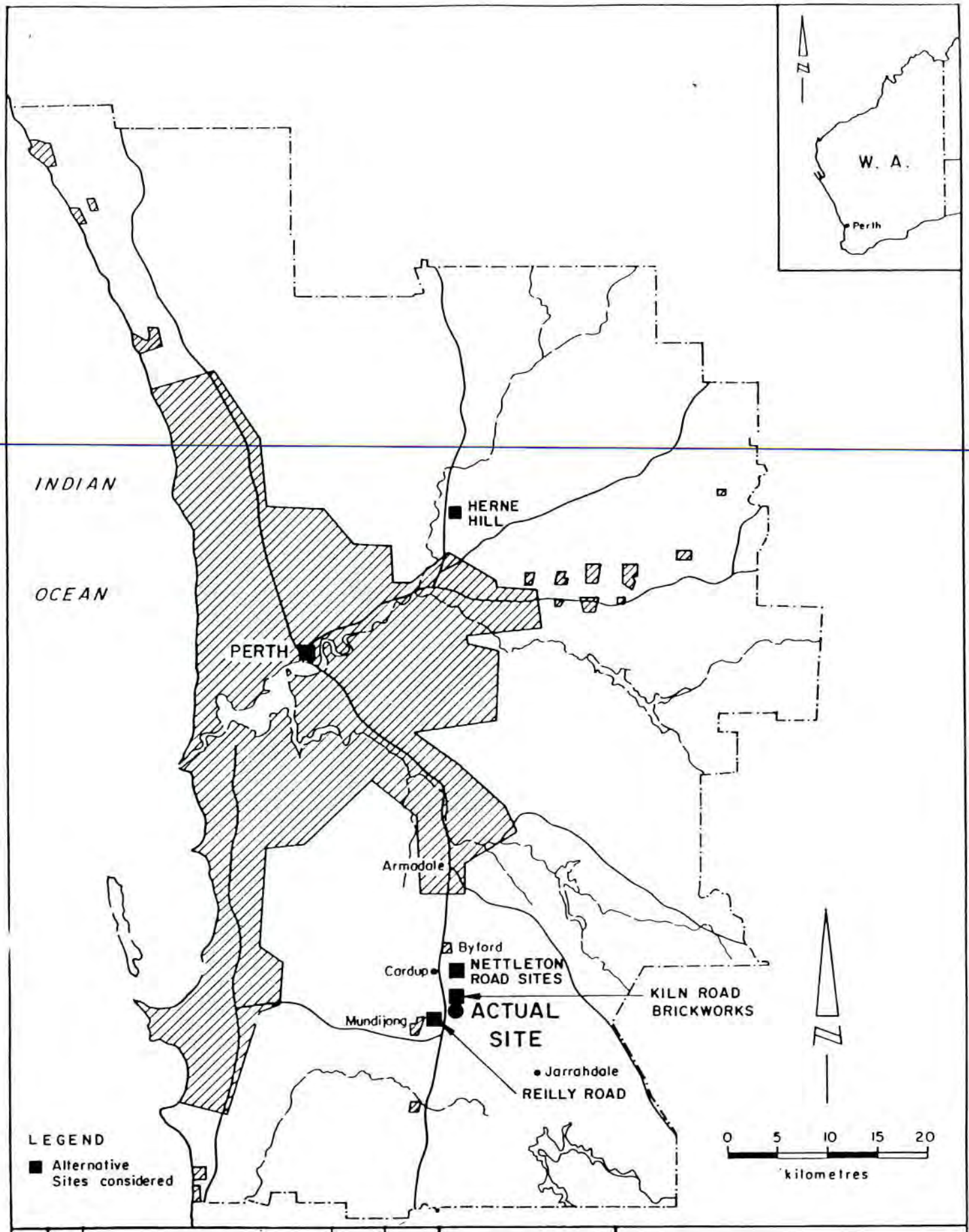


REVISIONS				
	Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AGC
Woodward-Clyde

LOCALITY PLAN

Date Jan. '93 | Dwg. 2535-1 | Fig. 1

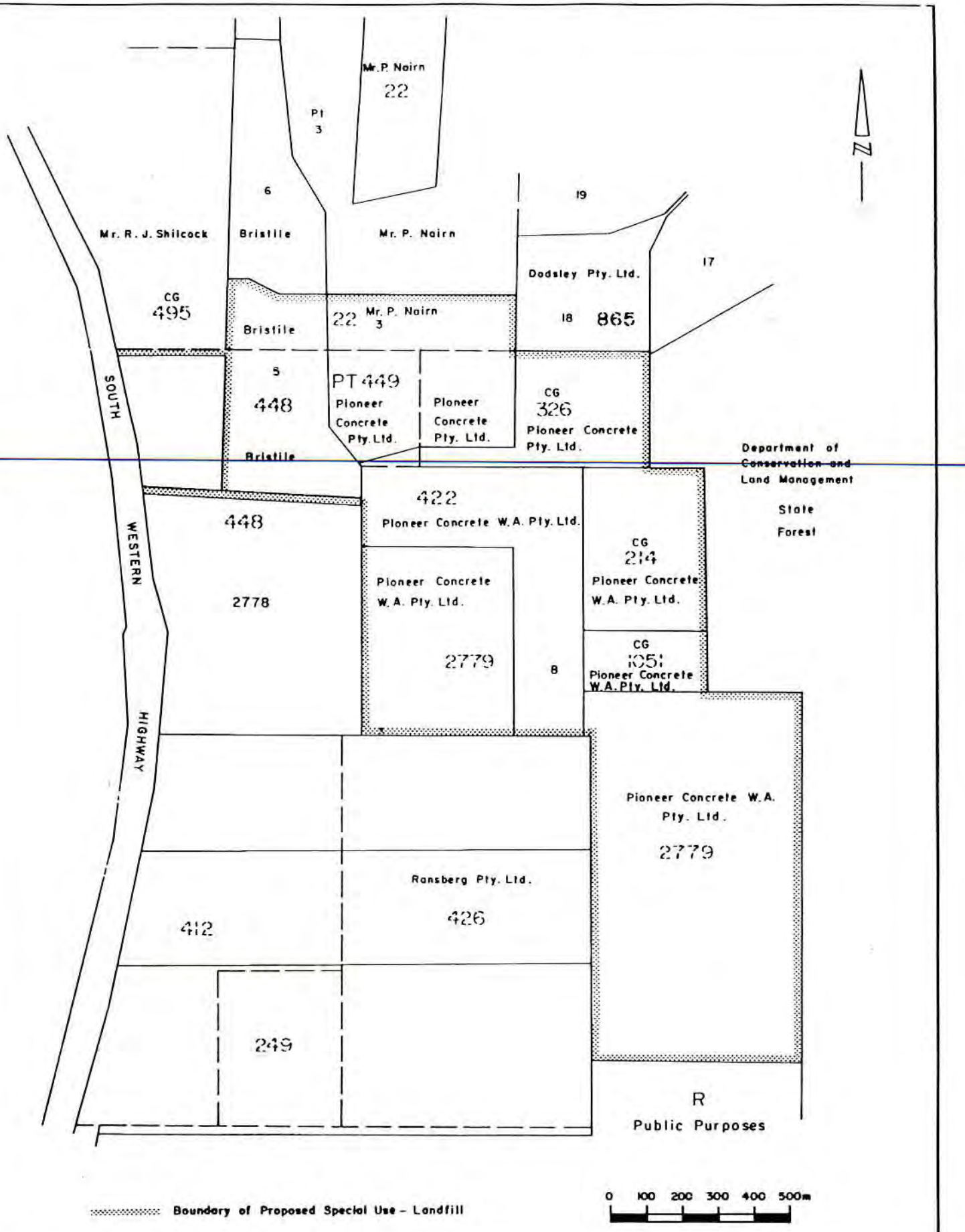


REVISIONS				
Rev.	DESCRIPTION	Drawn Date	Chk'd Date	

AGC Woodward-Clyde

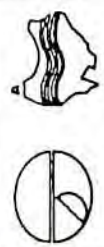
ALTERNATIVE SITES CONSIDERED

Date Jan. '93 | Dwg. 2535-2 | Fig. 2

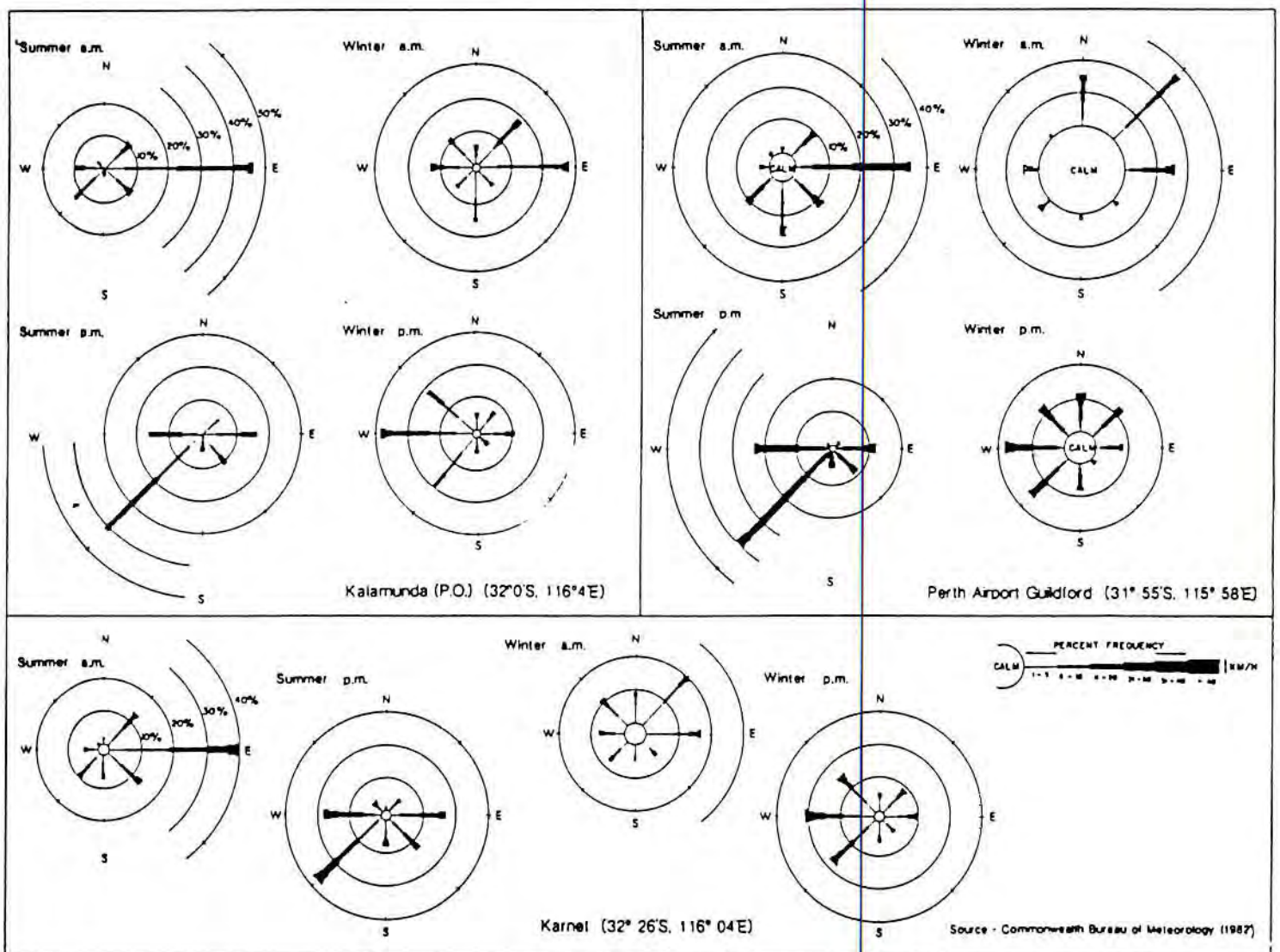


REVISIONS					AGC Woodward-Clyde	TITLE PLAN		
	Rev.	DESCRIPTION	Drawn Date	Chk'd Date		Date Jan. '93	Dwg. 2535-3	Fig. 3

REVISIONS				
Rev.				
DESCRIPTION				
Drawn Date				
Chk'd Date				

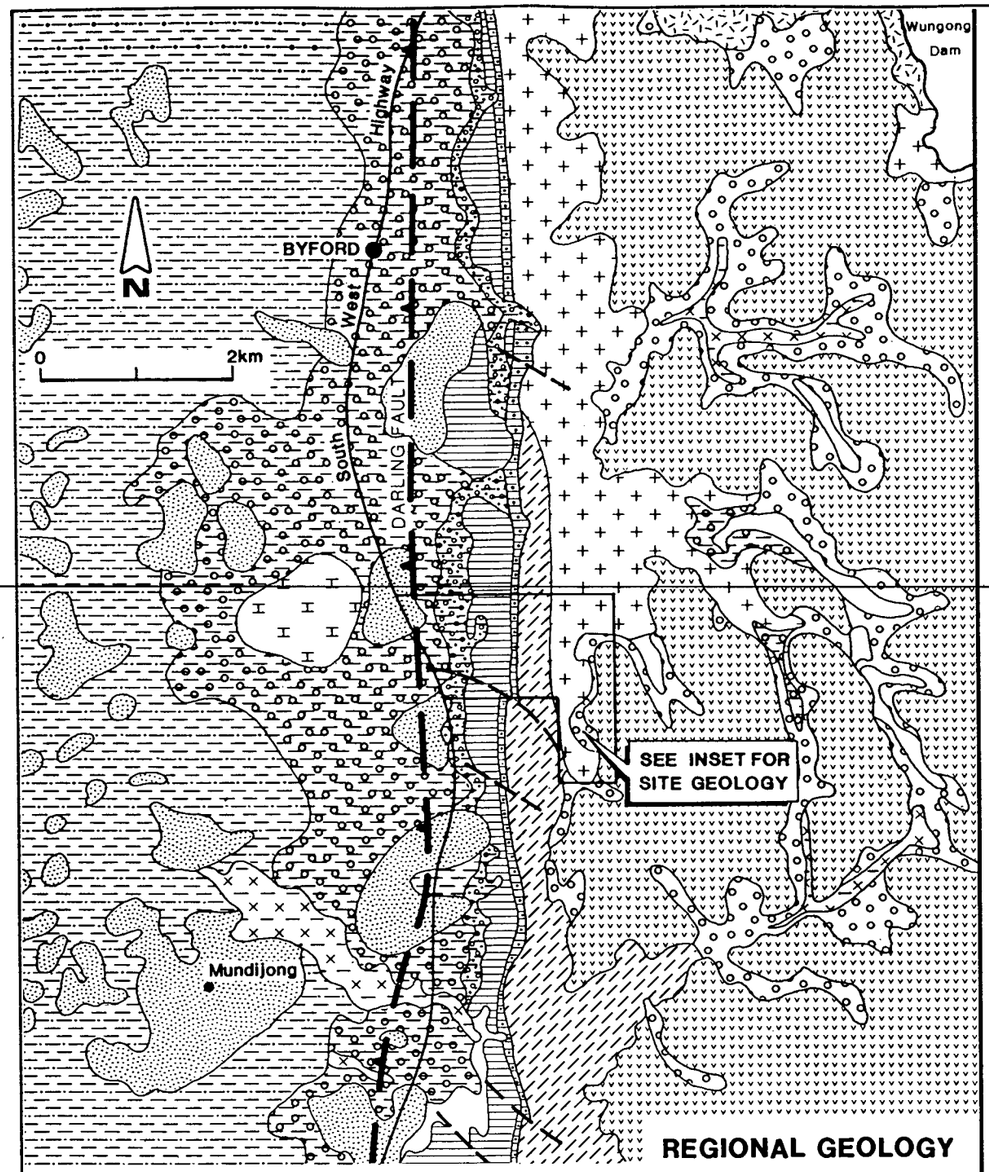


AGC Woodward–Clyde



WIND ROSES

Date	Dwg.	Fig.
Jan. '93	2535-4	4

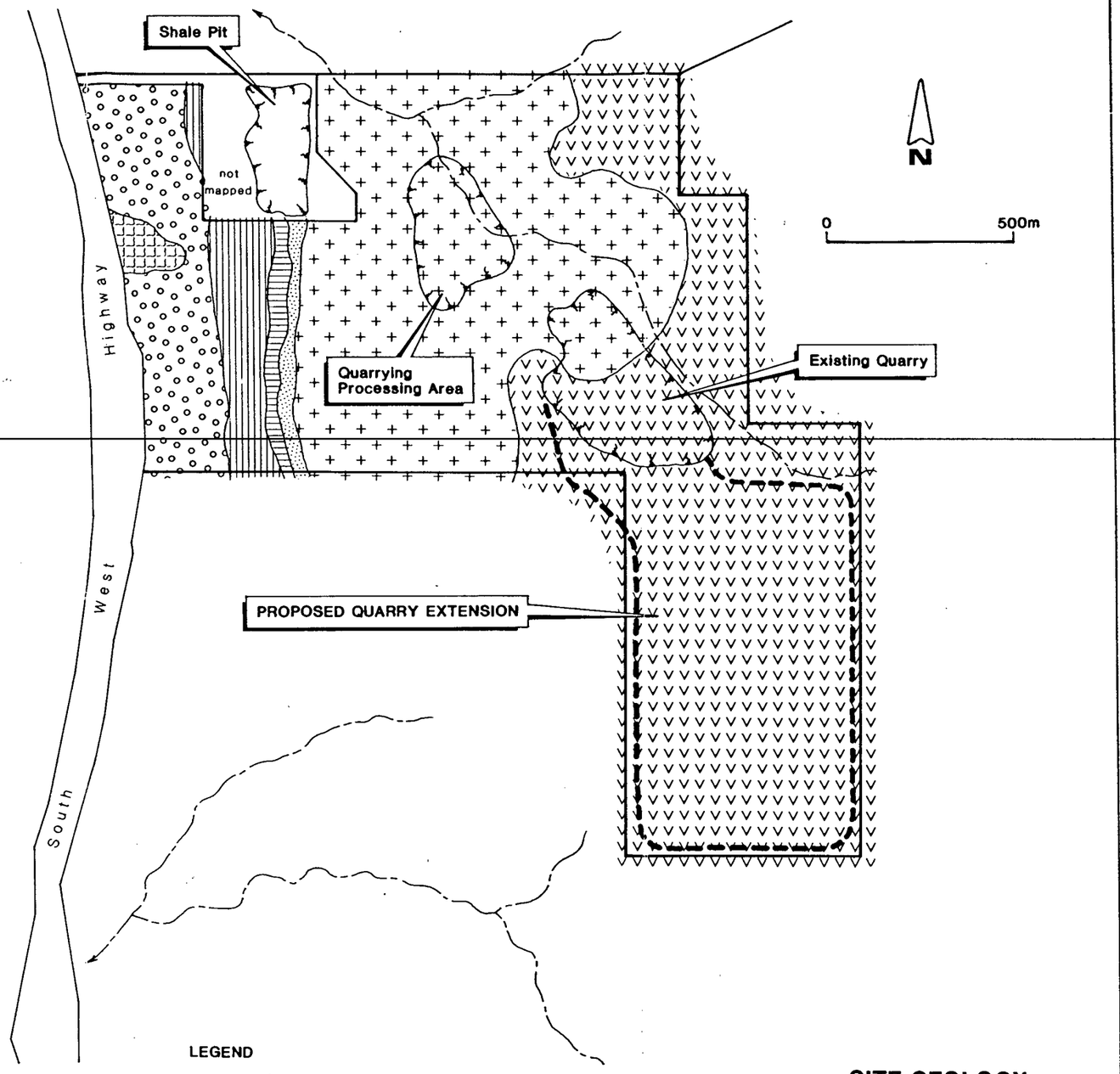


REGIONAL GEOLOGY

LEGEND

- **Clayey sandy silt** alluvial origin
- **Gravelly clayey sand** – decomposed bedrock, gravel rock fragments, quartz/feldspar sand, colluvial origin
- **Gravelly sandy clay** – variable with lenses of silt and gravel, quartz sand, colluvial origin
- **Sand** – white to pale grey over yellow sand, aeolian origin
- **Sand** – of Guildford formation, white to pale grey over yellow sandy clay
- **Sandy clay** white, grey-brown, of alluvial origin
- **Sand** – yellow, quartz, feldspar and heavy minerals common, of colluvial origin
- **Ironstone** – red-brown limonite gravel of alluvial origin
- **Gravel** – red, brown-black pisolitic, highly variable sand content, of colluvial origin
- **Laterite** – massive, vuggy to cemented pisolites up to 4m thick, of residual origin
- **Shale** – brown, green to black, silty with interbeds of siltstone and fine sandstone
- **Sandstone** basal conglomerate and silty sandstone
- **Granite** – fine- to coarse-grained mesocratic rocks of granite and granodiorite, porphyritic, even-grained
- **Gneiss** fine- to medium-grained mesocratic gneiss
- **Granites and gneisses** – association of coarse-grained granites and gneisses and fine-grained dolerites
- **Major fault**
- **Minor fault**

After: Jordan (1986)



SITE GEOLOGY

LEGEND

- **Granites and mafic gneisses** – mixed rocks; various granites, migmatite and basic rock. Sheared in places
- **Laterite and clays over granitic rocks and mafic gneisses**
- **Yoganup Formation:** leached or ferruginised beach sand conglomerate and dunes
- **Whitby Sandstone:** orthoquartzite and conglomerate
- **Neerigen Formation:** sandstone and shale
- **Armadale Shale:** white to black shale with thin sandstone
- **Colluvium** – from Archean rocks of the Darling Range variably laterised and podsolised
- **Quarry – existing**

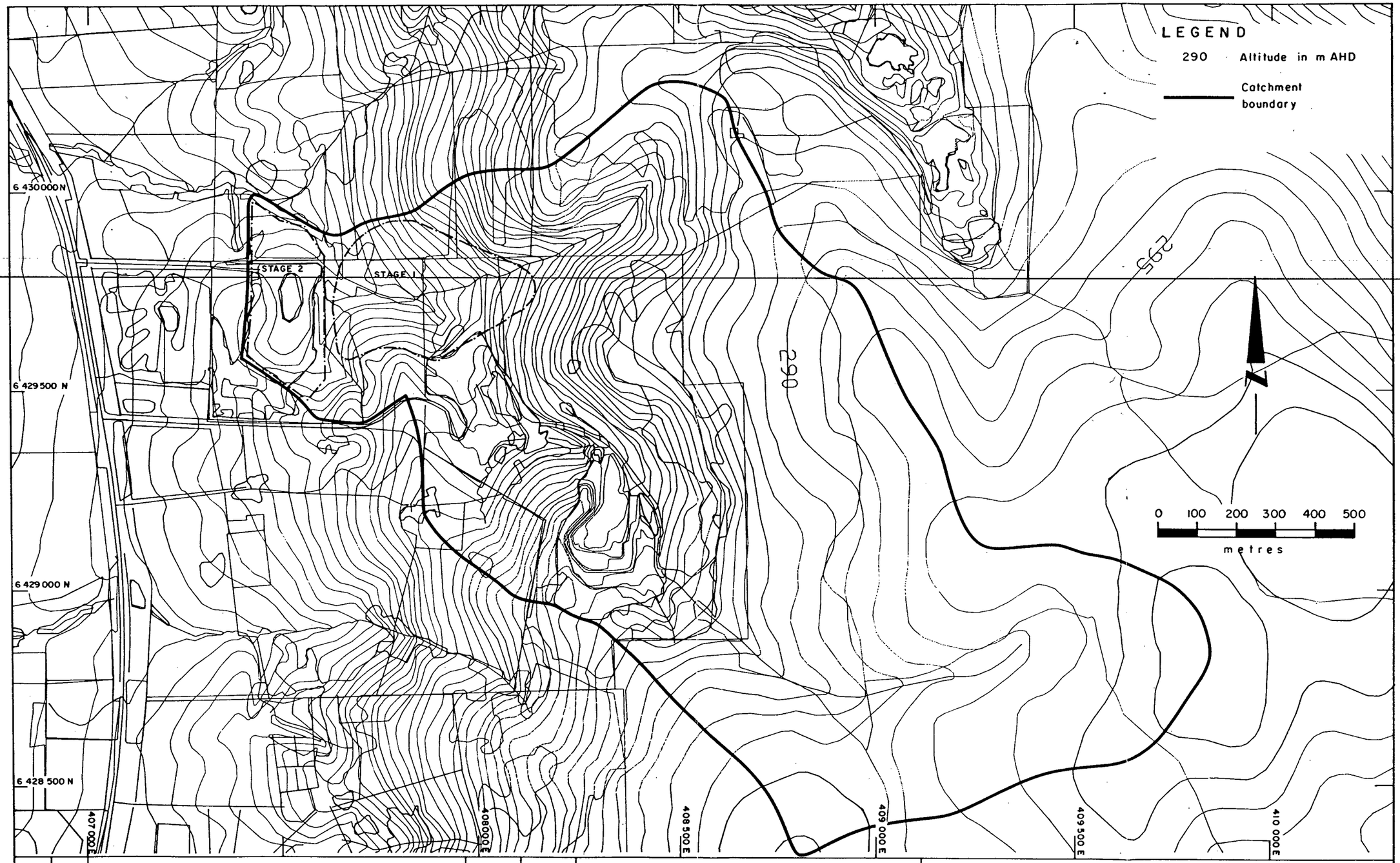
After: Stephens (1991)

REVISION		DESCRIPTION	Drawn Date	Chk'd Date

AGC Woodward-Clyde

REGIONAL AND SITE GEOLOGY

Date January 1993 | Dwg. 2535 - 5 | Fig. 5

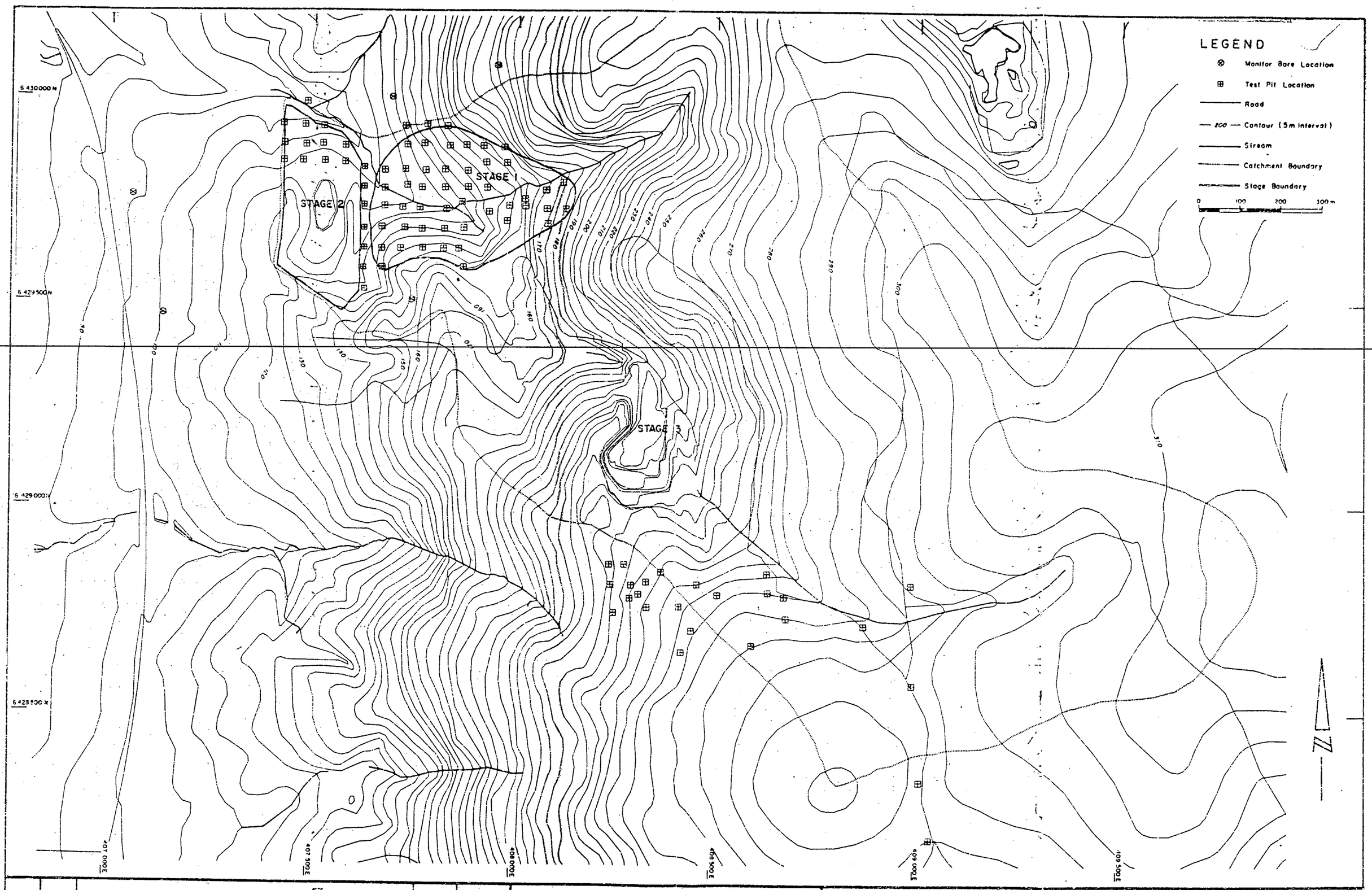


REVISIONS					
	NO.	DESCRIPTION	DATE DRAWN	DRAWN BY:	

AGC Woodward–Clyde

SURFACE WATER HYDROLOGY AND TOPOGRAPHY

DATE: January 1993 | DWG: 2535 - 6 | FIG. 6



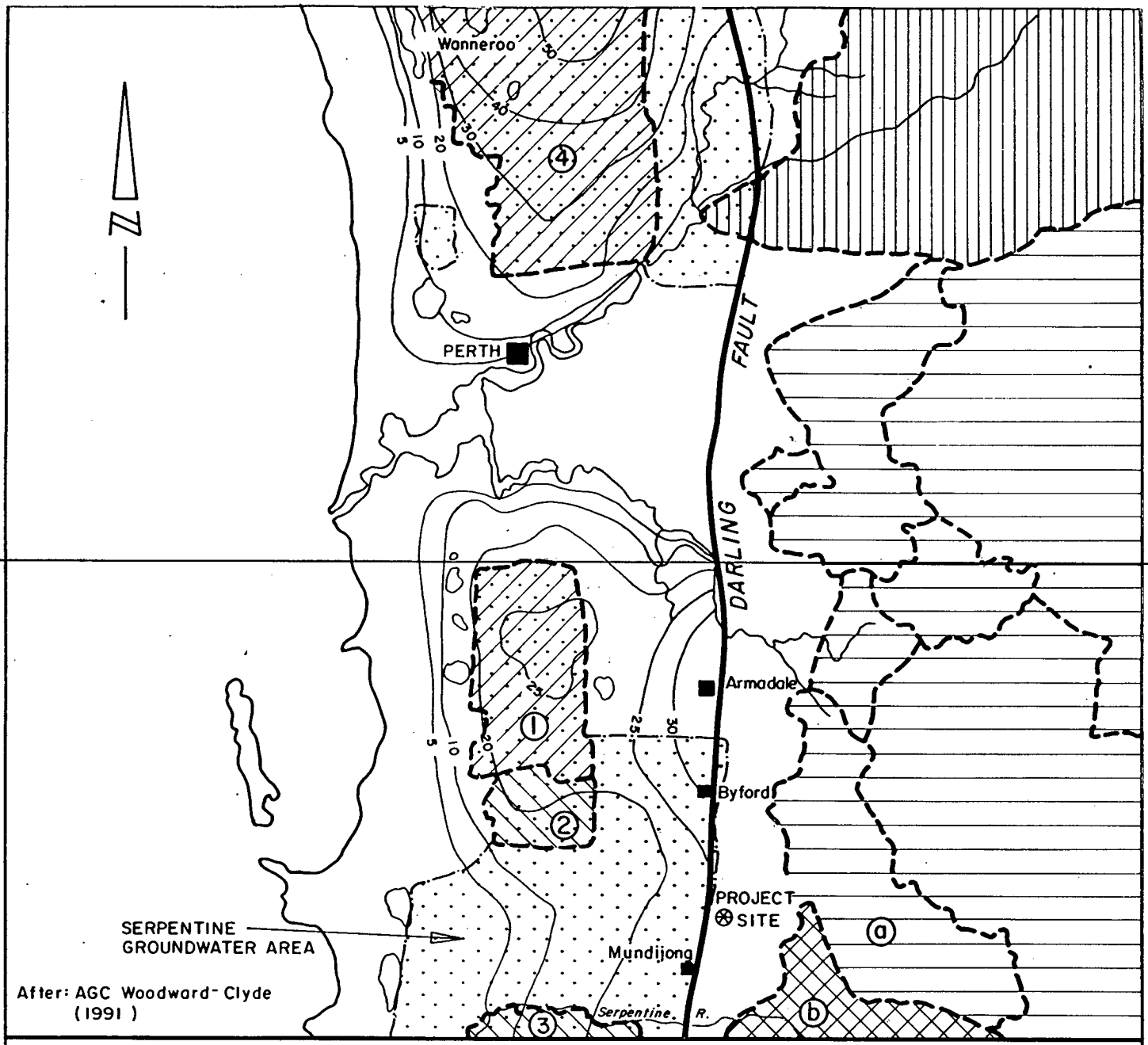
REVISION				
	DESCRIPTION	Drawn Date	Chk'd Date	

AGC Woodward-Clyde

300 ALBANY HIGHWAY, VICTORIA PARK, W.A. 6100, NEW ZEALAND

LOCATIONS OF GEOTECHNICAL TEST PITS AND MONITORING BORES

Date January 1993 | Dwg. 2535-7 | Fig. 7



SURFACE WATER

- Proclaimed and used for public water supply
- Proclaimed with plans for future public water supply
- Potential for public water supply but not proclaimed
- —20— Water table contour (m AHD)
- Catchment boundary
- ⓐ Wungong catchment
- ⓑ Gooralong water reserve

GROUND WATER

- Proclaimed and used for public water supply
- Proposed to be proclaimed for public water supply
- Proclaimed and used for groundwater management
- ① Jandakot
- ② Jandakot South
- ③ Karnup
- ④ Gnangara

0 5 10 15 20
kilometres

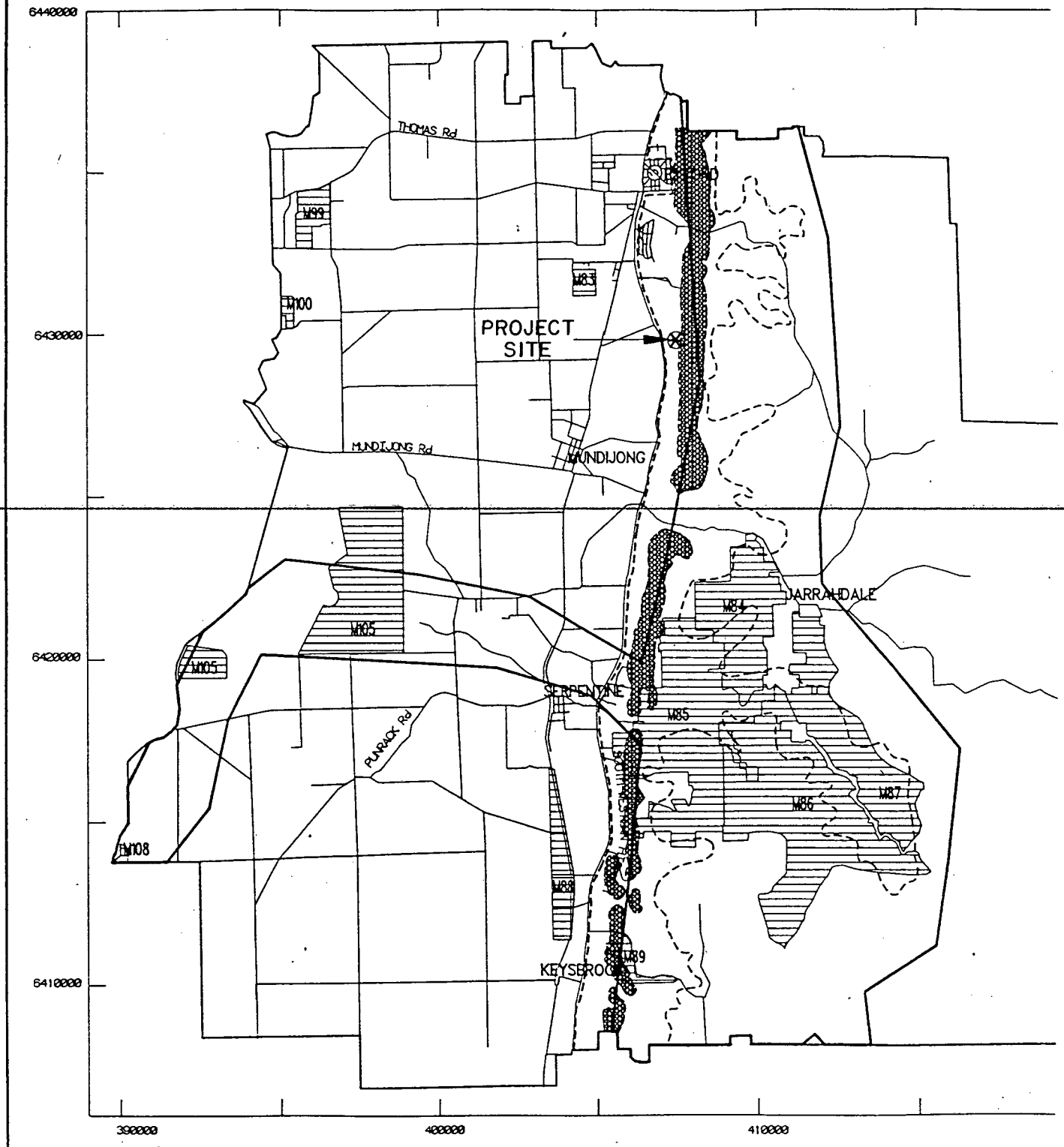
REVISIONS

Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AGC Woodward-Clyde

WATER SUPPLY AREAS

Date Jan. '93 | Dwg. 2535-8 | Fig. 8



Sources:
System 6 areas - D.C.E.(1983).
Potential regional parks - Murdoch University (1989).
Landscape areas - Dept of Planning & Urban Development.
Digital data courtesy of State Water Planning, Water Authority of W.A. and Peel-Harvey Catchment Support Group, W.A. Dept of Agriculture

System 6 recommendation areas - D.C.E. (1983)

Visually prominent landscape

Areas of high landscape value

Potential regional parks (Darling Scarp and Serpentine River)

N

0 1.5 3 4.5 6 7.5
kilometres

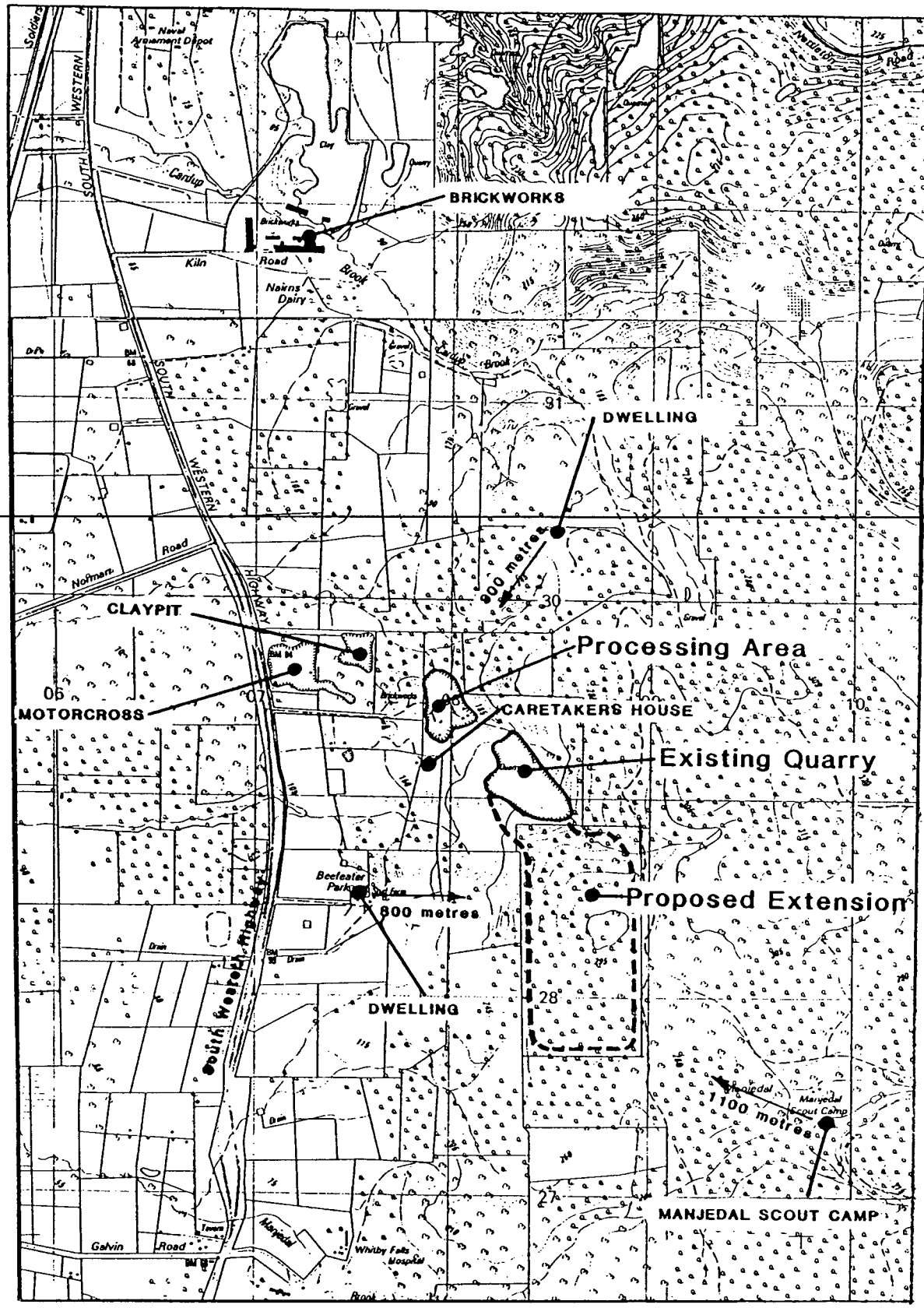
Source: AGC Woodward-Clyde (1991)

REVISIONS	Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AGC Woodward-Clyde

IMPORTANT LANDSCAPE CONSERVATION AREAS SHIRE OF SERPENTINE-JARRAHDALE

Date Jan. '93 | Dwg. 2535-9 | Fig. 9



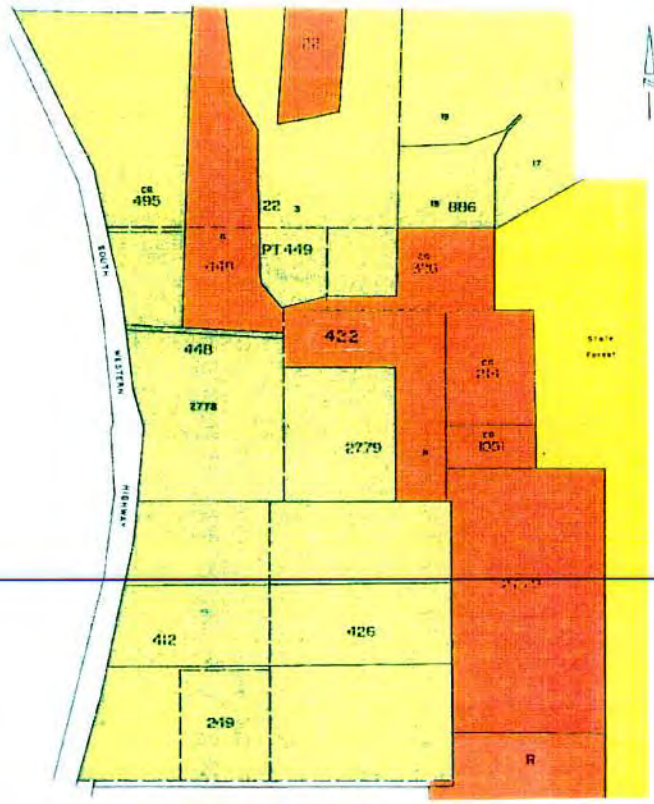
BASEMAP Department of Land Administration

0 500 1000 1500

metres

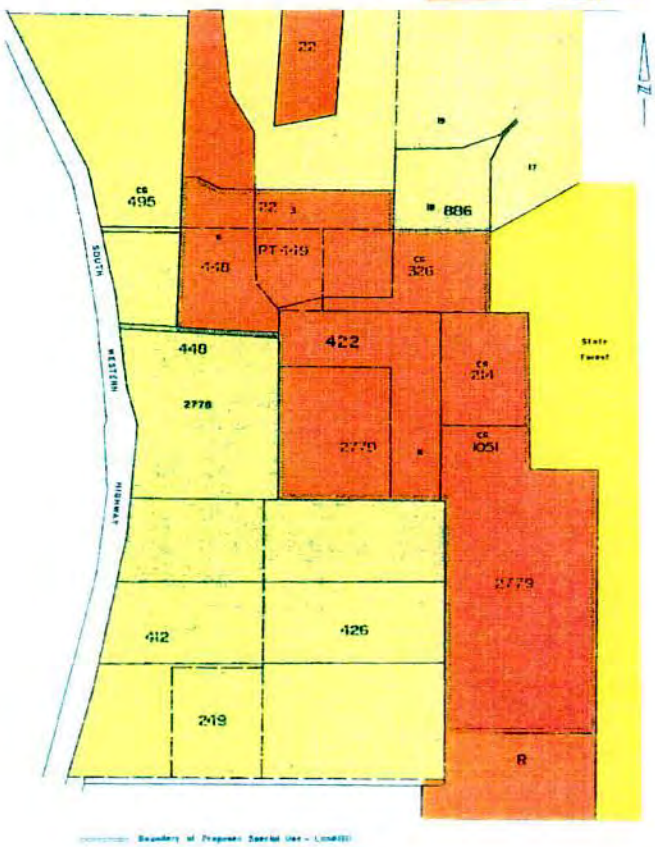
Source : Stephens (1991)

REVISIONS						
	Rev.	DESCRIPTION	Drawn Date	Chk'd Date	AGC Woodward–Clyde	EXISTING LAND USE
						Date Jon. '93 | Dwg. 2535-10 | Fig. 10



EXISTING ZONING

- SPECIAL USE
- RURAL
- R PUBLIC PURPOSES
- STATE FOREST



PROPOSED ZONING

- SPECIAL USE
- RURAL
- R PUBLIC PURPOSES
- STATE FOREST

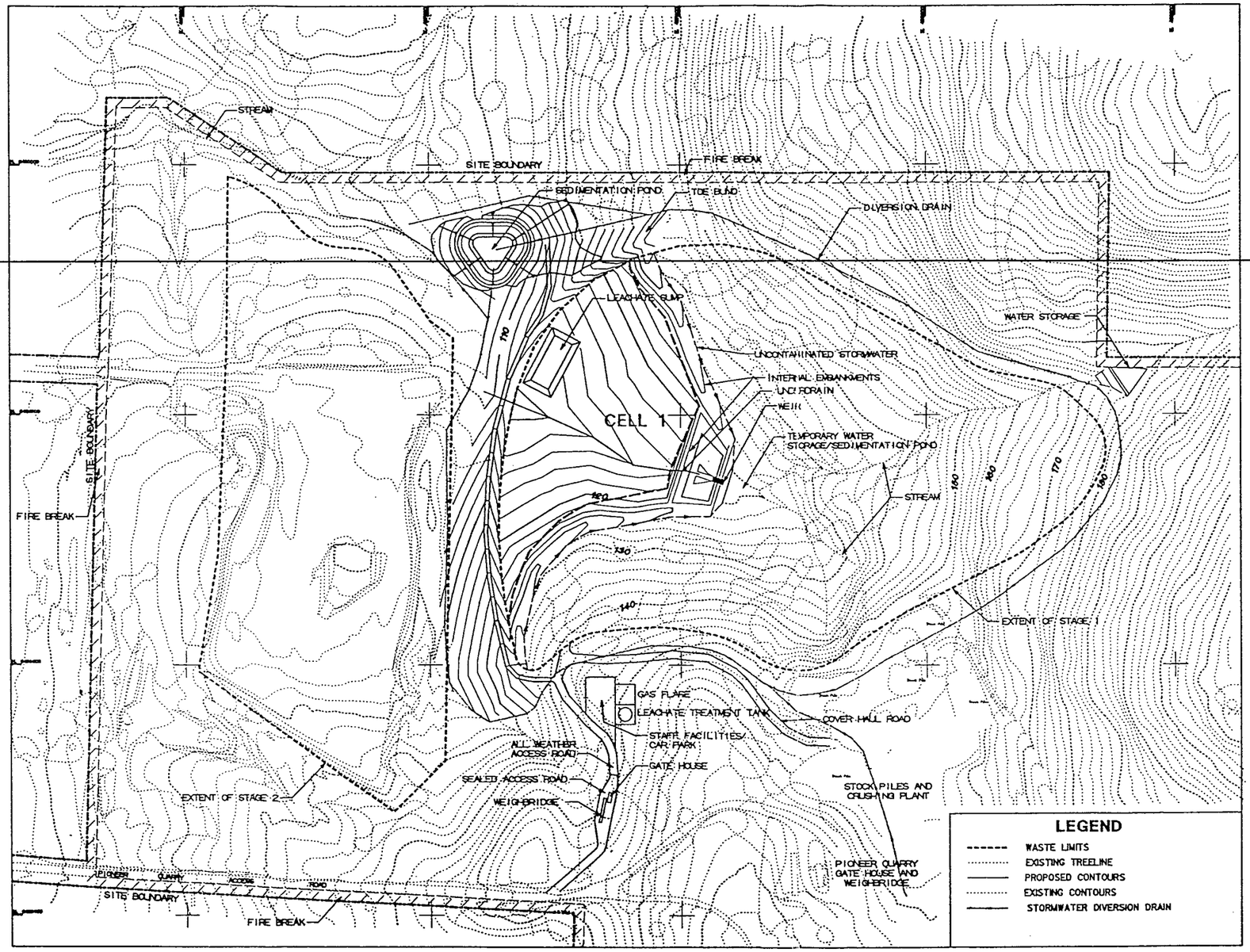
0 200 400 600 800 1000 m

REVISIONS	Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AGC Woodward–Clyde

CURRENT AND PROPOSED LAND USE ZONINGS

Date Jan. '93 | Dwg. 2535-22 | Fig. 11



0 50 100
GRAPHIC SCALE (METRES)

NOTES :
AREA 1 (WITHIN WASTE LIMIT) : 169741.7B SQ. METRES
AREA 2 (WITHIN WASTE LIMIT) : 76735.07 SQ. METRES
CONTOUR INTERVAL : 2 METRE
HORIZONTAL DATUM : A.M.G.
VERTICAL DATUM : A.H.D.
DATE OF PHOTO : AUGUST 1992
ACCURACY : BY LENDER SURVEYS
HORIZ. : 0.3M
VERT : 0.3M
GROSS AIRSPACE :
PHASE 1 : 1960928 CU. METRES
PHASE 2 : 1049729 CU. METRES
(TOP OF CAP TO EXCAVATION BOTTOM)

CONTRACT No.

FILE No.

PROJECT No.

CONTRACT

SOUTHERN SANITARY LANDFILL
SOUTH CARDUP
WESTERN AUSTRALIA

DRAWING TITLE

INITIAL
DEVELOPMENT PLAN

DRAWING No.
P-2

SCALE
1:2000

DATE

PCS
CAD CENTRE
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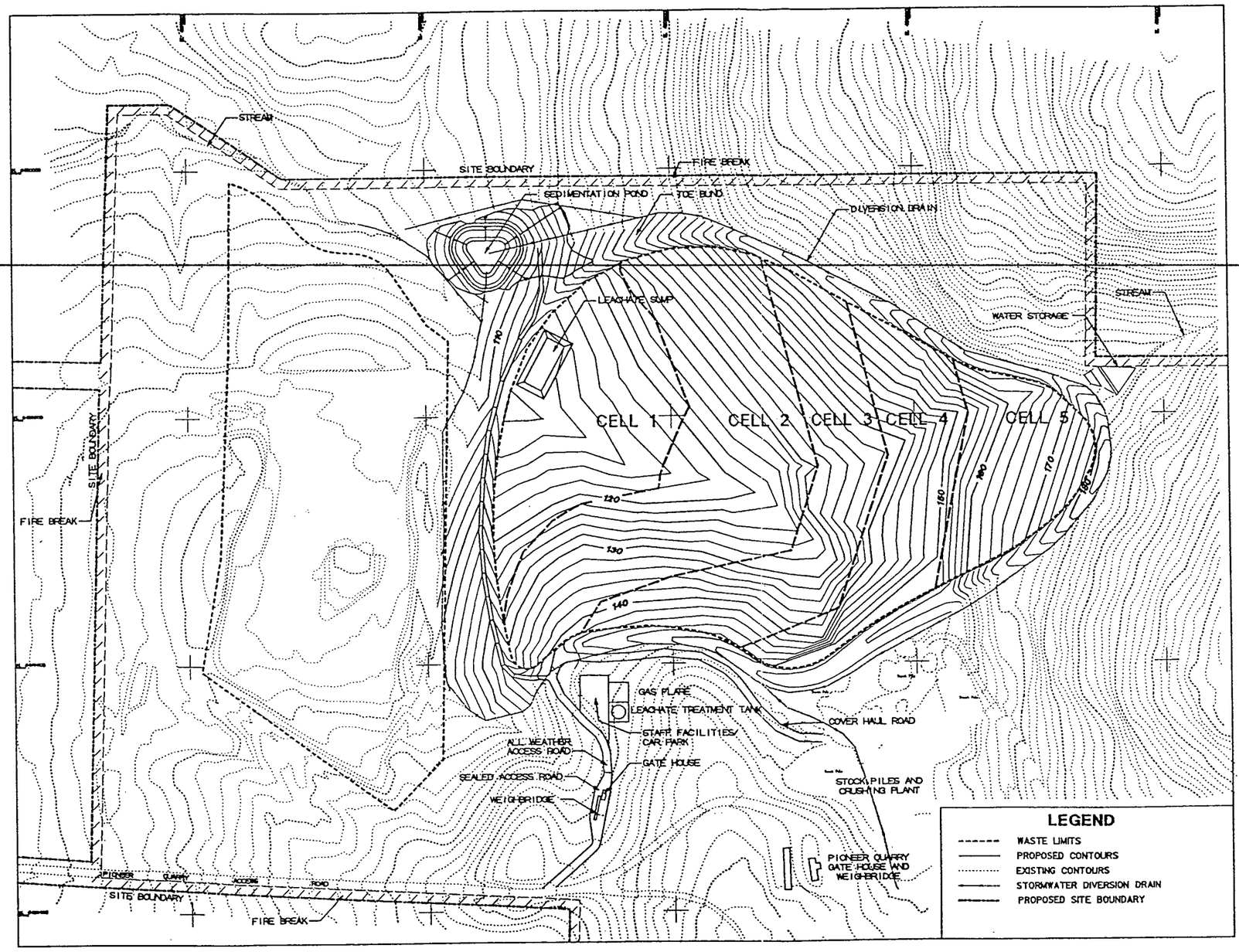
Mitcham 3132
Ph. 873 4606

FIGURE 12
Dwg No. 2535-32

CONCEPTUAL DRAWING
NOT FOR CONSTRUCTION

763 X 490mm

A1



0 50 100
GRAPHIC SCALE (METRES)

NOTES :
AREA 1 (WITHIN WASTE LIMIT) : 86974.75 SQ. METRES
AREA 2 (WITHIN WASTE LIMIT) : 76735.07 SQ. METRES
CONTOUR INTERVAL : 2 METRE
HORIZONTAL DATUM : A.M.G.
VERTICAL DATUM : A.H.D.
DATE OF PHOTO : AUGUST 1992
ACCURACY : BY LENDER SURVEYS
HORIZ. : 0.3M
VERT : 0.3M
GROSS AIRSPACE :
PHASE 1 : 1960922 CU. METRES
PHASE 2 : 1049729 CU. METRES
(TOP OF CAP TO EXCAVATION BOTTOM)

FIGURE 13
Dwg No. 2535-33

CONCEPTUAL DRAWING
NOT FOR CONSTRUCTION

CONTRACT No.

FILE No.

PROJECT No.

CONTRACT

SOUTHERN SANITARY LANDFILL
SOUTH CARDUP
WESTERN AUSTRALIA

DRAWING TITLE

STAGE 1
EXCAVATION PLAN

DRAWING No. P-3

SCALE 1:2000

DATE Jan 1993

PCS
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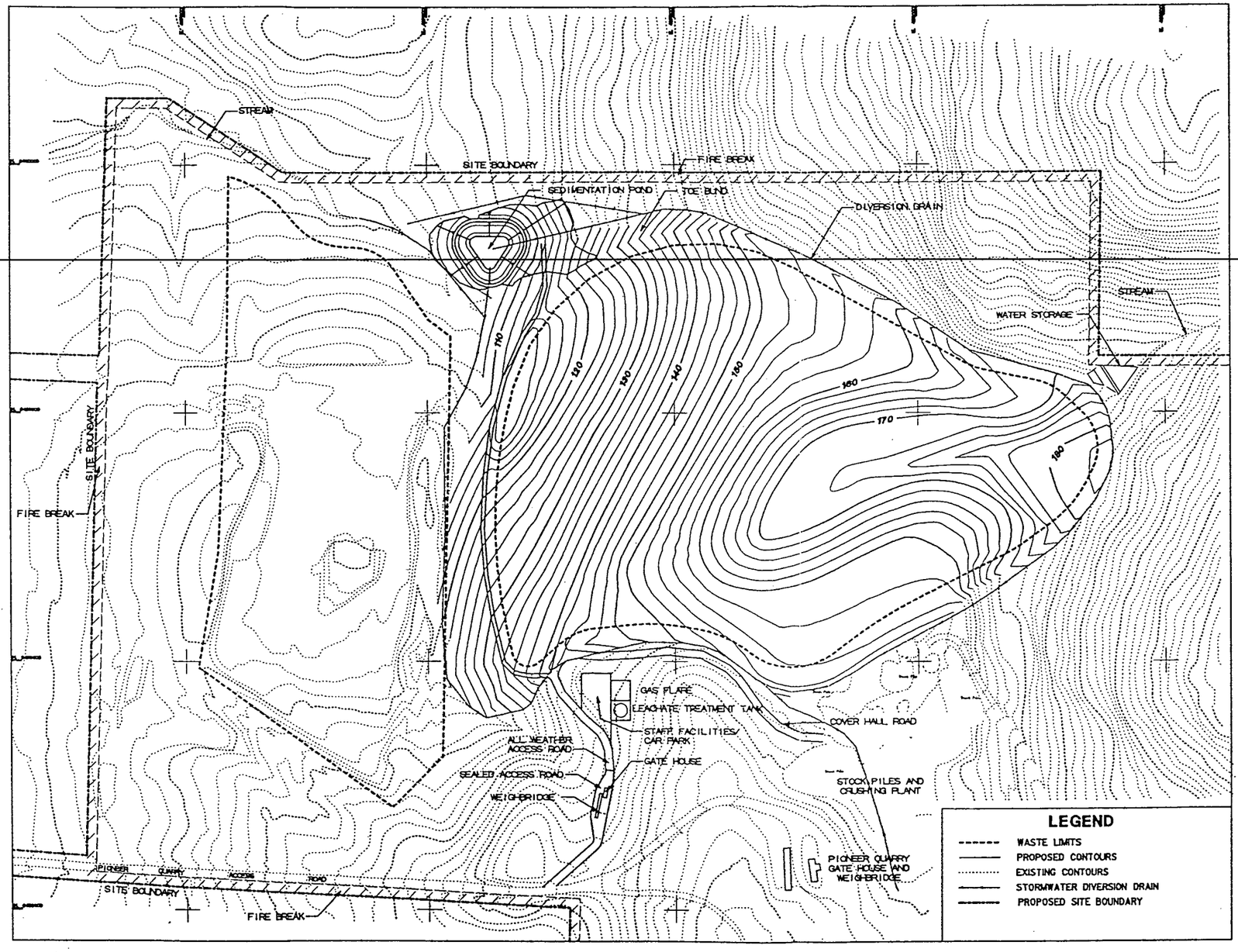
Suite 4, 585 Whitehorse Rd
Mitcham 3132
Ph. 873 4605

Pioneer

BFI

763 X 498mm

A1



0 50 100
GRAPHIC SCALE (METRES)

NOTES :
AREA 1 (WITHIN WASTE LIMIT) :
86974.78 SQ. METRES
AREA 2 (WITHIN WASTE LIMIT) :
76735.07 SQ. METRES
CONTOUR INTERVAL : 2 METRE
HORIZONTAL DATUM : A.M.G.
VERTICAL DATUM : A.H.D.
DATE OF PHOTO : AUGUST 1992
ACCURACY : BY LENDER SURVEYS
HORIZ : 0.3M
VERT : 0.3M
GROSS AIRSPACE :
PHASE 1 : 1960922 CU. METRES
PHASE 2 : 1049729 CU. METRES
(TOP OF CAP TO EXCAVATION BOTTOM)

CONTRACT No.

FILE No.

PROJECT No.

CONTRACT

SOUTHERN SANITARY LANDFILL
SOUTH CARDUP
WESTERN AUSTRALIA

DRAWING TITLE

STAGE 1
FINAL CAP
CONTOURS

DRAWING No.
P-4

SCALE
1:2000

DATE
Jan 1993

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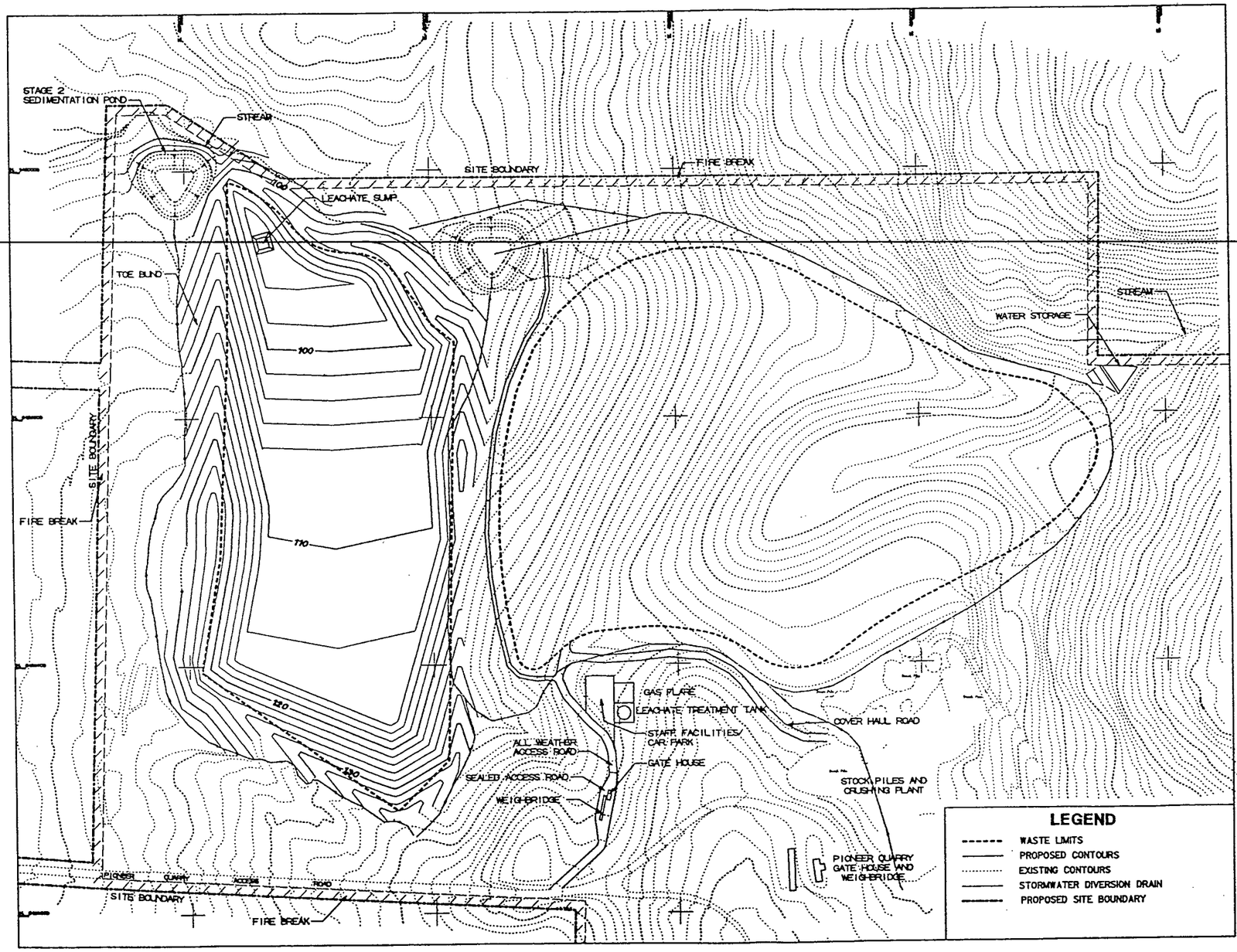
Ph. 873 4505

FIGURE 14
Dwg No. 2535-34

CONCEPTUAL DRAWING
NOT FOR CONSTRUCTION

763 X 490mm

A1



0 50 100
GRAPHIC SCALE (METRES)

NOTES :
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869174.78 SQ. METRES
AREA 2 (WITHIN WASTE LIMIT) :
767335.07 SQ. METRES
CONTOUR INTERVAL : 2 METRE
HORIZONTAL DATUM : A.M.G.
VERTICAL DATUM : A.H.D.
DATE OF PHOTO : AUGUST 1992
ACCURACY : BY LENDER SURVEYS
HORIZ. : 0.3M
VERT : 0.3M
GROSS AIRSPACE :
PHASE 1 : 1960921 CU. METRES
PHASE 2 : 1049729 CU. METRES
(TOP OF CAP TO EXCAVATION BOTTOM)

CONTRACT No.

FILE No.

PROJECT No.

CONTRACT

SOUTHERN SANITARY LANDFILL
SOUTH CARDUP
WESTERN AUSTRALIA

DRAWING TITLE

STAGE 2
EXCAVATION PLAN

DRAWING No.
P-5

SCALE
1:2000

DATE
Jan 1993

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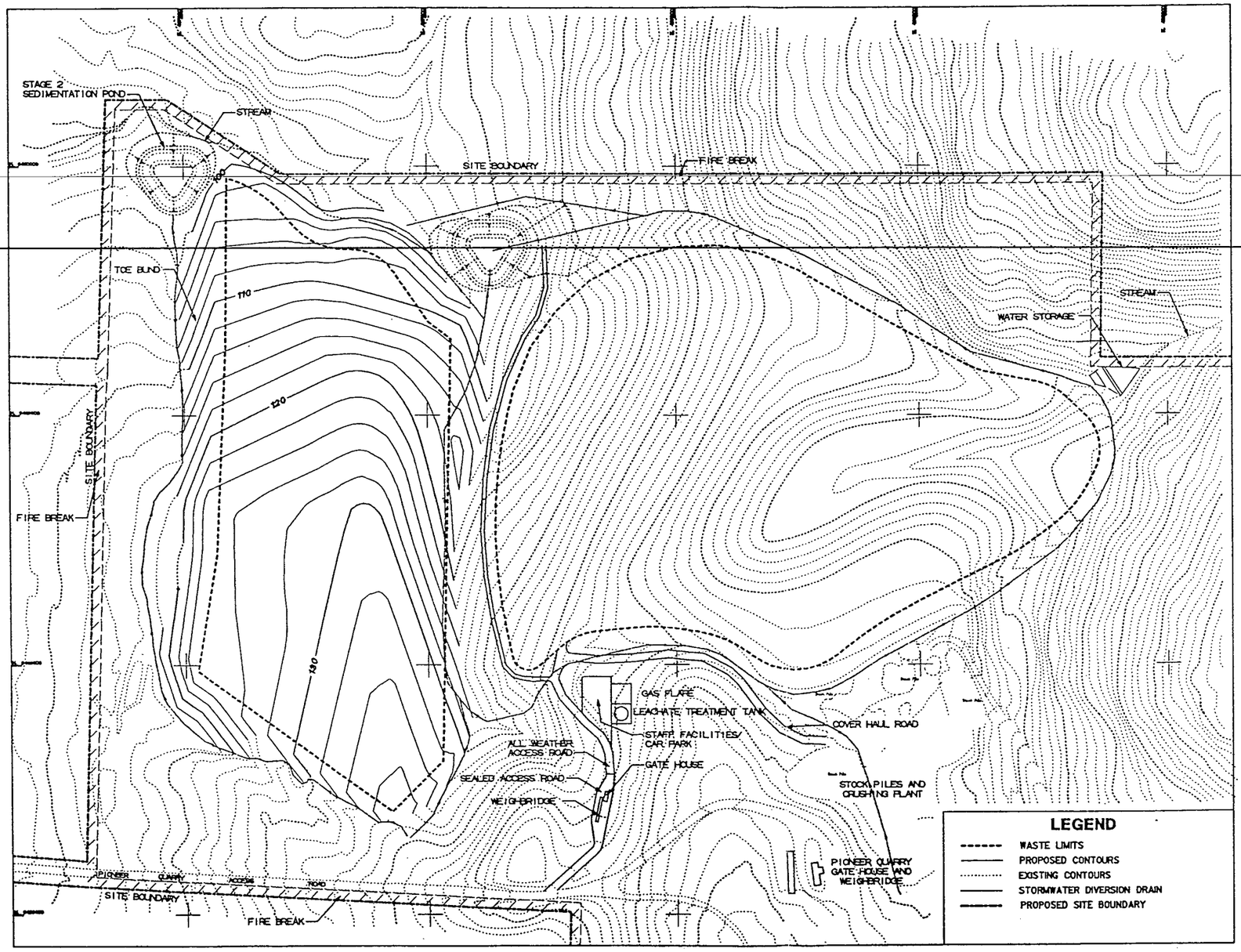
FIGURE 15
Dwg No. 2535-35

CONCEPTUAL DRAWING
NOT FOR CONSTRUCTION

763 X 490mm



0 50 100
GRAPHIC SCALE (METRES)

NOTES :
AREA 1 (WITHIN WASTE LIMIT) :
86974.75 SQ. METRES
AREA 2 (WITHIN WASTE LIMIT) :
76735.07 SQ. METRES
CONTOUR INTERVAL : 2 METRE
HORIZONTAL DATUM : A.M.G.
VERTICAL DATUM : A.H.D.
DATE OF PHOTO : AUGUST 1992
ACCURACY : BY LENDER SURVEYS
HORIZ. : 0.3M
VERT : 0.3M
GROSS AIRSPACE :
PHASE 1 : 1960923 CU. METRES
PHASE 2 : 1049729 CU. METRES
(TOP OF CAP TO EXCAVATION BOTTOM)

CONTRACT No.

FILE No.

PROJECT No.

CONTRACT

SOUTHERN SANITARY LANDFILL
SOUTH CARDUP
WESTERN AUSTRALIA

DRAWING TITLE

STAGE 2
FINAL CAP
CONTOURS

DRAWING No.
P-6

SCALE
1:2000

DATE
Jan 1993

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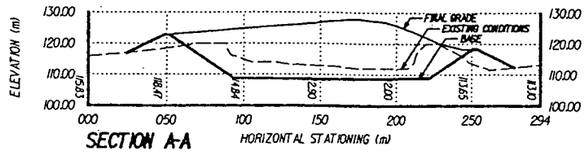
Mitcham 3132
Ph. 873 4606

FIGURE 16
Dwg No. 2535-36

CONCEPTUAL DRAWING
NOT FOR CONSTRUCTION

763 X 490mm

A1



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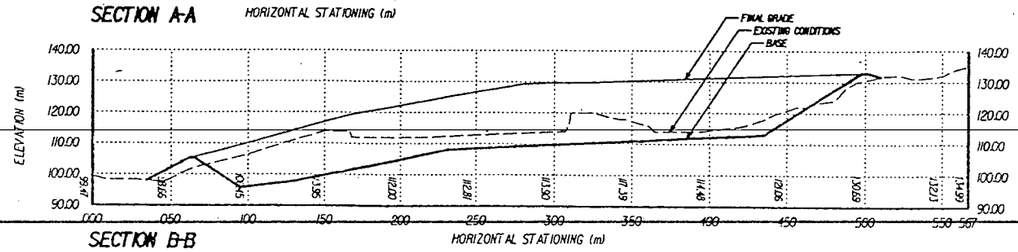
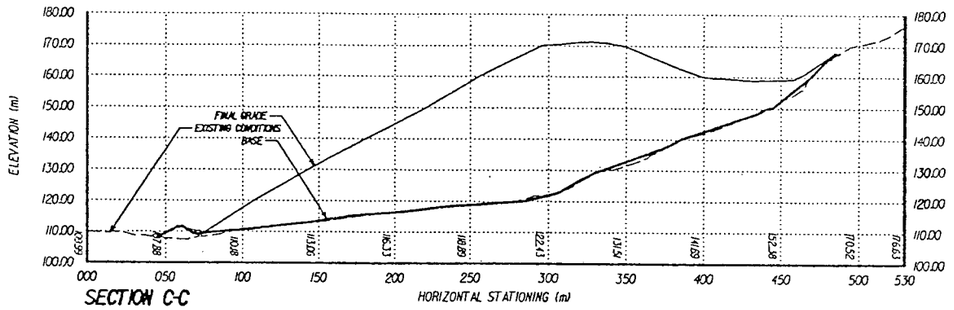
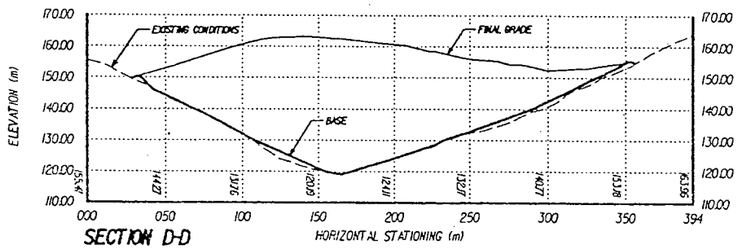


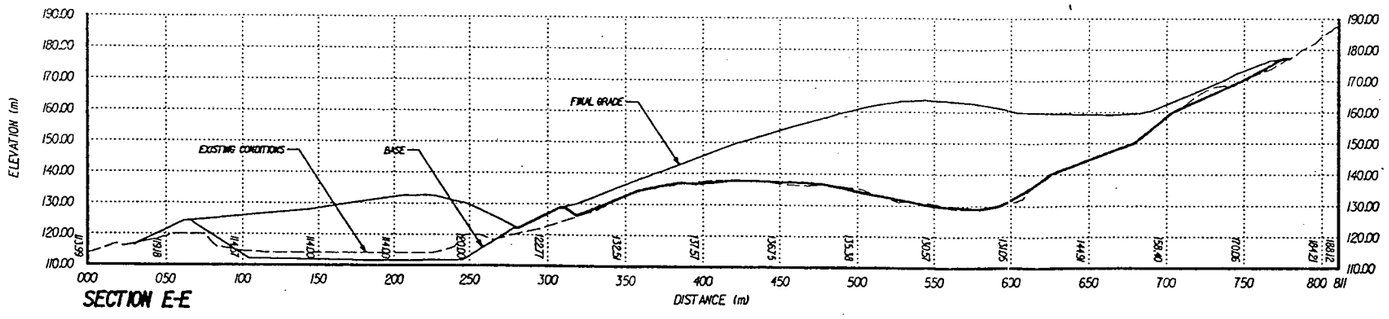
SECTION B-B



SECTION C-C



SECTION D-D



SECTION E-E

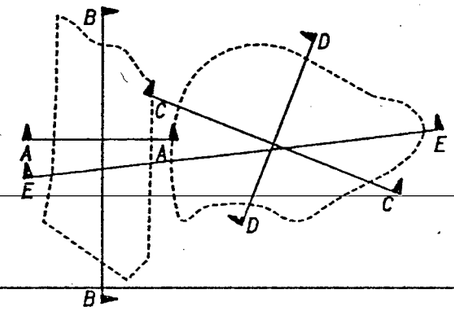


FIGURE 17

Dwg No. 2535 - 37

CONCEPTUAL DRAWING
NOT FOR CONSTRUCTION

CONTRACT No.

FILE No.

PROJECT No.

CONTRACT

SOUTHERN SANITARY LANDFILL
SOUTH CARDUP
WESTERN AUSTRALIA

DRAWING TITLE

CROSS SECTIONS

DRAWING No.

D-7

SCALE
NONE

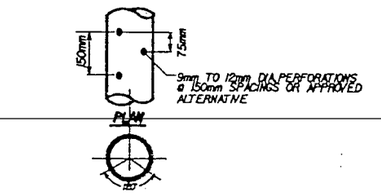
DATE
Jan 1993

PCS
CAD CENTRE
Suite 4, 585 Whitehorse Rd
Mitcham 3132
Ph. 873 4606

Pioneer

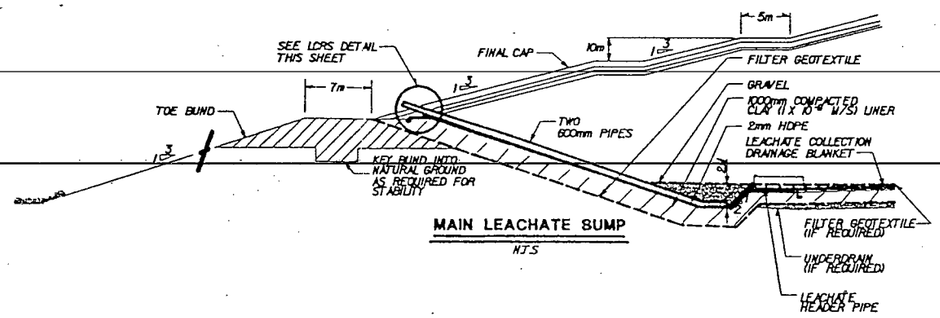
763 X 490mm

A1



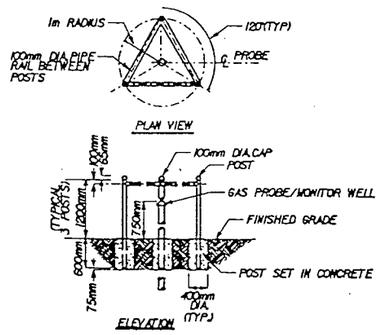
LEACHATE COLLECTION PIPE PERFORATION DETAIL

N.T.S



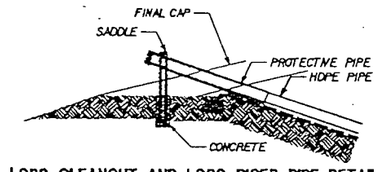
MAIN LEACHATE SUMP

N.T.S



TYPICAL PROTECTION FOR GAS PROBES AND MONITOR WELLS

N.T.S



LCRS CLEANOUT AND LCRS RISER PIPE DETAIL

N.T.S.

FIGURE 18
Dwg No. 2535 - 38

CONCEPTUAL DRAWING
NOT FOR CONSTRUCTION

CONTRACT No.

FILE No.

PROJECT No.

CONTRACT

SOUTHERN SANITARY LANDFILL
SOUTH CARDUP
WESTERN AUSTRALIA

DRAWING TITLE

LANDFILL DETAILS

DRAWING No. D-8

SCALE AS SHOWN

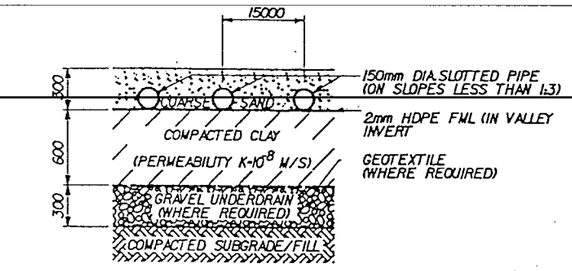
DATE Jan 1993

PCS
CAD CENTRE
Suite 4, 555 Whitehorse Rd
Mitcham 3132
Ph. 873 4606

Pioneer

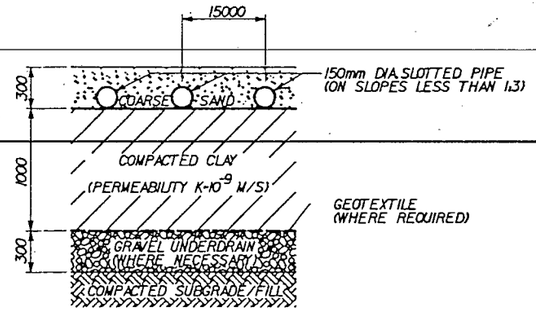
763 X 490mm

A1



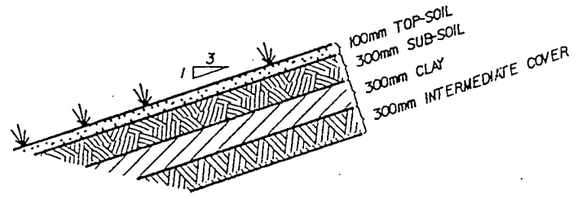
COMPOSITE LINER

N.T.S.



CLAY LINER

N.T.S.



FINAL CAP DETAIL

N.T.S.

FIGURE 19
Dwg No. 2535 - 39

CONCEPTUAL DRAWING NOT FOR CONSTRUCTION

CONTRACT No.

FILE No.

PROJECT No.

CONTRACT

SOUTHERN SANITARY LANDFILL
SOUTH CARDUP
WESTERN AUSTRALIA

DRAWING TITLE

CAP / LINER DETAILS

DRAWING No.

D-9

SCALE

AS SHOWN

DATE

Jan 1993

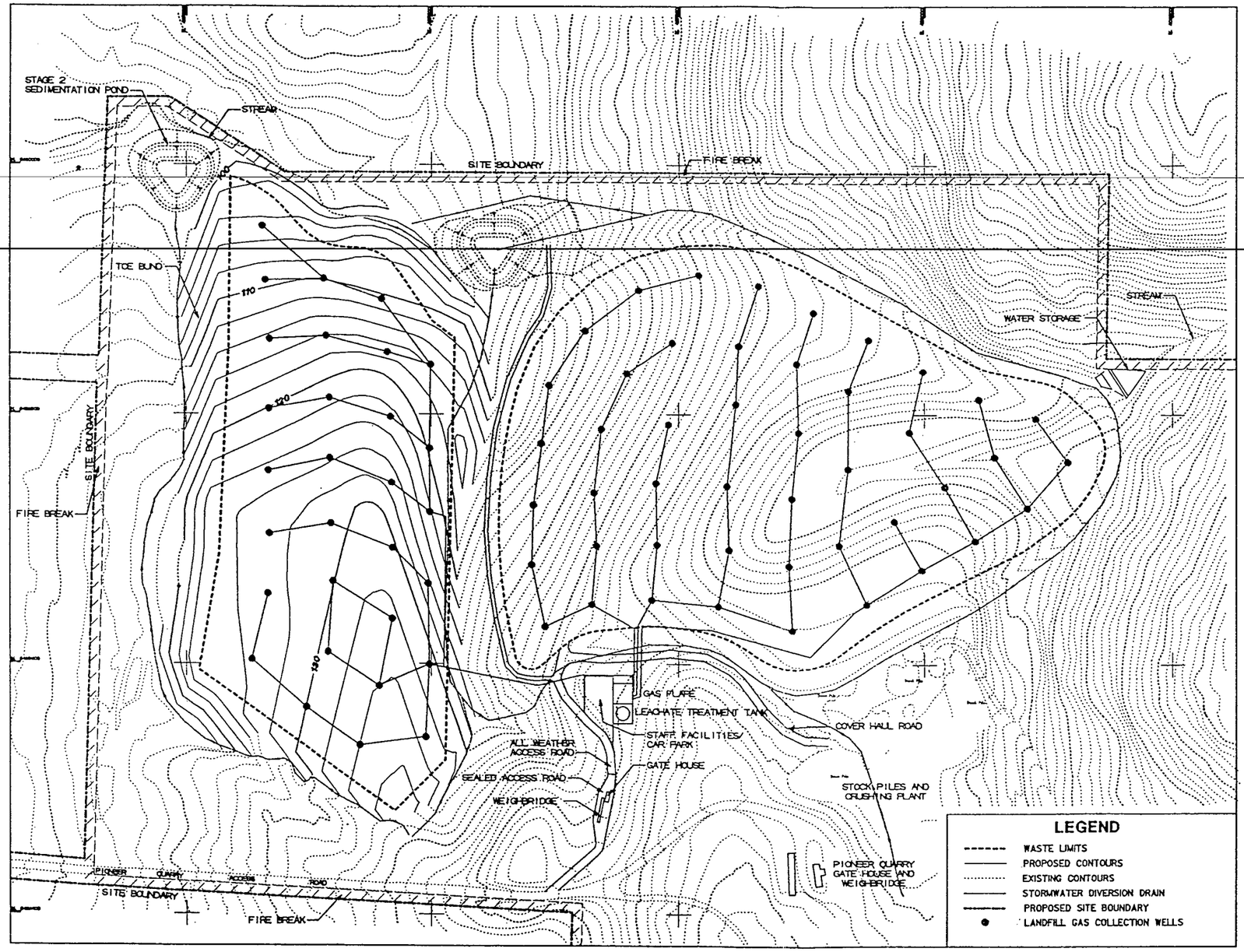
PCS
CAD CENTRE
Suite 4, 335 Whitehorse Rd
Mitcham 3132
Ph. 873 4606

Pioneer

BFI

763 X 498mm

A1



0 50 100
GRAPHIC SCALE (METRES)

NOTES :
AREA 1 (WITHIN WASTE LIMIT) :
16974.75 SQ. METRES
AREA 2 (WITHIN WASTE LIMIT) :
76735.07 SQ. METRES
CONTOUR INTERVAL : 2 METRE
HORIZONTAL DATUM : A.M.G.
VERTICAL DATUM : A.H.D.
DATE OF PHOTO : AUGUST 1992
ACCURACY : BY LENDER SURVEYS
HORIZ. : 0.3M
VERT : 0.3M
GROSS AIRSPACE :
PHASE 1 : 1960920 CU. METRES
PHASE 2 : 1049729 CU. METRES
(TOP OF CAP TO EXCAVATION BOTTOM)

CONTRACT No.

FILE No.

PROJECT No.

CONTRACT

SOUTHERN SANITARY LANDFILL
SOUTH CARDUP
WESTERN AUSTRALIA

DRAWING TITLE

LANDFILL GAS COLLECTION
AND DISPOSAL PLAN

DRAWING No.
P-13

SCALE
1:2000

DATE
Jan 1993

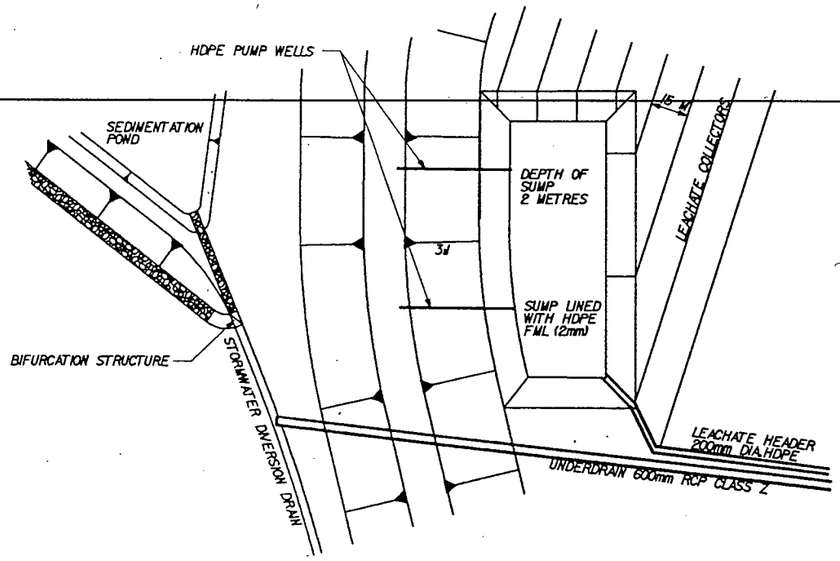
PCS
CAD CENTRE
Suite 4, 555 Whitehorse Rd
Mitcham 3132
Ph. 873 4606

FIGURE 22
Dwg No. 2535-42

CONCEPTUAL DRAWING
NOT FOR CONSTRUCTION

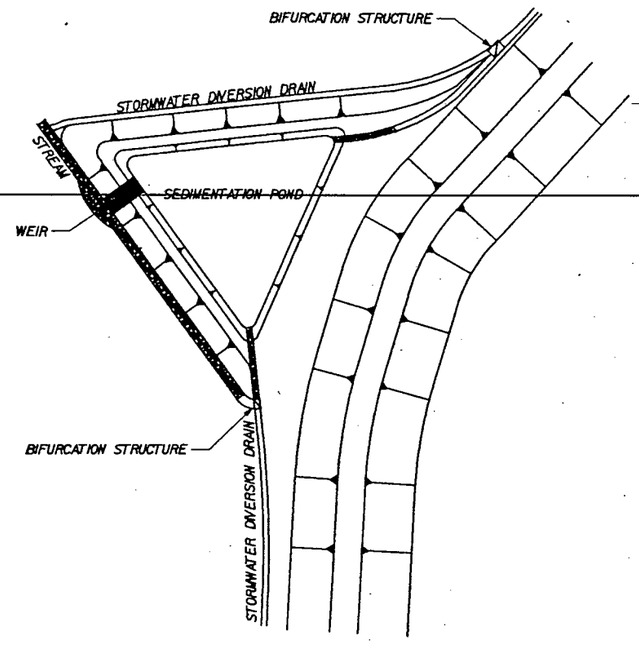
763 X 490mm

A1



LEACHATE SUMP

N.T.S.



STAGE 1 SEDIMENTATION POND

N.T.S.

FIGURE 20
Dwg. No. 2535 - 40

CONCEPTUAL DRAWING
NOT FOR CONSTRUCTION

CONTRACT No.

FILE No.

PROJECT No.

CONTRACT

SOUTHERN SANITARY LANDFILL
SOUTH CARDUP
WESTERN AUSTRALIA

DRAWING TITLE

LEACHATE COLLECTION AND SEDIMENTATION POND DETAILS

DRAWING No.

D 10

SCALE

AS SHOWN

DATE

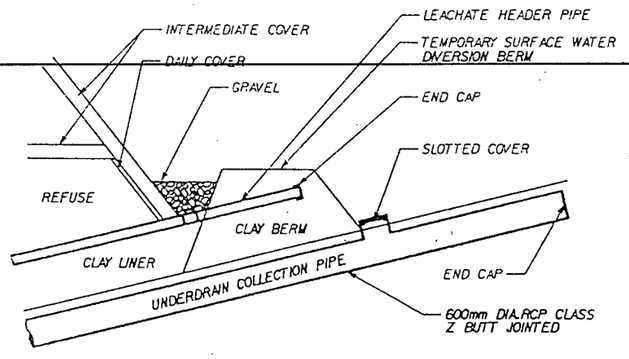
PCS
CAD CENTRE
Suite 4, 536 Whitehorse Rd
Mitcham 3132
Ph. 873 4606

Pioneer

BFI

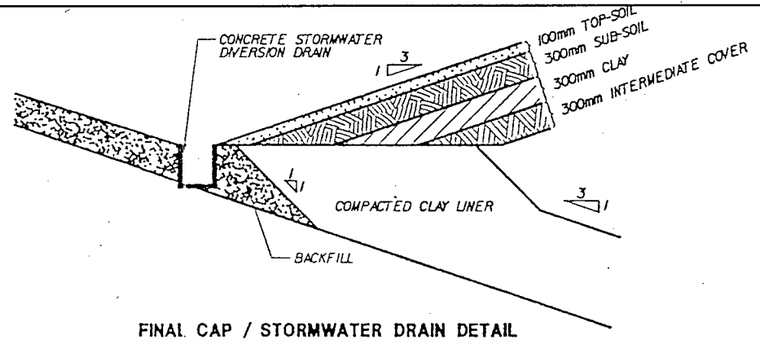
763 X 490mm

A1



TEMPORARY BERM DETAIL

N.T.S.



FINAL CAP / STORMWATER DRAIN DETAIL

N.T.S.

NOTE:
DETAILS SHOWN ARE PROVISIONAL FOR TENDER PURPOSES ONLY. FINAL DETAILS WILL INCLUDE CONSIDERATION OF VARIOUS EROSION AND SEDIMENT CONTROL PRACTICES AS OUTLINED ON DWG NO. D 12

CONTRACT No.

FILE No.

PROJECT No.

CONTRACT

SOUTHERN SANITARY LANDFILL
SOUTH CARDUP
WESTERN AUSTRALIA

DRAWING TITLE

DRAINAGE DETAILS

DRAWING No.
D-11

SCALE
AS SHOWN

DATE
Jan 1993

PCS
CAD CENTRE
Suite 4, 555 Whitehorse Rd
Mitcham 3132
Ph. 873 4606

Pioneer

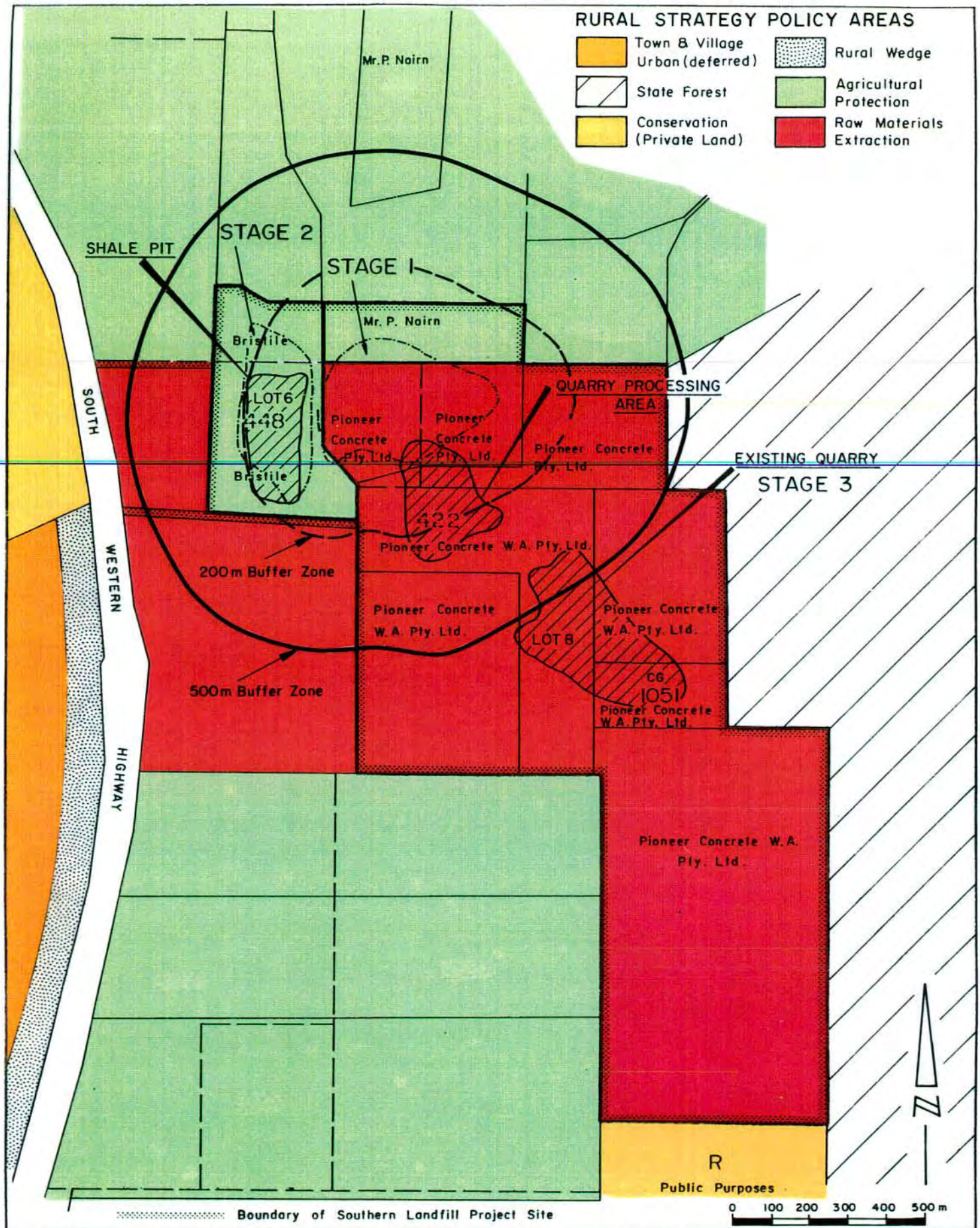
BFI

FIGURE 21
Dwg No. 2535 - 41

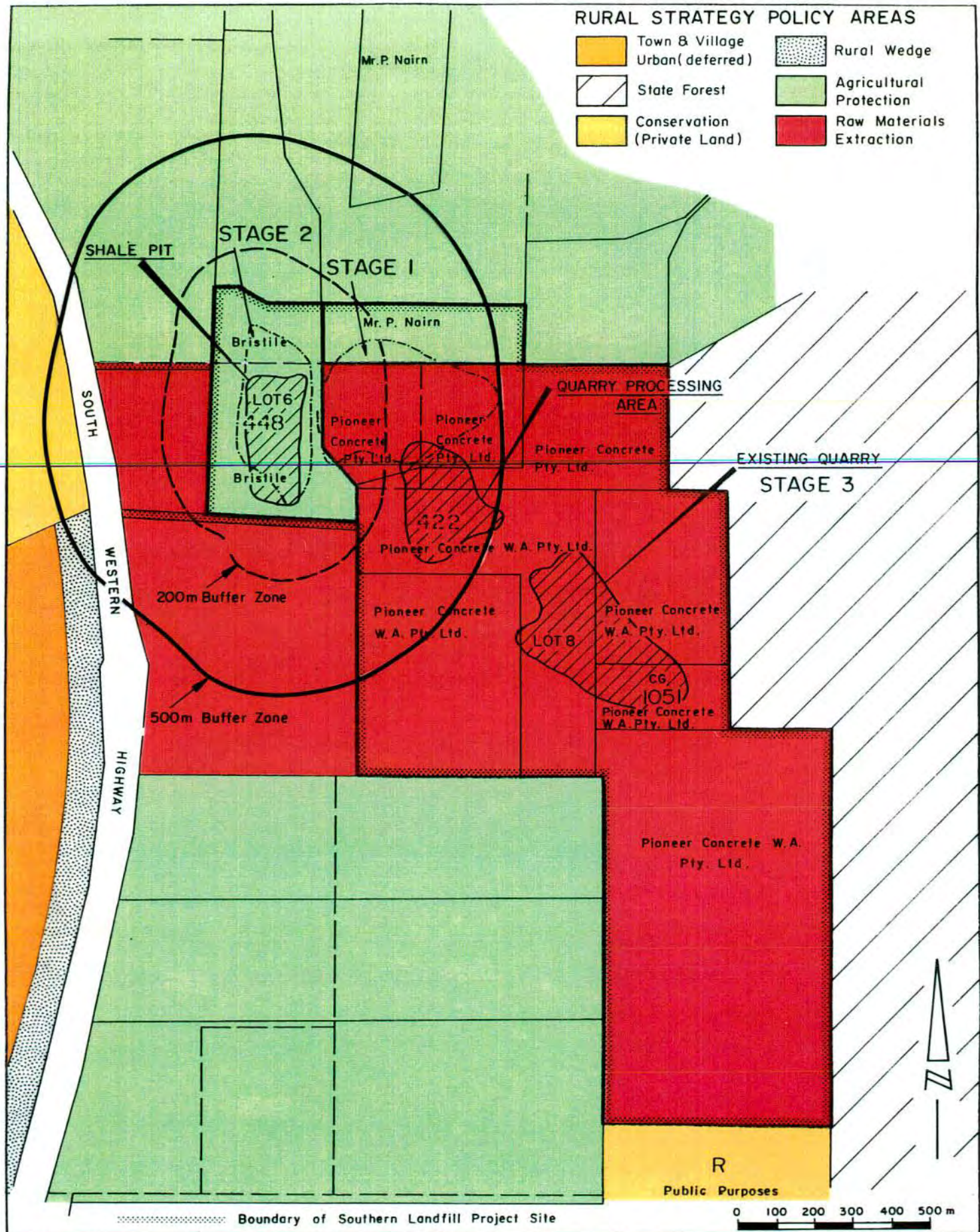
CONCEPTUAL DRAWING
NOT FOR CONSTRUCTION

763 X 490mm

A1



REVISIONS					AGC Woodward--Clyde	PROPOSED BUFFER ZONE FOR STAGE I		
	Rev.	DESCRIPTION	Drawn Date	Chk'd Date		Date March '93	Dwg. 2535 - 43	Fig. 23

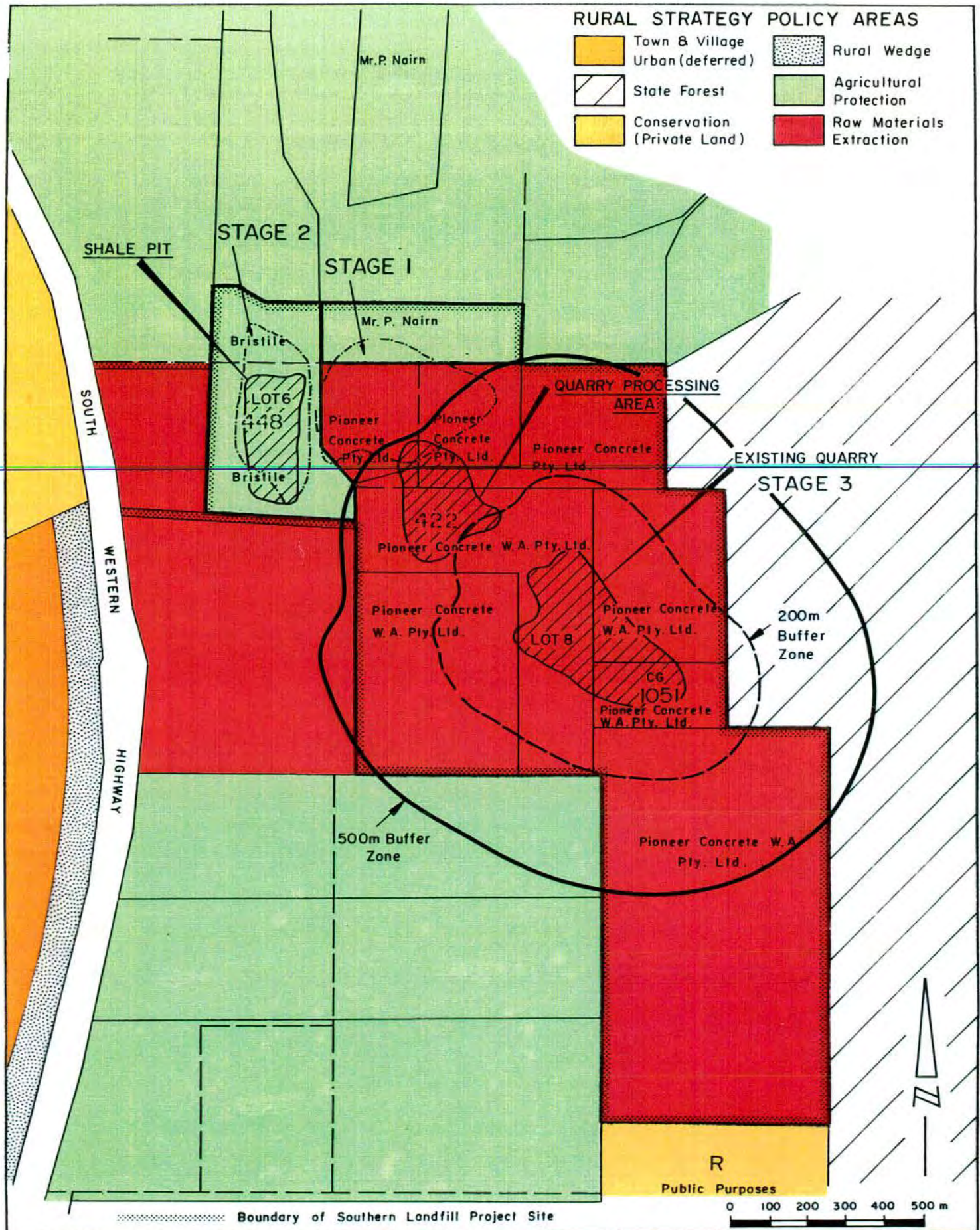


REVISIONS					
Rev.	DESCRIPTION		Drawn Date	Chk'd Date	

AGC Woodward-Clyde

PROPOSED BUFFER ZONE FOR STAGE 2

Date March '93 | Dwg. 2535-44 | Fig. 24



REVISIONS					AGC Woodward-Clyde	PROPOSED BUFFER ZONE FOR STAGE 3		
	Rev.	DESCRIPTION	Drawn Date	Chk'd Date		Date March '93	Dwg. 2535-45	Fig. 25

APPENDIX A

SOUTHERN LANDFILL

PUBLIC ENVIRONMENTAL REVIEW GUIDELINES

SOUTHERN LANDFILL PROJECT - SOUTH CARDUP (741)

PUBLIC ENVIRONMENTAL REVIEW GUIDELINES

1 Introduction

These Guidelines identify issues that should be addressed within the Public Environmental Review (PER). They are not intended to be exhaustive and the proponent may consider that other issues should also be included in the document.

1.1 Purpose of an Public Environmental Review (PER)

The primary function of an PER is to provide the basis for the Environmental Protection Authority to provide advice to the Government (through the Minister for the Environment) on protecting the environment. An additional function is to communicate clearly with the public so that Environmental Protection Authority can obtain informed public comment. As such, environmental impact assessment is quite deliberately a public process. The PER should set out the series of decisions taken to develop this proposal at this place and time and why, and for each impact describe any environmental management steps the proponent believes would avoid, mitigate or ameliorate that impact.

The PER should focus on the major issues and anticipate the questions that members of the public will raise. Data describing the environment should be directly related to the discussion of the potential impacts of the proposal. Both should then relate directly to the actions proposed to manage those impacts.

The PER is intended to be a brief document; its purpose should be explained, and the contents should be concise and accurate as well as being readily understood by interested members of the public. Specialist information and technical description should be included where it assists in the understanding of the proposal. It may be appropriate to include ancillary or lengthy information in technical appendices. A glossary may be useful to assist the public to understand technical issues or terminology.

1.1.1 Format of the PER

It should be noted that the guidelines are not intended to convey the Authority's wishes with respect to the format of the document. Excepting a requirement for an overview summary, a summary of the commitments and some information on how to make a submission at the front of the document, the format is a matter for the proponent. The overview summary should include a brief summary of:

- salient features of the proposal;
- reasons for the proposal;
- investigations undertaken and proposed;
- alternatives considered;
- description of receiving environment;
- analysis of potential impacts and their significance;
- environmental monitoring, management, safeguards and commitments as to proposed mitigation of any significant environmental impacts; and
- conclusions.

A copy of these guidelines should appear as an appendix in the PER.

1.2 Key issues

The Environmental Protection Authority has identified the following key issues:

- the need for measures to protect ground and surface water from contamination (particularly from leachates) and monitoring to ensure water quality protection measures are working;
- maintenance of an adequate buffer zone around the site whilst it is operating;
- management of site operations to minimise off-site impacts;
- acceptance criteria for wastes other than domestic wastes at this site;
- management of methane emissions to reduce greenhouse gas impacts;
- management of social issues; and
- closure and post-closure management with particular reference to long term responsibility, funding and management of the site.

The Authority notes that some of the key issues were identified by the proponent in referral documentation.

It should be noted that the last two key issues identified above do not apply to the composting part of the proposal.

The Public Environmental Review should consider the proposal with due regard to recent State Government policies and discussion papers such as;

- Criteria for Landfill Management 1992, published by the Health Department of WA;
- State Recycling Blueprint, published by the Department of State Development; and
- The WA Advantage, published by the State Government.

2 Guidelines to address the key issues

The Environmental Protection Authority considers that the key issues should be fully addressed in the Public Environmental Review document. However, the Authority recognises that some of the issues are manageable and could be addressed in an Environmental Management Plan prepared to the requirements of the Environmental Protection Authority after other approvals have been received, but prior to construction. Any Environmental Management Plan prepared subsequent to approvals being issued must be available to the public, preferably both before and after the final working document is adopted.

2.1 Protecting ground and surface water quality

The Public Environmental Review should address the following;

- site hydrogeology, with particular reference to distance between groundwater and waste, existing groundwater quality, groundwater movement and surface water flows;
- existing and proposed beneficial uses for surface and groundwater downstream;
- leachate management with particular reference to engineering criteria to ensure adequate lining of the site and proposed method of leachate treatment or disposal;
- adequacy of monitoring bores in relation to site hydrogeology;
- stormwater management with particular reference to engineering criteria for diversion drains, settlement ponds and the like;
- frequency of monitoring and parameters to be monitored for surface and ground waters; and

- water quality criteria which trigger management responses.

The water pollution control requirements detailed in the "Criteria for Landfill Management 1992" provide some guidance in regard to several of the above issues. Reference should also be made to the "Guideline on groundwater monitoring at municipal landfill sites" available from the Health Department of WA.

2.2 Buffer zones

Existing and proposed uses within 750m of the site should be described. Measures proposed to ensure an adequate buffer zone remains in place during the life of the site should be detailed.

2.3 Management of site operations to minimise off-site impacts

Management measures with respect to the landfill operation requirements detailed in the Criteria for Landfill Management 1992 should be described. Other issues such as noise and hours of operation should also be considered.

2.4 Acceptance criteria

If wastes other than domestic waste are to be accepted, criteria should be developed to determine whether the waste (either before or after treatment) is suitable for co-disposal, disposal in separate cells or not suitable for disposal at this site. The acceptance criteria should be developed in consultation with the Health Department of WA.

2.5 Minimising greenhouse gas effects

A methane management plan which details a proposed monitoring programme, action criteria (Eg flaring will commence when a certain volume of gas is being produced), and the engineering approach proposed for methane extraction and treatment (such as flaring) should appear in the Public Environmental Review.

2.6 Social issues

Potential social issues include;

- impact on residents and recreational uses within buffer areas;
- traffic impacts, especially in nearby towns such as Byford;
- landscape and visual impacts (Eg from west of South West Highway); and
- historical, archeological and ethnographic sites.

2.7 Closure, long-term responsibility and funding

Closure details such as final cover material (staging and placement), final contours, rehabilitation measures proposed and final land use should be described.

A post-closure management plan which details likely long term responsibility, likely management requirements and costs, and funding of those costs should be included in the Public Environmental Review. The time for the waste to degrade to a non-polluting state should be estimated.

3 Evaluation of alternatives

A discussion of alternatives should be given whenever appropriate. For example various methods of managing leachate may be detailed. The rationale for choosing certain alternatives should be clear.

4 Public participation and consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the Public Environmental Review. It should describe the activities undertaken, the dates, the groups or individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management for the proposal which should clearly indicate how community concerns have been addressed. Where these concerns are dealt with through other departments or procedures, outside the Environmental Protection Authority process, these can be noted and referenced here.

5 Regionalisation

The PER should describe whether the proposal is integrated into the regional strategy for the South West Zone. (Enquiries regarding this issue should be directed to the Health Department of WA).

6 Other issues

The Public Environmental Review should briefly address other issues which are likely to be raised by the public such as;

- how this proposal fits with regard to regionalisation of refuse sites;
- influence of katabatic winds;
- impact on groundwater supplies in special rural zones such as Cardup and Karbro Drive;

7 Summary of commitments

The commitments being made by the proponent to protect the environment should be clearly defined and separately listed. Where an environmental problem has the potential to occur, there should be a commitment to rectify it. They should be numbered and take the form of:

(a) **WHO** will do the work;

(b) **WHAT** the work is;

(c) **WHEN** the work will be carried out; and

(d) **TO WHOSE REQUIREMENTS** the work will be carried out.

All actionable and auditable commitments made in the body of the document should be numbered and summarised in this list.

8 References

All references used in the PER should be listed. These references need to be available to the public through normal sources.

APPENDIX B

GEOTECHNICAL STUDIES

CONTENTS

CONTENTS (CONT'D)

TABLES

FIGURES **DWG NO.**

SUMMARY

Geotechnical studies have been carried out over Stages 1, 2 and 3 of the proposed landfill development at South Cardup in the Shire of Serpentine-Jarrahdale, WA, on behalf of Pioneer-BFI Waste Services.

A full summary of the collated field and laboratory data, and an assessment of the soil profiles overlying the respective sites and of the availability and suitability of clay in particular have been prepared for Pioneer-BFI Waste Services. This Appendix is a summary of the findings and conclusions from that report.

There is an estimated recoverable volume of clay over the Stage 1 landfill area of around 45 000-50 000 m^3. The clay alluvial horizon contains a significant portion of durable, cobble and boulder size material. The properties of the clay indicate the material is likely to meet the required low permeability criteria for construction of a liner. However, the difficulty, and hence cost of recovering the clay and removing the oversize material, is likely to render utilization of the material unattractive.

The sites for Stages 2 and 3 are similarly deficient in suitable clay. The area lying immediately to the north of Stages 1 and 2 appears to offer limited scope for sourcing clay. The proposal is therefore that clay liner material, meeting the necessary criteria for low permeability, will be obtained from off-site sources. Similarly, sand for underdrainage works will be sourced externally.

It was necessary to assess the potential of obtaining material of appropriate specification to construct the low permeability liner from off-site sources. An initial desk study was directed towards obtaining an understanding of the regional distribution of clay deposits.

B1 INTRODUCTION

The report summarizes the geotechnical studies carried out for the proposed Southern Landfill project by AGC Woodward Clyde Pty Limited. A full report has been submitted to Pioneer-BFI Waste Services.

The main purpose of these investigations has been to assess the geotechnical characteristics of the site and, in particular, to evaluate both the quantity and suitability of the in situ clay soils for use in the construction of the necessary low permeability liner. The study was extended to include an assessment of off-site clay sources.

The proposed scope of work for the site investigation included a drilling programme on a grid pattern across the originally proposed Stage 1 and Stage 2 landfill areas. Early on in the investigations, the study was expanded to include an additional stage for the landfill development adjacent to the Stage 1 site. This additional site became Stage 2 whilst the original Stage 2 became Stage 3.

Prior to initiating the drilling programme, an appraisal of the site identified outcrop, indications of shallow bedrock and the likely presence of a significant component of cobbles and boulders in the colluvial and alluvial deposits.

A preliminary programme of pitting was carried out to better define likely drilling conditions. Each of the pits excavated encountered refusal on weathered bedrock. In anticipation that bedrock would be encountered at shallow depth across the site, it was decided to implement a detailed programme of test pitting on a closely spaced grid pattern rather than carry out the drilling programme. Subsequently, all pits excavated on Stages 1, 2 and 3 reached refusal on bedrock.

Representative samples of the in situ clayey materials were collected and submitted to a NATA registered laboratory for determination of the material properties, compaction characteristics and permeability.

An investigation into off-site clay sources was conducted, initially in the form of a desk study, followed by a preliminary pitting and sampling programme at the most prospective off-site clay source.

The collated field information and test results are included in the report together with an assessment of the availability and suitability of on-site clay for blanket construction.

B2 SCOPE OF STUDY

The scope of the studies have encompassed the geotechnical characterization of Stages 1, 2 and 3 of the facility.

The studies have included a test pitting programme over the full extent of the proposed Stage 1 area on a 50 m grid spacing. All pits were excavated to refusal using a tracked Komatsu PC200 excavator capable of excavating to depths in excess of 6 m.

The proposed Stage 2 area lies immediately to the west of the Stage 1 area and incorporates the shale pit owned by Metro Brick. Pitting was carried out over an area approximately 1.7 ha in extent lying immediately to the north of the shale pit. In addition, a line of test pits was excavated along the eastern margin of the area.

The Stage 3 area includes the existing Pioneer quarry lying to the south east of the Stage 1 and 2 areas and the proposed quarry extension to the south of the present quarry limits. Pits have been excavated immediately to the south of the quarry along the western margin of the landfill area. Much of the proposed quarry extension is heavily timbered and pits within this area were excavated where access permitted.

All pits were logged and representative samples of the clay types encountered at the three locations were collected for laboratory testing.

Each of the proposed landfill stages have been dealt with separately in the report to Pioneer-BFI Waste Services. The test pit layouts for Stages 1 and 2 and for Stage 3 are shown on Figures B1 and B2, respectively.

B3 STAGE 1 INVESTIGATIONS

B3.1 General

The proposed Stage 1 area is approximately 11.5 ha in extent and occupies a small valley lying to the north and north-west of the Pioneer Concrete quarry stockpile area. The valley lies on the lower west facing slopes of the Darling Scarp and is drained by a small stream course that runs initially westwards and then north-westwards.

Along part of the south-eastern border of the area, waste rock from quarry operations has formed a steep scree slope that may eventually need to be removed for longer-term site development.

At the time of the field studies (Spring 1992), a small stream issued from the toe of the scree slope joining the westerly flowing stream draining the valley. It is understood that this flow represents collected runoff from a sub-catchment that has been piped beneath the quarry stockpile area.

The general topography of the Stage 1 area and the relative locations of the test pits are shown on Figure B1.

B3.2 Field Studies

The test pitting programme comprised 49 pits excavated on an approximate 50 m grid pattern across the site. All pits were excavated to refusal using a Komatsu PC200 excavator.

With the exception of pits 1/18 and 1/47, excavated over shallow subcrop, the pits ranged in depth between 0.65 m and 4.7 m with an average of 2.3 m. In general, the deeper pits were those located on the lower slopes of the valley or on the valley floor.

Access to the south-eastern and parts of the north-eastern margin of the Stage 1 area was limited due to particularly steep slopes and dense vegetation.

The upper soil profile, where well developed, generally consists of a variable depth of red, brown and yellow mottled clays giving way to 'pallid' zone clay and weathered bedrock. The deeper alluvial clay profiles, often having a high proportion of cobbles and boulders, were encountered in those test pits excavated along the floor of the valley and on the lower northern slopes. The oversize alluvial material in the pits varied in size up to 1 m in diameter and consisted of largely unweathered, high strength dolerite. The underlying 'pallid' zone clay generally has a higher content of

sand size particles than the alluvial clay and this is reflected in the plastic behaviour of the material.

The pits excavated at higher elevation on the south-eastern and north-eastern slopes of the valley generally encountered weathered bedrock at relatively shallow depths. Significant variations in topsoil thickness occurred within these pits and the clays were poorly developed.

The volume of in situ clay is estimated at 45 000 - 50 000 m^3, which includes the volume of the oversize material occurring in the formation.

Seepage and water in-flows into the pits occurred either at the base of the gravelly topsoil horizon. Seepage at greater depth usually occurred due to a high component of gravel and oversize material in the alluvial soils or where excavation intersected fractured bedrock. The more significant in-flows occurred at depth, more commonly in those pits excavated adjacent to the stream which flows through the centre of the area, but also in a few pits located on the relatively steep southern and eastern valley slopes. These inflows appear to relate to near surface runoff and are not considered to be indicative of a shallow water table.

B3.3 Laboratory Testwork

Representative samples of the clayey soils collected from the test pits were submitted to a NATA registered laboratory and selectively tested for the following properties:

- field moisture content;
- particle size distribution;
- Atterberg limits;
- density/moisture content relationship;
- permeability; and
- dispersivity.

The results of the testwork are summarized in Table B1. They indicate that the clays are variable, ranging from low plasticity to highly plastic. The low plasticity indices obtained generally reflect the high sand content of the -0.425 mm fraction used in the Atterberg test. Plots of liquid limit vs plasticity index fall marginally above the 'A' Line, indicating the inorganic nature of the clays. The plots are shown on Figure B3.

Compaction characteristics of the clay indicate a maximum dry density of the order of 1.59 - 1.66 t/m^3 within a range of moisture contents of 20 - 25%. This compares with the range of field moisture contents of 20 - 31%. A clayey sand sample collected at 2 m depth in one pit (1/7) gave a higher dry density of 1.89 t/m at an OMC of 15%. This was the only sample that indicated a potential for dispersion.

TABLE B1

STAGE 1 TEST RESULT SUMMARY

Test Pit No.	Depth (m)	Soil Description	Gradings		Atterbergs			Compaction		In Situ Condition		Perm (k) (m/s)		Comment
			Fines (-75μm)	Gravel (+2.36 mm)	LL (%)	PI (%)	LS (%)	SMDD (t/m^3)	OMC (%)	Field Dry Density (t/m^3)	Field Moisture Content (%)	Distilled Water	Permeant Solution	
1/1	0.6 - 1.2	Yellow-brown clay	78	1	63	38	16.5	1.66	20.5		23.7	2.9×10^{-10}		Disp. ND1
1/1	1.3	Yellow-brown clay	-	-	-					1.64	22.7	2.2×10^{-10}		Undisturbed
1/4	0.6 - 2.0	Yellow-brown clay	78	0	85	58	21.0				33.5			
1/5	1.4	Yellow-brown clay	40	37	37	18	4.0				14.4			
1/5	2.1 - 2.3	Yellow-brown clay	78	2	41	17	7.0				27.0			
1/6	1.15	Yellow-brown clay	-	-	-	-	-			1.5	30.2	1.8×10^{-10}		Undisturbed
1/7	2.0	Yellow-brown clay	36	6	33	9	4.5	1.89	15.0		11.0	7.0×10^{-10}		at 97% SMDD. Disp. PD2
1/14	1.0 - 1.2	Yellow-brown clay	85	5	70	42	17.0	1.59	24.5		27.2			
1/14	1.1 - 1.2	Yellow-brown clay									27.5	3.4×10^{-11}	2.4×10^{-11}	Bulk undisturbed
1/19	1.1 - 1.4	Yellow-brown clay	28	6	32	9	4.0				16.0			
1/33	0.25 - 1.0	Yellow-brown clay	78	5	46	26	14.0				22.7			
1/39	1.0 - 1.75	Yellow-brown clay	48	15	61	33	15.0				31.1			
1/43	0.6 - 1.4	Yellow-brown clay	86	2	94	67	14.5	1.62	23.5		26.8	5.0×10^{-10}	3.0×10^{-10}	
1/46	1.1 - 1.7	Yellow-brown clay	62	14	61	40	14.0	1.60	23.0		23.9	5.3×10^{-10}	1.5×10^{-10}	
1/48	1.0 - 1.75	Yellow-brown clay	60	25	56	27	15.0				30.1	1.4×10^{-10}	1.2×10^{-10}	

LL Liquid Limit
PI Plastic Index
LS Linear Shrinkage
PD Potentially Dispersive

SMDD Standard Maximum Dry Density
OMC Optimum Moisture Content
ND Non-dispersive

The laboratory falling head permeameter tests for which results are available were carried out on either 'undisturbed' samples or samples compacted to a relative density of ±97% of standard maximum dry density. All results fell within the range 10^{-9} to 10^{-11} m/s. Tests have been undertaken, initially with distilled water and then with a permeant solution representative of a landfill-derived leachate. The results generally show a very slight reduction in permeability with the use of the prepared permeant. This decrease in permeability is too small to be conclusive of the long-term effects that such liquor may have on the clay. The gypsum (sulphate-sulphur (SO_4-S)) content of the clay, summarized in Table B2, is very low. The possibility of secondary permeability due to the solution of salts is therefore not an issue.

TABLE B2

STAGE 1 BULK SAMPLE SULPHATE-SULPHUR RESULTS

Bulk Sample No.	Test Pit No.	Sample Depth (m)	Sulphate-Sulphur Content (ppm)
8926	1/45	1.7 - 2.1	0.01 (0.02 repeat)
	1/46		
8927	1/31	0.8 - 1.3	0.01
	1/41		
	1/37		
8928	1/13	0.7 - 1.0	<0.01
	1/28	0.4 - 0.7	

B3.4 Assessment

While the test results indicate that much of the in situ clay is probably suitable for use in the construction of a low permeability blanket, the lateral variation in thickness and distribution of the clay and the high content of oversize material would require that the clay be excavated and the oversize material removed prior to liner construction. Removal of the oversize component would likely reduce the available estimated volume significantly. Construction of the first cell of the Stage 1 landfill will require approximately 35 000 m^3 of clay, indicating a possible shortfall of recoverable clay material on site. The cost of recovery, modifying and placing and compacting the clay would probably render the use of the in situ material economically unattractive.

B4 STAGE 2 INVESTIGATIONS

B4.1 General

The proposed Stage 2 area includes the shale pit currently owned by Bristile Ltd lying to the west of the Stage 1 area and an area of approximately 1.7 ha lying immediately to the north of the shale pit. Bristile Ltd has indicated that this latter area represents a proposed northern extension to the shale pit as the soils are considered suitable for the manufacture of bricks. Nevertheless, the area to the north of the existing shale pit was pitted out on a 50 m grid and samples were collected and submitted to a NATA laboratory for testing.

The area is bounded on the northern margin by the stream that flows through the Stage 1 area and the ground generally falls away northwards towards this stream. The general topography and relative pit locations are shown on Figure B1.

A line of pits was excavated along the eastern boundary of the Stage 2 area, approximately 30 m to the east of the margin of the shale pit. Two attempts to pit in the floor of the shale pit met refusal within 200 mm of the surface.

B4.2 Field Studies

Thirteen (13) test pits were excavated within the area lying to the north of the shale pit and south of the stream. A further four pits were excavated along the eastern boundary of the Stage 2 area and two attempts were made to excavate in the floor of the shale pit. All pits were excavated to refusal.

Pit depths ranged from 1.3 m to 3.4 m with the greatest depths generally occurring adjacent to the stream on the north eastern boundary. Water was observed seeping into the base of pits 2/3, 2/6 and 2/10 at depths below 1.3 m and into pits 2/4 and 2/13 at depths below 1.9 m. The seepage is considered to be derived from perched near surface run-off.

The soil profiles encountered to the north of the shale pit consisted largely of weathered shale and silty clay, with alluvial soils restricted to the northernmost section of the Stage 2 area.

The clays are generally residual in nature and represent 'pallid' zone material. The greatest thickness of clay occurred in the northern part of the area where alluvial clay overlies the residual deposits. The alluvial clay deposits generally contain a significant component of rounded cobble sized material and to a lesser extent, boulder sized material.

The total estimated quantity of clay available in the area to the north of the shale pit is 14 000 m^3. As with the Stage 1 area in situ clay, this material would require some reworking to remove the cobbles and boulders before it could be used for lining the base of the storage area.

B4.3 Laboratory Testwork

Representative samples collected from selected pits were submitted to a NATA registered laboratory for a similar testing programme as that for the Stage 1 material.

In general, the gradings of the samples and the Atterberg limits were more consistent across the area than those obtained for Stage 1. One sample, collected at depth from pit 2/10, graded as a clayey sand with a plasticity index of 14%. The plasticity indices determined on the rest of the samples all fell within the range 19 - 28%.

Higher standard maximum dry densities and lower optimum moisture contents were obtained on the samples collected from the area to the north of the shale pit than on samples collected to the east of the shale pit. This reflects the predominantly residual nature of the clays to the north of the shale pit.

Preliminary results of the permeability tests, which were carried out on samples compacted into the permeameter mould at field moisture content, fell short of the required performance criteria of 1×10^{-9} m/s. The sample collected from pit 2/9 was the only one of four samples tested to have a laboratory derived permeability result lower than the required value.

The test results are summarized in Table B3.

B4.4 Assessment

The results of the testwork carried out on selected samples indicate that the available clay on the Stage 2 site is unlikely to have an adequately low permeability for blanket construction. It should be noted that the samples were compacted into the permeameter at moisture contents 2 to 3% wet of optimum and improved results may be obtained at higher compaction levels, although it is doubtful that the potential improvement would be sufficient to enable the material to pass the specification required for the liner.

The attempts to excavate pits in the existing floor of the shale pit at two widely spaced locations met refusal at shallow depth. Excavation to greater depth would require heavier plant than was available for the investigation. Much of the material visible in the side walls of the shale pit was similar to

that encountered to the north of the pit, having a high content of indurated shale fragments.

On the basis of the overall results, it would be preferable to obtain a higher quality clay material from alternative sources.

TABLE B3

STAGE 2 TEST RESULT SUMMARY

Test Pit No.	Depth (m)	Soil Description	Gradings		Atterbergs			Compaction		In Situ Condition		Perm (k) (m/s)		Comment
			Fines (-75 μm)	Gravel (+2.36 mm)	LL (%)	PI (%)	LS (%)	SMDD (t/m^3)	OMC (%)	Field Dry Density (t/m^3)	Field Moisture Content (FMC) (%)	Distilled Water	Permeant Water	
2/2	0.8 - 1.5	Silty clay	65	21	53	22	9.0	1.76	16.5		20.1	4.2×10^{-9}	1.6×10^{-10}	Compacted FMC
2/3	0.7 - 1.3	Silty clay	76	13	47	23	11.0	1.69	16.5		19.9	5.7×10^{-9}	5.5×10^{-9}	Compacted FMC
2/9	0.4 - 1.0	Clay	73	7	44	20	9.0	1.77	16.0		18.1	3.9×10^{-10}	4.0×10^{-10}	Compacted FMC
2/10	2.8 - 3.2	Clay	35	18	31	14	-				10.7			SPD 2.73
2/11	1.0 - 1.4	Clay	95	2	53	28	-				27.1			SPD 2.75
2/13	1.0 - 1.5	Gravelly clay	58	12	46	19	-	1.6	23.0		29.9	4.8×10^{-9}	1.5×10^{-9}	Compacted at FMC. SPD 2.86
2/17	0.3 - 0.95	Clay	85	3	53	28	-	1.57	24.5		25.2			SPD 2.82

LL Liquid Limit
PI Plastic Index
LS Linear Shrinkage
PD Potentially Dispersive

SMDD Standard Maximum Dry Density
OMC Optimum Moisture Content
ND Non-dispersive

FMC Field Moisture Content
SPD Soil Particle Density

B5 STAGE 3 INVESTIGATIONS

B5.1 General

The Stage 3 area includes the quarry currently being operated by Pioneer Industries and an extensive area lying to the south and south-south-east of the existing limits of the quarry.

Much of the area proposed for future extensions to the quarry is heavily timbered and, in view of the long lead time before the Stage 3 landfill would commence, the field investigation was limited to the excavation of a number of pits at accessible locations that did not require the removal of trees. The general layout of the pits is shown on Figure B2.

B5.2 Field Studies

A total of twenty-five (25) test pits were excavated within the proposed extension of the existing Pioneer Quarry in order to assess the pre-strip material that would need to be removed prior to extending the quarry limits southwards.

Pits 1 to 12 were set out on a grid pattern over a largely cleared area lying within 200 m of the southern face of the quarry. The remaining pits were excavated at accessible locations within the heavily timbered area lying to the south-south-east of the quarry.

The area is generally underlain by granitic rocks with a variable weathering profile and topsoil thickness. Much of the south-eastern section of the area is covered by a durable laterite hardcap that prevented pit excavation. Mobilization of a drill rig to penetrate the hardcap and evaluate the possible underlying clay profile was not considered justifiable in view of proposed scheduling of the Stage 3 development.

Subcropping granitic rocks occur at various locations across the site, concentrated towards the crest of the ridge.

The pits excavated on the gentle western slope, near the crest of the ridge, generally showed a relatively thin, organic rich topsoil horizon overlying soils of various thickness representing decomposed granite. The residual soil matrix generally displays a distinct segregation with depth of fines from the coarse felspar and quartz sand. This is not unusual within the granite weathering profile. The colour change is generally from a yellow to reddish yellow sandy clay, through a red and greyish white mottled zone into a pale grey to white sandy zone at the base of the profile. This, in turn, overlies more competent granitic bedrock.

Water was generally observed to enter the pits through the sandy horizon at the base of the soil profile.

All pits were excavated to refusal. Pit depths varied considerably reaching a maximum depth of 6.2 m in pit 3/1. Some pits met refusal at shallow depth on hard bedrock.

Reasonable quality clay soils generally occur in the upper part of the granitic soil profile. The availability of suitable clay for extraction and use in liner construction appears to be limited and the small quantities that do occur tend to be confined to isolated pockets of limited extent.

B5.3 Laboratory Testwork

A number of samples were collected from the pits located along the western margin of the area and submitted to the laboratory for testing. The results are summarized in Table B4.

The grading analyses showed a comparatively low fines content throughout, generally less than 70%. The plasticity indices varied considerably within the range 21-59%. Field moisture contents were generally slightly above optimum.

Two permeability tests were carried out on samples compacted to a relative density of 98% of the standard maximum dry density. Both tests gave permeability values in excess of 10^{-9} m/s, greater than the maximum allowed for the liner. It is doubtful whether significant improvement in the material performance could be achieved in the field even if a greater compacted density could be achieved.

B5.4 Assessment

The quality and limited availability of clay within the area proposed for the quarry extension appears to discount the area as a potential source of clay for liner construction. There would seem to be little purpose in carrying out an early pre-strip on this area to provide clay material for the Stage 1 landfill. The area may provide quantities of suitable material as a final covering for the Stage 2 landfill area.

TABLE B4

STAGE 3 TEST RESULT SUMMARY

Test Pit No.	Depth (m)	Soil Description	Gradings		Atterbergs			Compaction		In Situ Condition		Perm (k) m/s	Comment
			Fines (-75μm)	Gravel (+2.36 mm)	LL (%)	PI (%)	LS (%)	SMDD (t/m^3)	OMC (%)	Field Dry Density (t/m^3)	Field Moisture Content (%)		
3/1	0.8 - 1.8	clay	48	23	75	39	16.0				21.4		
3/1	2.2 - 3.2	clay	62	20	91	59	18.0				21.7		
3/1	4.6	sandy clay	57	7	55	27	9.0				21.4		
3/1	1.5 - 5.0	bulked sample	60	17	61	28	11.5	1.68	19.5		23.2	7.5×10^{-9}	Disp. ND1 98% SMDD
3/2	1.5	clay	44	11	42	21	9.0				18.5		
3/6	0.7 - 1.2	clay	69	8	64	33	13.5				26.5		
3/6	1.7 - 2.2	clay	59	11	61	36	15.0				22.0		
3/12	1.0 - 2.5	bulked clay	62	4	47	22	10.0	1.67	19.5		16.5	5.2×10^{-9}	Disp. ND1 98% SMDD

LL Liquid Limit
PI Plastic Index
LS Linear Shrinkage
PD Potentially Dispersive

SMDD Standard Maximum Dry Density
OMC Optimum Moisture Content
ND Non-dispersive

B6 OFF-SITE CLAY DEPOSITS

B6.1 Overview

The test pitting programme over the proposed landfill sites has determined that the available in situ clay is insufficient to meet the overall requirement for the Stage 1 project. The clay that is available generally contains a high proportion of cobbles and boulders, and the economics of reworking the material to remove this oversize component are unattractive.

It was therefore necessary to assess the potential of obtaining material of appropriate specification to construct the low permeability liner from off-site sources.

An initial desk study was directed towards obtaining an understanding of the regional distribution of clay deposits. This included a review of available literature and discussions with personnel from various government authorities including the Geological Survey of WA (GSWA) and representatives of companies that utilize clay borrow material.

B6.2 Major Off-site Clay Deposits

A total of seven known clay deposits were considered, all of which lie within the clay or sandy clay deposits of the Guildford Formation. The major clay deposits considered are listed in Table B5 below:

TABLE B5

MAJOR OFF-SITE CLAY DEPOSITS

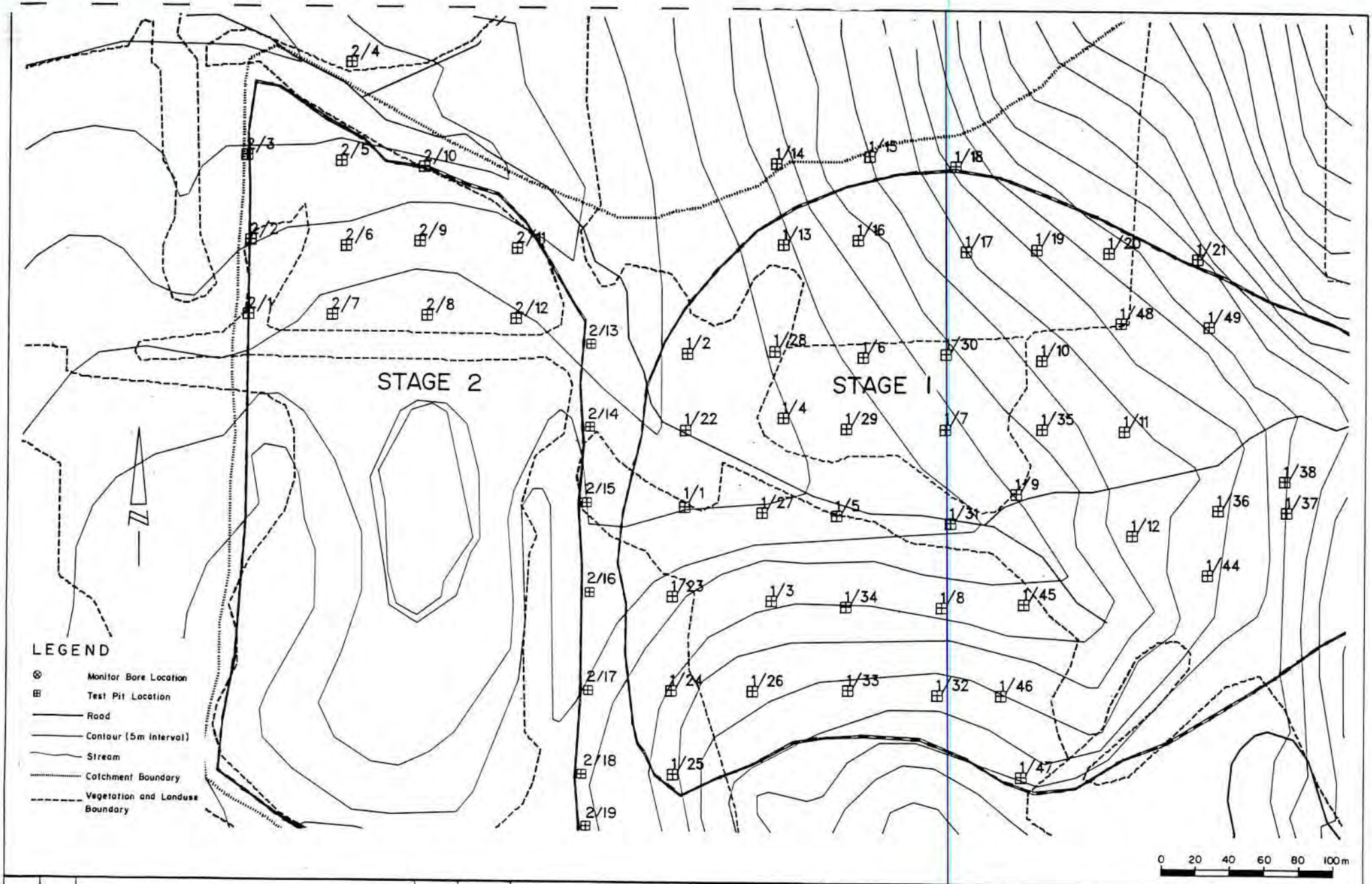
Site Name/Owner	Location	Distance to Project Area (km)
Alcoa	Wellard	25
Alcoa	Mundijong Road, Baldivis	20
WA Waterski Park	Baldivis	17
Bellways	Baldivis	23
Metro Brick	Pinjarra	47
Metro Brick	Lot 187, Thomas Road	10
Neville Rodwell	Lot 275, Mundijong Road	13
Bristile	South Cardup	<1

B6.3 Lot 275, Mundijong Road - Geotechnical Assessment

As a follow-up to the assessment of off-site clay sources, attention was focused on Lot 275, Mundijong Road, and a limited geotechnical programme undertaken.

An assessment of the test pit data and laboratory test results from this site indicate a possible source of material for liner construction. Further evaluation will, however, be necessary to confirm that the material can meet the required specification for liners.

FIGURES

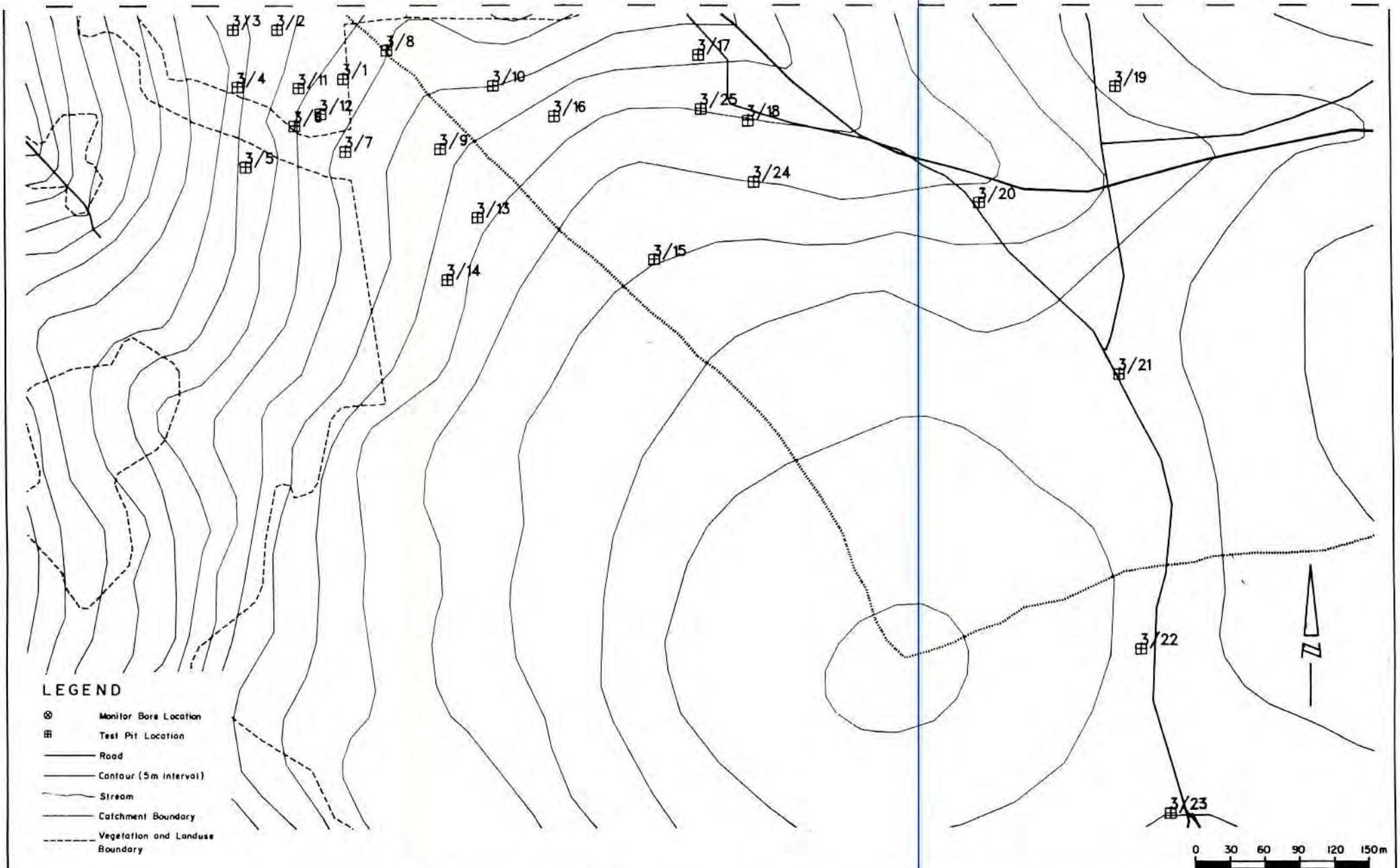


REVISION				
	DESCRIPTION	Drawn Date	Chk'd Date	

AGC Woodward-Clyde

STAGES 1 AND 2 – TEST PIT LAYOUT PLAN

Date January 1993	Dwg. 2535-23	Fig. B1



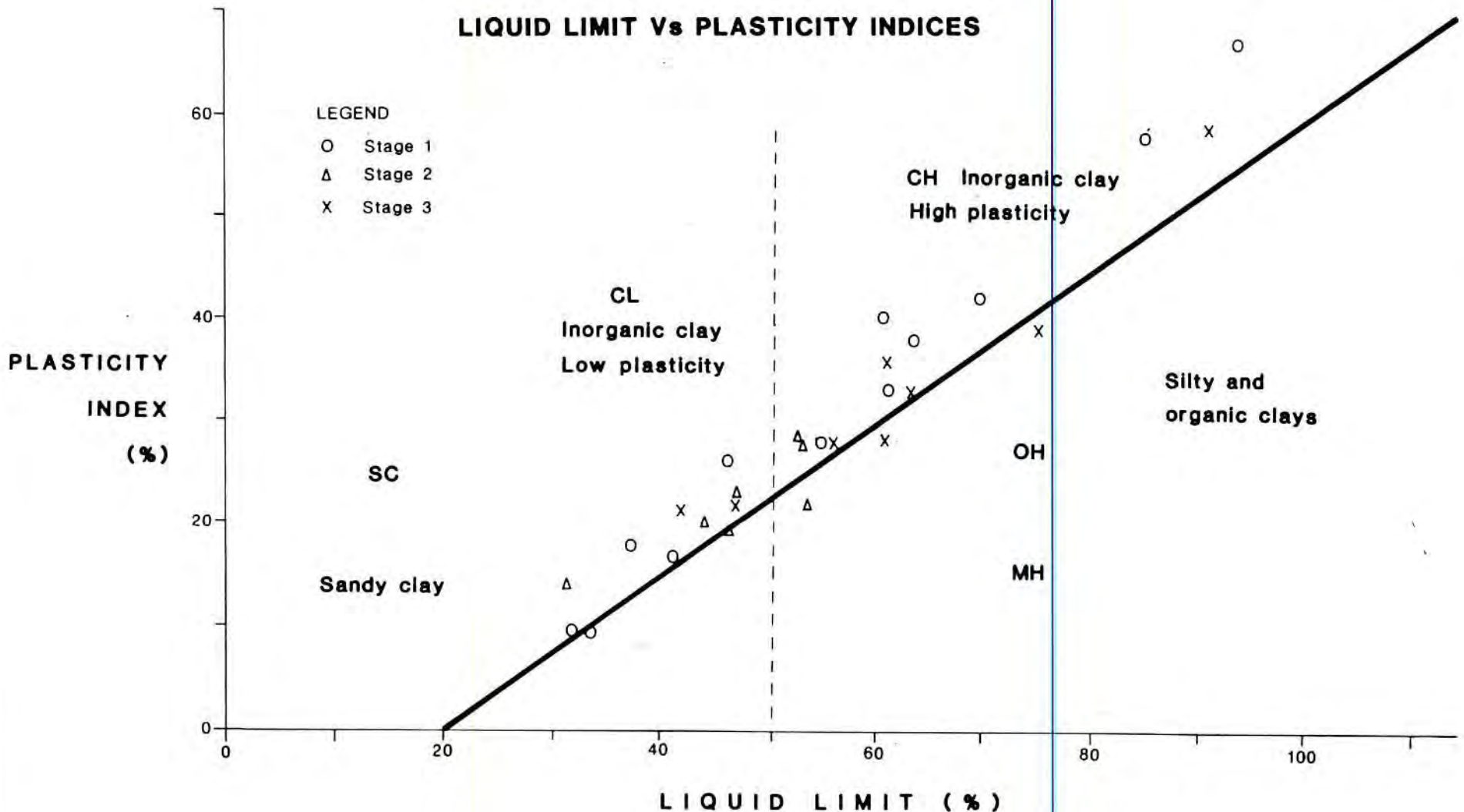
REVISION				
	DESCRIPTION	Drawn Date	Chk'd Date	

AGC Woodward-Clyde

STAGE 3-TEST PIT LAYOUT PLAN

Date January 1993	Dwg. 2535 - 24	Fig. B2

LIQUID LIMIT Vs PLASTICITY INDICES



REVISION		DESCRIPTION	Drawn Date	Ch'd Date

AGC Woodward-Clyde

Date JAN. 1993 | Dwg. 2535 - 27 | Fig. B3

APPENDIX C

HYDROGEOLOGICAL STUDIES

CONTENTS

TABLES

CONTENTS (CONT'D)

C1 INTRODUCTION

Pioneer-BFI Waste Services proposes to develop a sanitary landfill, located near South Cardup, approximately 45 km south of Perth, Western Australia. The landfill, named the Southern Landfill, would be designed for putrescible, non-putrescible and selected commercial wastes. AGC Woodward-Clyde Pty Limited (Woodward-Clyde) was engaged to carry out baseline hydrogeological studies to describe the hydrogeological setting and to establish permanent groundwater monitor bores.

This report provides the details of the drilling, construction and sampling of the groundwater monitor bores and a description of the hydrogeological conditions of the proposed landfill site.

C2 SITE GEOLOGY

The project site is located approximately 1 km east of the Darling Fault which separates the predominantly granitic Yilgarn Block from the deep thickness of sediments of the Perth Basin to the west. The subsurface geology of the site from west to east comprises:

- Armadale Shale Formation - a steeply dipping unit of thinly bedded silty shale with interbedded siltstone and sandstone. This unit is 75 to 200 m thick bounded to the west (off site) by the Darling Fault and to the east by the Neerigen Formation.

- Neerigen Formation - a steeply dipping unit approximately 75 to 200 m thick including sandstone with interbedded silty shale with a basal conglomerate. This unit appears to be in conformable contact with the Armadale Shale to the west and nonconformable contact with the granite block to the east.

- Granite - the vast Yilgarn Block granite including coarse-grained granites and gneisses with dolerite dykes.

A cross-section showing the diagrammatic relationship of the geological units of the site is given on Figure C1.

C3 SITE HYDROGEOLOGY

The proposed Stage 1 landfill is underlain mostly by granitic rock with local intruded dolerite dykes. These crystalline rocks have very little primary porosity or permeability and contain groundwater only where weathering or fracturing has resulted in secondary porosity and permeability.

In the site area, significant weathering has not been observed on the upper surfaces of these rocks. Therefore, groundwater forming the local water table only occurs within these rocks where there are open fractures. Temporary flows of groundwater occur after wet periods along the contact of the irregular soil horizon with the underlying crystalline rocks. These groundwater flows result in ephemeral springs and soaks as well as supporting the existing vegetation.

The movement of groundwater in fractured rocks can be very complex, controlled by the degree of connection, if any, between the various fracture sets. Because the fractures are planar features, groundwater moves in response to a hydraulic gradient through a network of interconnected fractures. Many fracture sets, although within tens of metres to other sets, may not have mutual hydraulic connection with the other fractures and form localized groundwater flows systems. This complexity makes it difficult or inappropriate to correlate hydraulic data, such as water levels, from one location to another.

The Stage 2 landfill area is down-gradient from Stage 1 and is located within the Bristle shale pit. The shale is part of the Armadale Shale Formation separated from the granitic rocks by the Neerigen Formation. Both of these formations are steeply dipping, nearly vertical, and strike perpendicular to the topography and expected hydraulic gradient. Neither formation, particularly the Armadale Shale, is expected to transmit appreciable groundwater. The Armadale Shale has low permeability and its steep dip means that groundwater movement would be perpendicular to the bedding planes which is the direction of lowest permeability. The occurrence and orientation of these formations create a barrier to deep groundwater movement from the landfill areas to the Swan Coastal Plain to the west.

A veneer of colluvial material comprising clays, silts, sands and gravel locally drapes the Armadale Shale, forming a wedge up against the scarp. This colluvium can sometimes be thick enough to host a perched water table, generally some hundreds of metres west of the slopes, but still on the granite side of the Darling Fault. This colluvium persists westwards across the fault to overlie the sediments of the Perth Basin. The Stage 2 landfill is sited entirely upon the Armadale Shale and is thus separated from the colluvium.

C4 EXISTING GROUNDWATER USE

A search was made of the records held by the Water Authority of Western Australia (WAWA) and the Department of Minerals and Energy to retrieve the existing information regarding the existence of groundwater bores in the immediate area of the proposed Southern Landfill.

The nearest recorded bores are located on Pt. Lot 448, installed in 1977 for Pioneer Concrete and are now believed abandoned. These comprise three bores approximately 100 m apart drilled to depths between 10 m and 25 m into granite. The records indicate that the bores could supply approximately 1 L/s.

A bore is also located west of the South Western Highway on Lot 24, installed to a depth of 21 m. The recorded water quality has a salinity of 305 mg/L and the water reportedly used for stock and domestic uses. There is no record of the site geology but it is likely, based on the depth of the bore, that the bore is tapping a shallow perched aquifer within the alluvium.

Several farm properties along the Darling Scarp have small dams constructed to contain the seepage from local springs. These dams are then used for stock water supply and domestic purposes. One such soak is located within the project property and is used by Pioneer Concrete.

C5 MONITOR BORE INSTALLATION

C5.1 Installation Procedure

Groundwater monitor bores were installed at five locations during the period 17 November to 3 December 1992, including stoppages due to wet weather. The holes were drilled and bores constructed using a Gardener-Denver 1400 conventional rotary drilling rig. The monitor bores were constructed from 80 mm Class 12 uPVC bore casing, slotted as appropriate, and the annular space backfilled with rounded, siliceous gravel. After completion, each bore was developed by airlift pumping for a period of one hour. The locations of the monitor bores are shown on Figure C2.

Bore SL 1 is located down-gradient of the Stage 1 landfill and to the north of the small creek traversing the site. The hole was drilled to 26 m into a doleritic dyke by means of a downhole percussion hammer. Groundwater was encountered at 11 m during drilling. The bore was installed to a final cased depth of 26 m, slotted from 8 m to 26 m.

Bore SL 2 is located down-gradient from the Stage 1 landfill and to the south of the small creek. The hole was drilled to 23.5 m into granitic rock using a downhole percussion hammer, with groundwater first encountered at a depth of 16 m. The 80 mm uPVC casing was installed to 23.5 m, with the interval 5.5 m to 23.5 m being slotted.

Bore SL 3 is located down-gradient of the site, immediately to the east of the South Western Highway and near the access road to the shale pit. The hole was drilled to a depth of 24 m into clayey silt, sandy silt and clayey sand comprising a mantle of colluvial sediments over the Armadale Shale Formation which is mapped as underlying the location. Groundwater was encountered as moist drill cuttings at 20 m. The monitor bore was installed to 24 m, slotted from 6 m to total depth.

Bore SL 4 is located down-gradient from the site, near the intersection of the South Western Highway and the access road to the Pioneer Concrete quarry. The hole was drilled to a depth of 30 m into clay, silty clay and sandy silt, finally terminating in weathered shale (Armadale Shale). Groundwater was first encountered as dampness at 17.5 m and as a slight flow at 24 m. The monitor bore was installed to 28.5 m with the interval from 4.5 m to 28.5 m being slotted.

Bore SL 5 is located up-gradient of the Stage 1 landfill and to the north of the small creek. The site is on a relative steep slope. The hole intersected granite, beneath a thin veneer of soil, to 9 m where a doleritic dyke was encountered to the total depth of 22 m. Groundwater was first encountered at 16 m and a significant flow of water at 17 m associated with a small quartz vein.

The bore construction and geological logs are presented graphically on Figures C3 to C7.

C5.2 Groundwater Levels

Groundwater levels were measured in all monitor bores on 5-6 January 1993. The levels are listed in Table C1.

TABLE C1

GROUNDWATER LEVELS

Bore	Water Level (m bgl)	Water Level (m AHD)	Date
SL 1	2.00	112.85	6 Jan 93
SL 2	14.53	134.08	5 Jan 93
SL 3	23.65	75.48	5 Jan 93
SL 4	21.49	71.65	6 Jan 93
SL 5	14.25	167.55	6 Jan 93

The groundwater levels are generally sympathetic to the topography. Because of the anisotropic nature of the fractured granitic bedrock aquifer for bores SL 1, SL 2 and SL 5, and the interpreted hydraulic barrier between these bores and bores SL 3 and SL 4, no attempt has been made to construct a potentiometric contour map or to calculate groundwater throughflow.

It is expected that the groundwater levels would respond to seasonal rainfall. Groundwater levels would therefore be at the highest towards the end of winter and lowest at the end of summer.

C5.3 Groundwater Quality

Groundwater samples were collected from the monitor bores on 5 and 6 January 1993. Prior to sampling, each bore was purged of standing water by pumping or bailing. During purging, the electrical conductivity (EC) of the purged water was regularly measured. The purging was considered complete when a minimum of three well-volumes was purged and two successive EC measurements were essentially the same.

The groundwater samples were collected using either a stainless-steel submersible pump (Grundfos MP 1) or a Teflon® bailer. The samples were gently pumped or poured into the sample bottles to minimize agitation of the sample. Each sample bottle was properly labelled and immediately placed in an

ice-cooled container for transport to the analytical laboratory (Analabs - Perth). The samples were delivered to the laboratory on the day of sampling.

The water quality parameters are summarized in Table C2 and copies of the laboratory reports are given at the end of this Appendix.

The groundwater quality is variable across the site and down-gradient area. The observed salinity range is from 370 mg/L in Bore SL 3 to 2 800 mg/L in Bore SL 2. The pH varies from 5.0 to 6.6 with three of the five values being in the range pH 6 to 7. Soluble iron occurred in all samples, and cadmium was detected for bores SL 2, SL 3 and SL 5. All other metals were below the detection limit. Phenol (as total phenol) was detected in the sample from SL 1.

TABLE C2

SUMMARY OF WATER QUALITY

Bore	SL 1	SL 2	SL 3	SL 4	SL 5
Sample ID	8 760	8 761	8 762	8 763	8 764
EC*	1200	4700	690	1300	620
TDS**	740	2800	370	700	390
pH	6.6	6.2	5.2	5.0	6.0

* Electrical conductivity as μS/cm
** Total dissolved solids as mg/L

The groundwater from all bores except SL 2 is of relatively low salinity suggesting active recharge and throughflow. The highest salinity of 2 800 mg/L at SL 2 may be the result of local clearing.

The occurrence of detectable concentrations of cadmium appears anomalous as there is no obvious source. It is a parameter that must be verified by subsequent sampling and analysis.

The phenol detected in Bore SL 1 is believed to arise from the decay of natural organic materials. If total phenols are detected in subsequent analyses, the nature of specific phenolic compounds should be determined to allow identification of the phenol source.

The major ions show that the groundwaters are a sodium chloride-magnesium bicarbonate type water, except for SL 3 which is a sodium chloride-magnesium sulphate water.

C6 PROPOSED GROUNDWATER MONITORING PROGRAMME

C6.1 General

The monitor bores have enabled establishment of the baseline groundwater conditions prior to the installation of the landfill. The bores have also been constructed to monitor the local groundwater to determine if the operation of the landfill will impact the groundwater environment.

All bores were initially sampled during the period 5 to 6 January 1993 (Section C5).

C6.2 Recommended Sample Analysis

The required suite of analyses and the frequency of sampling will be established by the Environmental Protection Authority, in consultation with WAWA, as a condition of any approval for the landfill project. The following list of analytes is indicative of the expected requirements:

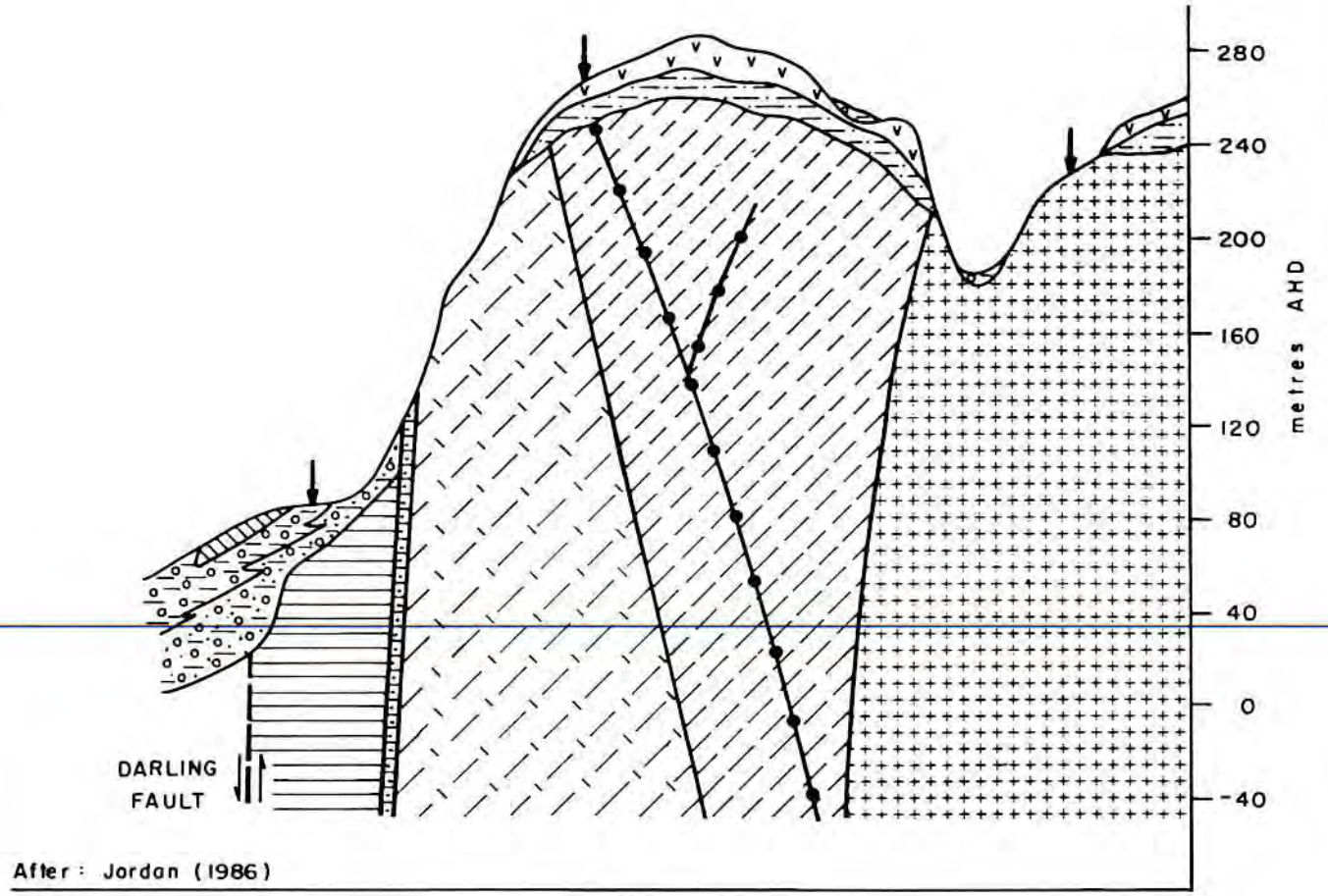
- Electrical conductivity
- Total dissolved solids
- pH
- Total organic carbon (TOC)
- Biochemical oxygen demand (BOD_5)
- Chemical oxygen demand (COD)
- Total alkalinity
- Total phenolics, as phenol
- Total phosphorus, as P
- Ammonia nitrogen, as N
- Nitrate nitrogen, as N
- Kjeldhal nitrogen, as N
- Total lead, as Pb
- Total iron, as Fe
- Sodium, as Na
- Potassium, as K
- Calcium, as Ca
- Magnesium, as Mg
- Sulphate, as SO_4
- Chloride, as Cl
- Bicarbonate, as HCO_3
- Total arsenic, as As
- Total mercury, as Hg
- Total cadmium, as Cd
- Total chromium, as Cr
- Total copper, as Cu
- Total zinc, as Zn

C7 SUMMARY

Five groundwater monitor bores have been installed in the area of the proposed Southern Landfill. The bores have been surveyed to Australian Map Grid coordinates and levelled to the Australian Height Datum (AHD). Rest water levels have been measured and corrected to AHD. Groundwater samples have been collected from each monitor bore and the samples analysed for the appropriate parameters.

A programme of on-going monitoring is proposed, and detailed in this Appendix.

FIGURES



After : Jordan (1986)

LEGEND

GRAVELLY CLAYEY SAND – decomposed bedrock origin, gravel rock fragments
Angular quartz / feldspar sand, colluvial origin

GRAVELLY SANDY CLAY – variable with lenses of silt and gravel, quartz sand, colluvial origin

SANDY CLAY – white, grey, brown, clay of alluvial origin

IRONSTONE –
red brown limonite gravel of alluvial origin

LATERITE – massive, vuggy to cemented pisolites up to 4 m thick, of residual origin

SHALE – brown, green black, silty with interbeds of siltstone and fine sandstone

SANDSTONE –
basal conglomerate and silty sandstone

GRANITE – fine to coarse grained mesocratic rocks of granite and granodiorite, porphyritic, even grained

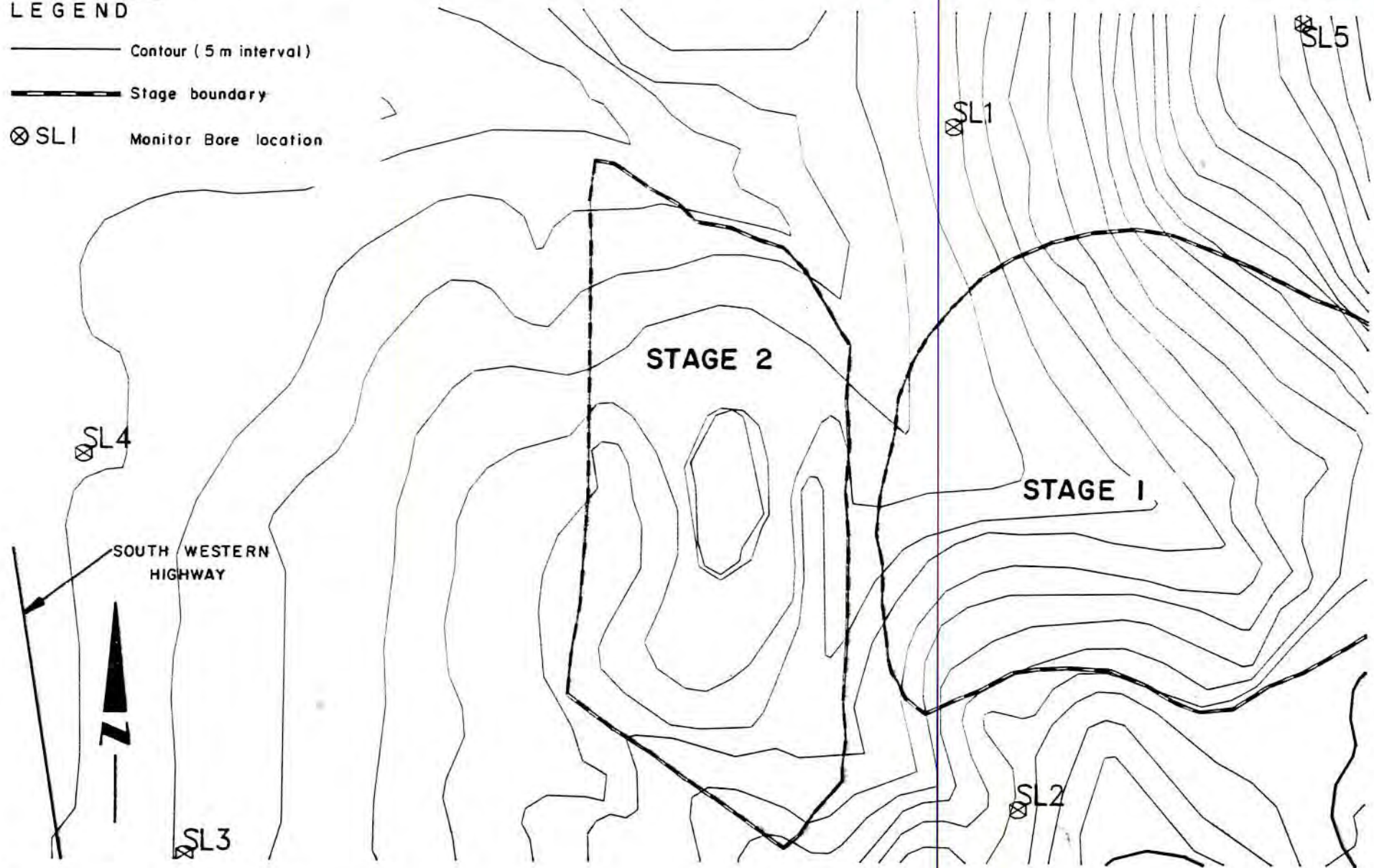
GNEISS –
fine to medium grained mesocratic gneiss

GRANITES AND GNEISS – intimate association of coarse grained granites and gneisses and fine grained dolerites

Dolerite dyke

Diagramatic monitor bore location

REVISIONS						
					AGC Woodward–Clyde	DIAGRAMMATIC RELATIONSHIP OF GEOLOGICAL UNITS
	Rev.	DESCRIPTION	Drawn Date	Chk'd Date		Date Jan. '93 | Dwg. 2535-17 | Fig. C1



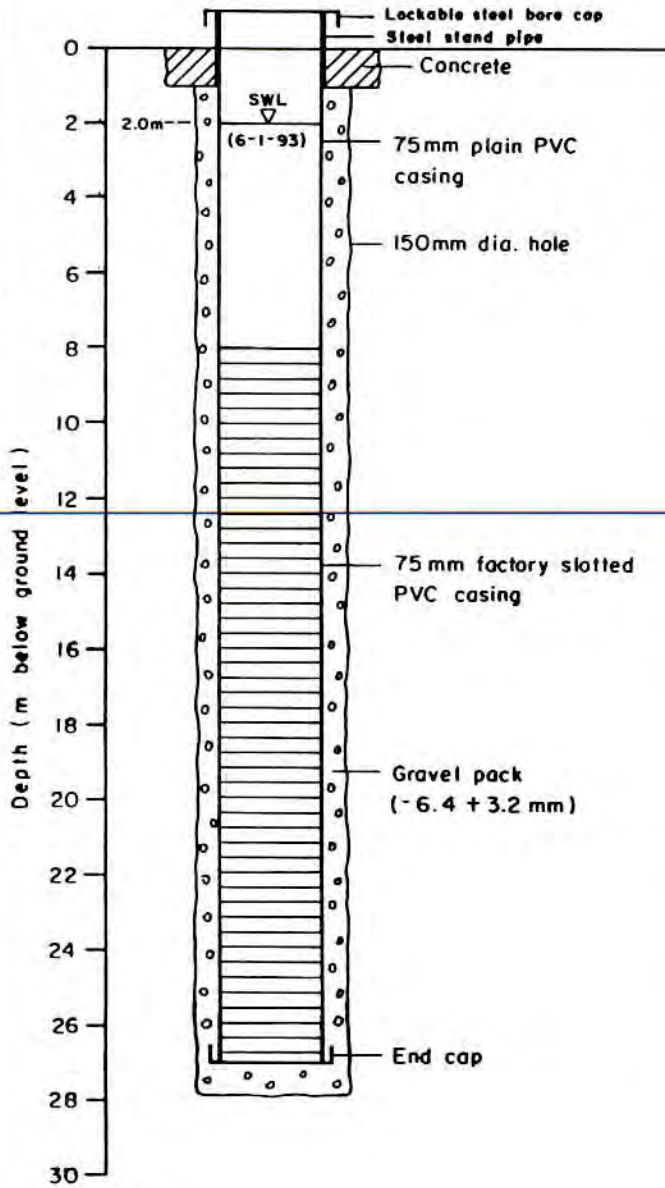
REVISION		DESCRIPTION	Drawn Date	Chk'd Date

AGC Woodward-Clyde

MONITOR BORE LOCATIONS

Date January 1993 | Dwg. 2535-25 | Fig. C2

CONSTRUCTION LOG



LITHOLOGY LOG

TOPSOIL, dark orange/brown silty loam, roots & vegetative matter

CLAY, khaki, silty

CLAY, reddy brown, silty

GRANITE, pinky grey, very weathered

GRANITE, grey/white, fine grained, high quartz content, some feldspars (10%), and hornblende (5%), highly acidic

DOLERITE, dark grey, hard, very fine grained, predominantly amphiboles

dolerite quartz vein, sulphides along contact

dolerite quartz content increases, rock becomes softer

individual grains becoming more discernible fine grained

Terminated at 27 m

LEGEND

- SILTY LOAM / TOPSOIL
- SILTY CLAY
- GRANITIC BEDROCK
- DOLERITIC BEDROCK

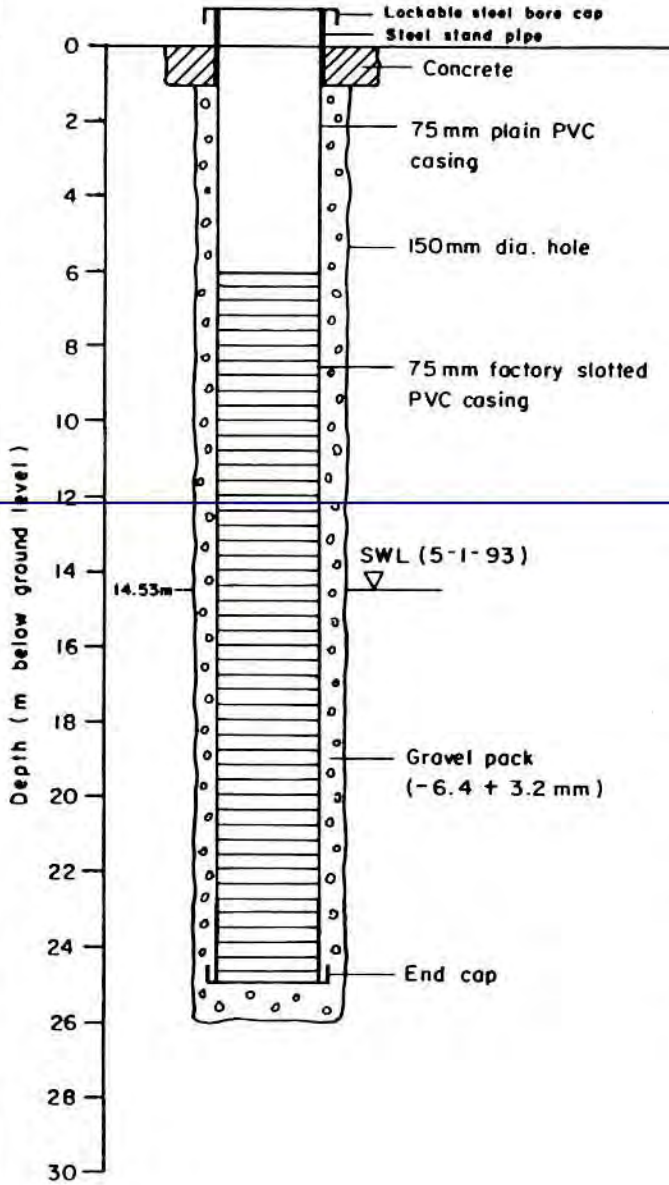
RL (m AHD) : 115.8

Co-ordinates : 6 430 009.4 N
407 692.1 E

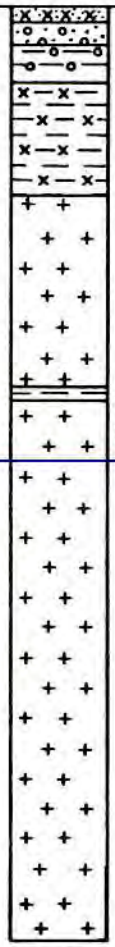
Bore completed : 18-11-92

REVISIONS						
Rev.	DESCRIPTION	Drawn Date	Chk'd Date	AGC Woodward-Clyde	COMPOSITE LOG BORE SL1	
					Date Jan. '93	Dwg. 2535-12 Fig. C3

CONSTRUCTION LOG



LITHOLOGY LOG



TOPSOIL, red/orange sandy silt

SAND, red/orange, gravelly, contains weathered quartz & gravel fragments up to 1 cm dia.

CLAY, grey/brown clay, fragments of weathered bedrock up to 2 cm dia., very plastic, pliable, moist

CLAY, orange/brown silty clay, weathered bedrock fragments up to 1cm dia., very plastic, moist

GRANITE, grey/white, fine grained, high quartz content, some feldspars and hornblende

CLAY, grey/orange, silty, very thin layer

GRANITE, grey/white, fine grained, high quartz content, some feldspars and hornblende

rock chips are moist

Terminated at 25 m

LEGEND

- SANDY SILT
- GRAVELLY SAND
- GRAVELLY CLAY
- SILTY CLAY
- CLAY
- GRANITIC BEDROCK

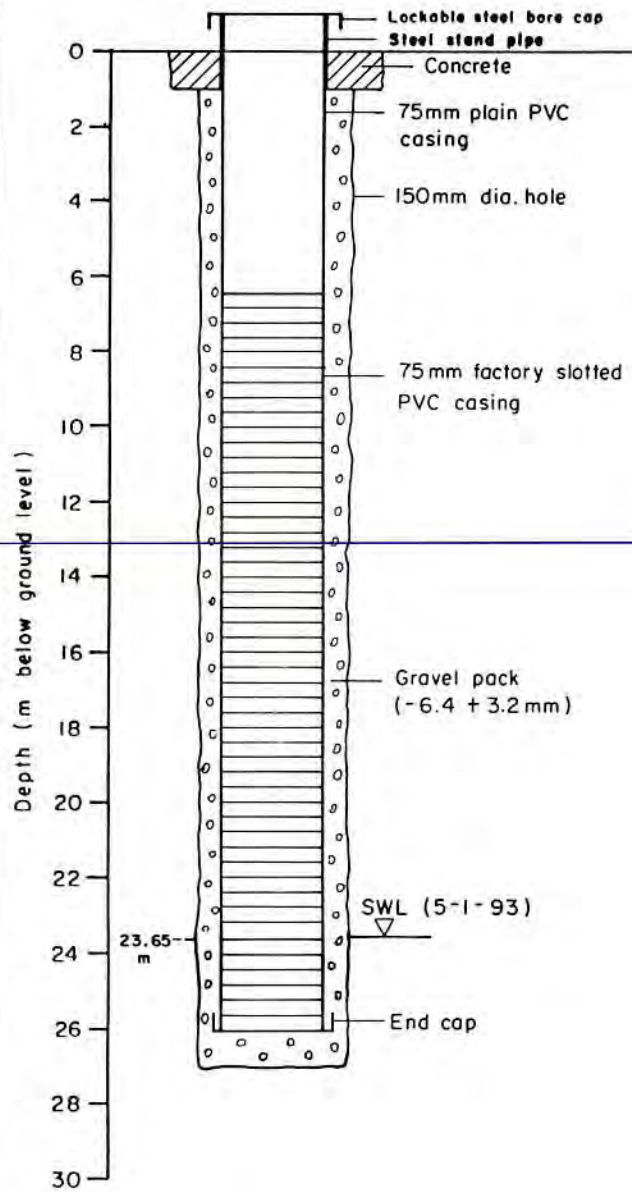
RL (m AHD) : 149.5 m

Co-ordinates : 6 429 512.1 N
407 743.8 E

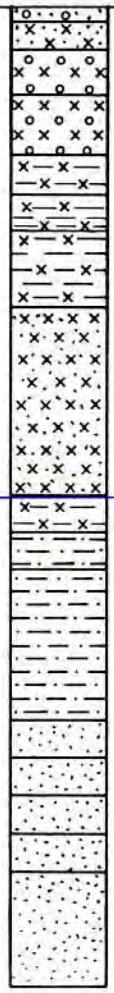
Bore completed : 19-11-92

REVISIONS						
Rev.	DESCRIPTION	Drawn Date	Chk'd Date	AGC Woodward-Clyde	COMPOSITE LOG BORE SL2	
					Date Jan. '93	Dwg. 2535-13 Fig. C4

CONSTRUCTION LOG



LITHOLOGY LOG



SAND, grey/orange, gravelly
SAND, orange, silty
SILT, orange, gravelly; weathered pisoliths, easily crushed between fingernails, up to 0.5cm dia
SILT, orange, gravelly, gravel up to 1cm dia
CLAY, orange, silty
CLAY, red, slightly damp, silty clay, "pebbles" - easily crushed between fingers, have light grey/orange centres
CLAY, red, silty, damp, increasing clay "pebbles" up to 0.5 cm
SILT, deep red, sandy
CLAY, red, silty, damp
CLAY, orange / red, dry, sandy
CLAY, red, sandy, dry
SAND, red, clayey, dry
SAND, red, clayey, damp
SAND, red, damp, hard ferruginised fragments appearing-dark red/black, dry
SAND, red, clayey, damp
SAND, red, wet

Terminated at 26 m

LEGEND

- GRAVELLY SAND
- SILTY SAND
- GRAVELLY SILT
- SILTY CLAY
- SANDY SILT
- SANDY CLAY
- SAND

RL (mAHD) : 100.1

Co-ordinates : 6 429 476.0 N
407 127.4 E

Bore completed : 30-11-92

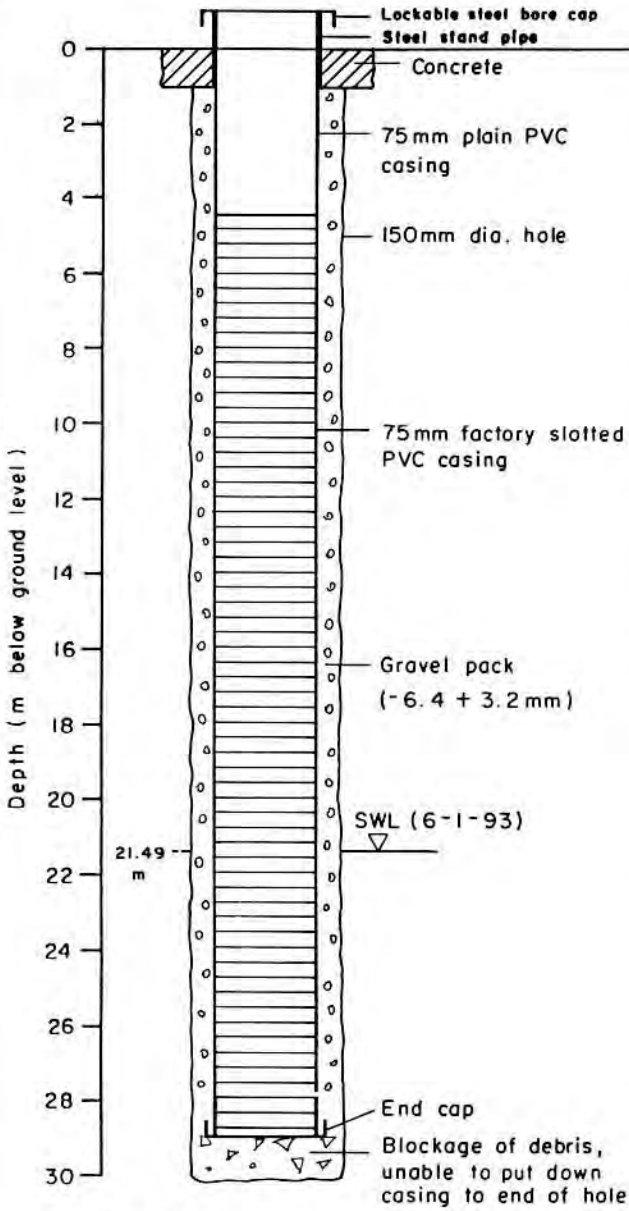
REVISIONS					
	Rev.	DESCRIPTION	Drawn Date	Chk'd Date	

AGC Woodward-Clyde

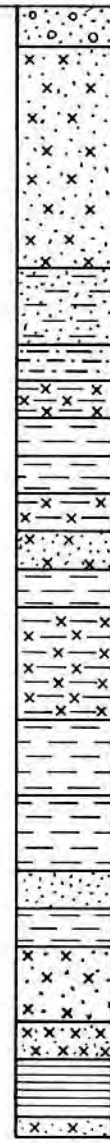
COMPOSITE LOG BORE SL3

Date Jan. '93 | Dwg. 2535-14 | Fig. C5

CONSTRUCTION LOG



LITHOLOGY LOG



SAND, orange/yellow, some gravels up to 2cm dia.

SAND, orange, silty, som gravels up to 0.5cm dia.

SAND, red/pink, clayey, damp

CLAY, red/pink, sandy, slightly damp

CLAY, deep red/pink, silty, damp, contains clay "pebbles" which have grey clay interiors

CLAY, grey, stiff, damp

CLAY, red/dark pink, damp

CLAY, pink/red, silty

SAND, deep red, silty

CLAY, light pink/grey, damp

CLAY, deep red, silty, damp

CLAY, grey with deep red coating, hard baked deep red/black flakes appearing, damp

CLAY, grey/orange, damp

SAND, orange/red, damp

CLAY, red, very wet, quartz fragments up to 0.5cm

SAND, red, silty, very wet

SILT, red, sandy

SHALE, red, pink, weathered, easily crushed between fingernails

SAND, red, silty, very wet

Terminated at 29 m

LEGEND

- GRAVELLY SAND
- SILTY SAND
- CLAYEY SAND
- SANDY CLAY
- SILTY CLAY
- CLAY
- SANDY SILT
- SHALE

RL (mAHD) : 94.2 m

Co-ordinates : 6 429 766.5 N
407 050.3 E

Bore completed : 2 - 12 - 92

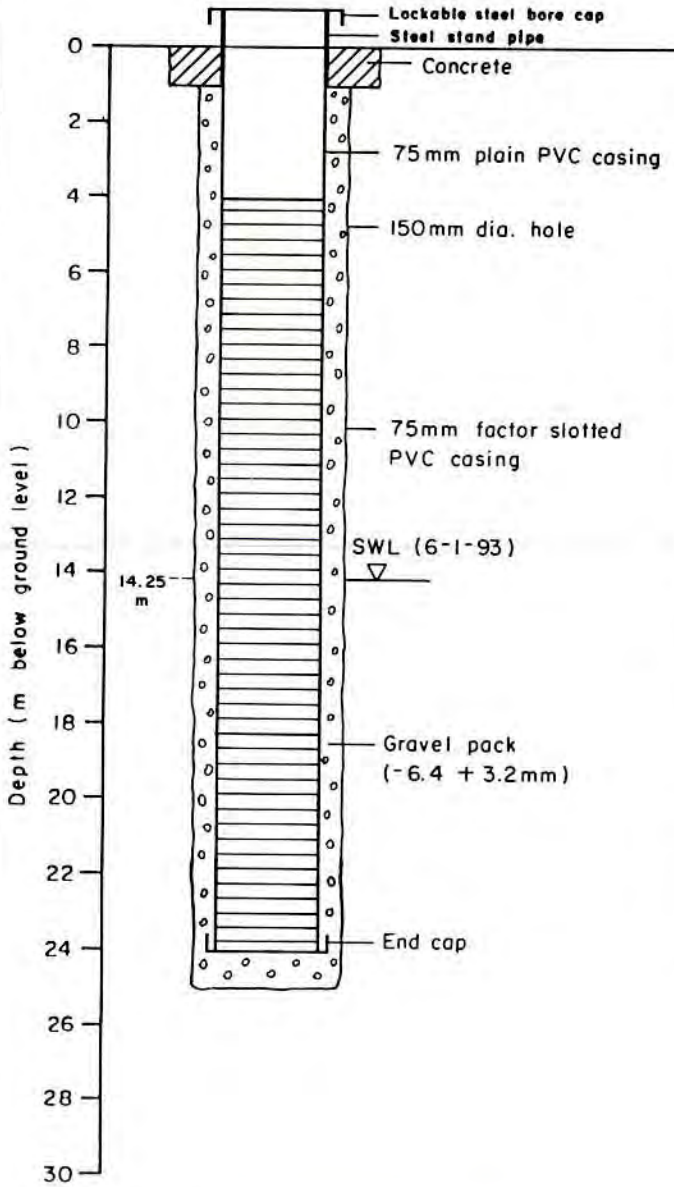
REVISIONS	Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AGC Woodward-Clyde

COMPOSITE LOG
BORE SL4

Date Jan. '93 | Dwg. 2535-15 | Fig. C6

CONSTRUCTION LOG



LITHOLOGY LOG

CLAY, yellow/brown, silty, weathered bedrock fragments

GRANITE, light grey/white, very hard, highly acidic, high quartz content, some hornblende (5%)

DOLERITE, dark grey, hard, very fine grained, dominantly amphiboles

DOLERITE, grey/green, hard, altered, shear fracture

DOLERITE, dark grey, hard, very fine grained, dominantly amphiboles

DOLERITE, light grey/white, very hard, quartz rich vein, wet

Terminated at 24 m

LEGEND

SILTY CLAY

GRANITIC BEDROCK

DOLERITIC BEDROCK

RL (m AHD) : 182.9

Co-ordinates : 6 430 086.5 N
407 949.9 E

Bore completed : 3-12-92

REVISIONS					
Rev.	DESCRIPTION		Drawn Date	Chk'd Date	

AGC Woodward-Clyde

COMPOSITE LOG BORE SL5

Date Jan. '93 | Dwg. 2535-16 | Fig. C7

APPENDIX D

POTENTIAL LEACHATE GENERATION AT THE SOUTHERN LANDFILL

CONTENTS

D1 INTRODUCTION

Leachate is liquid which has percolated through or drained from waste and which contains dissolved and/or suspended materials from the waste.

This document examines the potential generation of leachate at the proposed Southern Landfill, South Western Highway, South Cardup. Only Stages 1 and 2 of the proposed landfill have been discussed, as no design criteria are yet available for the proposed Stage 3 area.

It is anticipated that some 125 000 tonnes of waste per year will be supplied to the landfill for disposal, comprising:

- 5 000 tonnes of municipal waste;
- 70 000 tonnes of commercial waste;
- 50 000 tonnes of industrial waste.

The specific types of waste acceptable for disposal at the landfill are:

- domestic refuse;
- putrescible wastes (other than domestic refuse);
- special (prescribed) wastes as listed in Table D1; and
- low level contaminated soils.

Full details of screening procedures for determining acceptability of wastes are outlined in Appendix E of the Public Environmental Review for the Southern Landfill.

The chemical composition of landfill leachates is complex and reflects the leaching characteristics of the wastes within the disposal environment of the landfill cell(s). Putrescible wastes (especially those in domestic refuse) are typically broken down by chemical and biological reactions under anaerobic conditions. The resulting leachate is usually near-neutral, saline and rich in inorganic nitrogen and natural organic materials, especially during the advanced stage of degradation where methane gas is produced. Leachates produced by industrial wastes may contain a range of metals and organic compounds. The above screening procedures for determining acceptability of wastes (Appendix E) are designed to ensure that the leaching of metals and organic compounds from industrial wastes is kept to a minimum.

TABLE D1

ACCEPTABLE PRESCRIBED INDUSTRIAL WASTES

- Acidic sludges*
- Adhesives (cured)
- Alkaline sludges and residues*
- Antimony and antimony compounds
- Aqueous paint sludges and residues*
- Asbestos (all chemical forms)
- Barium and barium compounds
- Boiler blowdown sludge*
- Boron and boron compounds
- Cadmium and cadmium compounds
- Caustic sludges and residues*
- Chromium compounds
- Contaminated soils (greater than low level contaminant levels)
- Copper compounds
- Cyanide sludges and residues*
- Electroplating sludges and residues*
- Filter cake sludges and residues*
- Fish processing residues
- Fly ash
- Heat treatment salts
- Immobilized waste
- Inorganic cyanides and cyanide sludges and residues*
- Inorganic sulphur containing compounds
- Lead sludges and residues*
- Lime neutralized sludges*
- Lime sludges*
- Mercury sludges and residues*
- Metal finishing residues
- Nickel compounds
- Paint residues (solid only)*
- Polymeric lattices
- Poultry processing residues
- Resins (cured)
- Scallop processing residues
- Selenium and selenium compounds
- Tannery sludges and residues*
- Tars and tarry residues*
- Timber preserving residues*
- Treatment plant sludges and residues (excluding sewage and septic tank sludges and residues)*
- Vanadium and vanadium compounds
- Wool scouring residues*
- Zinc compounds*

Note: * To be acceptable for disposal at the landfill, these wastes mus pass an elutriation test (i.e. TCLP method 8080). (USEPA 1986.)

D2 PROPOSED LEACHATE COLLECTION SYSTEM

Appendix E (Proposed Operations Management Plan for the Southern Landfill) of the Public Environmental Review for the Southern Landfill outlines the proposed design criteria and operational management of all aspects of the Southern Landfill facility. Details pertaining to the leachate collection system are repeated here for completeness.

The leachate collection system will comprise 150 mm diameter slotted agricultural pipe laid in coarse sand, above the clay liner in each refuse cell. The liner will be graded to ensure that leachate will flow to the underlying collection drains.

The drainage system will comprise a 300 mm thick drainage blanket, directly overlying the basal clay liner, in which the drainage pipe will be installed (Figure D1).

Collected leachate will gravitate to a central double-lined sump located on the perimeter of the currently active landfill stage (Figure D1). The sump will be constructed at the same time as the clay liner, thereby ensuring that all runoff will accumulate in the sump. A HDPE liner will be installed in the sump and covered with gravel screenings. The leachate collection drains have been designed to ensure that the landfill remains free-draining even in the event of an unexpected increase in the quantity of leachate being generated.

From the sump, leachate will be pumped to a leachate treatment tank for storage, treatment and recirculation back into and onto the active landfill cell. Recycling of leachate is to be via a slotted pipe trickle irrigation system.

Following decommissioning of the landfill, collected leachate is to be transferred to tanker trucks for off-site disposal.

D3 POTENTIAL LEACHATE GENERATION

D3.1 The LANFILL Model

AGC Woodward-Clyde has developed a computer programme LANFILL, which simulates field conditions and provides an indicative prediction of the following landfill parameters:

- volume of leachate generated;
- volume of leachate requiring disposal; and
- typical leachate quality parameters (e.g. salinity).

The programme is necessarily indicative only, since landfills are complex reactors which are difficult to accurately define. The programme predictions have, however, been verified by monitoring at a number of landfill sites in Victoria and New South Wales.

D3.2 Modelling Assumptions

Leachate generated within a landfill is a function of the type and age of waste deposited, the prevailing physicochemical conditions, the microbiology and the water balance of the landfill.

The major factors which contribute to the water balance in a landfill are:

- water input, i.e. effective rainfall, surface and groundwater infiltration and liquid waste disposal;
- surface area;
- nature of wastes including its field capacity and initial moisture content;
- site geology; and
- leachate storage ponds.

Stages 1 and 2 of the Southern Landfill have been modelled using the following input data and assumptions:

- input data are average monthly rainfall and pan evaporation for Perth Airport (see Table D2);
- modelled simulation is for a total period of 30 years;

- landfill modelled in eight phases; the first five phases are equivalent to Cells 1-5 in the Stage 1 landfill, with each phase comprising an area of 2.34 ha and a thickness of 15.75 m. The last three phases encompass all of the Stage 2 landfill, each with a surface area of 2.56 ha and a thickness of 12.7 m. The landfill areas and volumes allow for a 1 m thick final cover layer;

- all phases have a duration of two years, i.e. Stage 1 would have an active life of 10 years and Stage 2 would have an active life of six years. All of the phases in the model are assumed to be rehabilitated immediately after completion of refuse disposal in the cell;

- refuse must reach field capacity prior to any leachate reaching the 300 mm thick underdrain at the refuse base, which immediately overlies the 1 m thick compacted clay layer. Once leachate gets to the underdrain, any leachate which reaches the top of the liner, at a rate which exceeds the volume able to seep into the liner, is collected in the primary leachate collection system;

- groundwater underflow has not been considered, but to prevent division by zero in the model programme, underflow has been assigned a negligible value of 0.0001 m^3/d;

- any groundwater which passes through the 1 m thick clay liner is assumed to be collected in the secondary leachate drain system located beneath the primary liner.

TABLE D2

AVERAGE RAINFALL AND EVAPORATION DATA

Month	Rainfall Perth Airport (mm)	Pan Evaporation Perth Airport (mm)
January	18	338
February	23	266
March	22	239
April	73	144
May	157	99
June	238	75
July	224	74
August	193	81
September	123	102
October	84	158
November	44	201
December	19	262
TOTAL	1 218	2 039

Source: Bureau of Meteorology

D3.3 Modelling Results and Discussion

Water input to the proposed landfill consists of rainfall infiltration into the cells both during operation and following rehabilitation. Although leachate generation will commence after the first year of landfill operation, rainfall infiltration (based on Table D2 data) will not cause the refuse to reach field capacity until approximately four years after the initial placement of refuse, assuming the worst case of each cell taking two years to fill. Upon reaching field capacity, leachate storage capacity within the landfill will be fully occupied and leachate release and collection will commence.

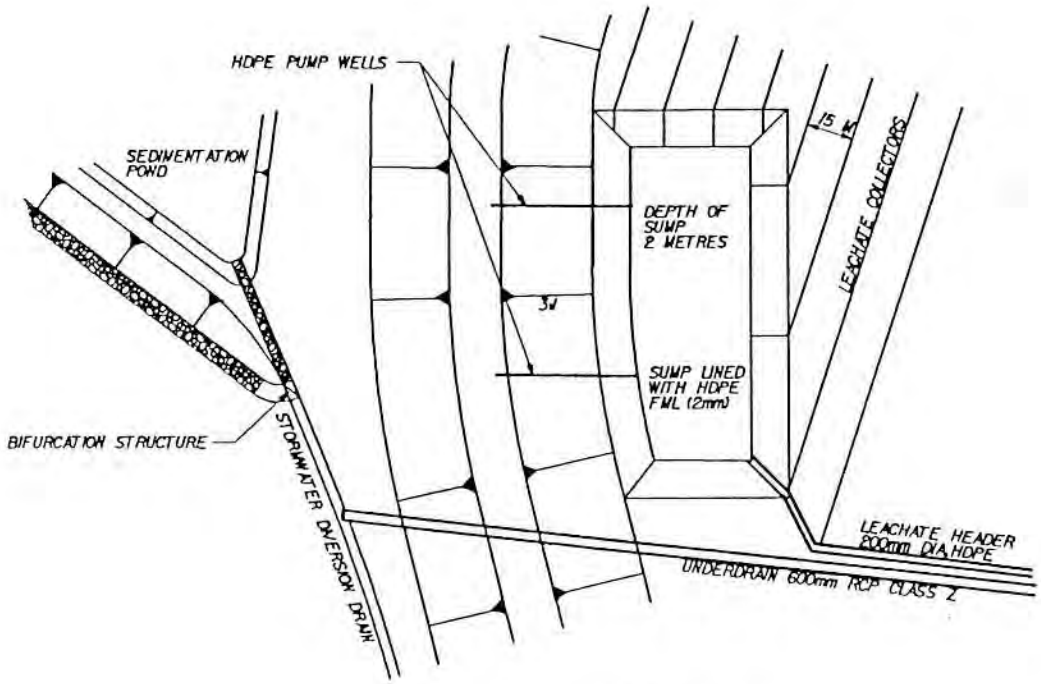
Peak leachate generation from Stages 1 and 2 of the landfill is expected to occur, some 18 years after initiation of the landfill, at a rate of some 85 m^3/d. Over the following year, leachate generation is expected to have declined to approximately 35 m^3/d in response to completion, capping and rehabilitation of the Stage 1 and Stage 2 landfills. Peak leachate release (i.e. discharge in excess of field capacity) is also expected to peak at approximately 35 m^3/d at the time when the two stages of the landfill are completed.

D4 REFERENCES

Department of Environment, 1986, *Landfilling Wastes*, United Kingdom Department of Environment Waste Management Paper No. 26, Her Majesty's Stationery Office, 1986.

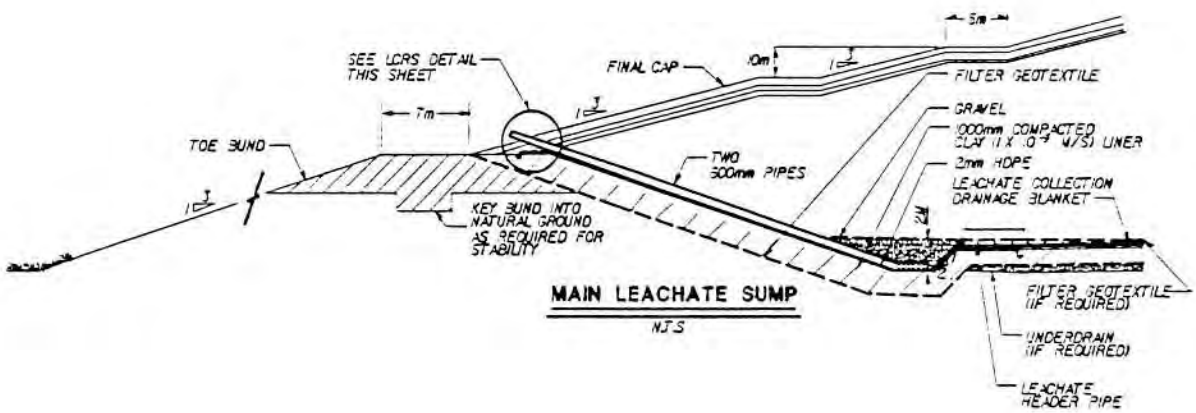
USEPA, 1986, *Test Methods for Extracting Solid Wastes, 3rd Ed.*, SW846.

FIGURE



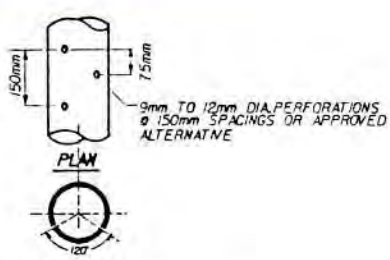
LEACHATE SUMP

N.T.S.



MAIN LEACHATE SUMP

N.T.S



LEACHATE COLLECTION PIPE PERFORATION DETAIL

N.T.S

REVISIONS	Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AGC Woodward-Clyde

CONCEPTUAL DESIGN OF LEACHATE COLLECTION SYSTEM

Date Feb. '93 | Dwg. 2535-31 | Fig. D1

APPENDIX E

PROPOSED OPERATIONS MANAGEMENT PLAN

FOR THE SOUTHERN LANDFILL

CONTENTS

TABLES

E1 INTRODUCTION

This document constitutes the Operations Management Plan for Pioneer-BFI Waste Services' proposed Southern Landfill at South Cardup, which is to be developed in accordance with the strategies outlined in the Public Environmental Review (PER) document entitled *Southern Landfill South Cardup.*

This document summarizes operational and management practices to be implemented following establishment of the landfill facility, and complements information and proposal commitments outlined in the PER.

This Plan will be progressively revised in response to operational experience, and will be formally updated in conjunction with preparation of the periodic performance reports. Pioneer-BFI Waste Services is responsible for maintaining the currency of this plan.

E2 OPERATIONAL AND MANAGEMENT PRACTICES

E2.1 The Facility

The proposed landfill is intended as a secure facility for the disposal of putrescible, non-putrescible, inert and low level commercial and industrial wastes, employing strictly controlled sanitary landfill practices. The landfill has not been designed for disposal of hazardous, liquid and soluble chemical wastes or other forms of intractable wastes and such wastes are to be specifically excluded.

The types of wastes acceptable for disposal at the Southern Landfill are:

- domestic refuse;
- putrescible wastes (other than domestic refuse);
- special (prescribed) wastes as listed in Table E1;
- low level contaminated soils; are
- other wastes not specifically excluded within Table E5, subject to written approval of the Environmental Protection Authority (EPA) and the Health Department.

It is anticipated that some 125 000 tonnes of waste per year will be supplied to the landfill for disposal, comprising:

- 5 000 tonnes of municipal waste from the Shire of Serpentine - Jarrahdale;
- 50 000 tonnes of commercial waste collected by BFI Waste Services;
- 20 000 tonnes of commercial waste collected by other waste collection companies; and
- 50 000 tonnes of industrial waste.

TABLE E1

ACCEPTABLE PRESCRIBED INDUSTRIAL WASTES

- Acidic sludges*
- Adhesives (cured)
- Alkaline sludges and residues*
- Antimony and antimony compounds
- Aqueous paint sludges and residues*
- Asbestos (all chemical forms)
- Barium and barium compounds
- Boiler blowdown sludge*
- Boron and boron compounds
- Cadmium and cadmium compounds
- Caustic sludges and residues*
- Chromium compounds
- Contaminated soils (greater than low level contaminant levels)
- Copper compounds
- Cyanide sludges and residues*
- Electroplating sludges and residues*
- Filter cake sludges and residues*
- Fish processing residues
- Fly ash
- Heat treatment salts
- Immobilized waste
- Inorganic cyanides and cyanide sludges and residues*
- Inorganic sulphur containing compounds
- Lead sludges and residues*
- Lime neutralized sludges*
- Lime sludges*
- Mercury sludges and residues*
- Metal finishing residues
- Nickel compounds
- Paint residues (solid only)*
- Polymeric lattices
- Poultry processing residues
- Resins (cured)
- Scallop processing residues
- Selenium and selenium compounds
- Tannery sludges and residues*
- Tars and tarry residues*
- Timber preserving residues*
- Treatment plant sludges and residues (excluding sewage and septic tank sludges and residues)*
- Vanadium and vanadium compounds
- Wool scouring residues*
- Zinc compounds*

Note: To be acceptable for disposal at the landfill, wastes marked with an '*' must consist only of components listed in Table E1 or Table E2 and be subjected to an elutriation test and not exceed the parameter maximum concentration listed in Table E3.

√ = either E2 value or E3 max value equals Class IV or above

TABLE E2

LOW LEVEL CONTAMINATED SOILS

Contaminant	Elutriable Fraction Maximum Concentration	
	(pH 5.0 extract) g/m³	(total) mg/kg dry weight
Arsenic	5.0 ✓	300
Cadmium	0.5 ✓	50
Chromium	5.0 ✓	2 500
Copper	10	1 000
Cobalt	-	500
Lead	5.0 ✓	3 000
Mercury	0.1 ✓	20
Molybdenum	-	400
Nickel	-	1 000
Tin	-	500
Selenium	1.0 ✓	100
Zinc	50	5 000
Cyanide	10	500
Fluoride	150	4 500
Phenols	-	10
Monocyclic Aromatic Hydrocarbons	-	70
Polycyclic Aromatic Hydrocarbons	-	200
Total Petroleum Hydrocarbons (C6 to C9)	-	1 000
Total Petroleum Hydrocarbons (>C9)	-	10 000
Organochlorine Compounds	-	10

Note: This table provides the contaminant limit criteria for low level contaminated soils by listing the contaminants and the elutriable fraction and maximum concentration allowed for each contaminant listed. These criteria are based on the elutriation test method EP (Extraction Procedure) TCLP (method 8080).

TABLE E3

ELUTRIATION TEST - ACCEPTANCE CRITERIA

Parameter		Maximum Concentration (g/m^3)
Aluminium		100
Barium		100
Boron		100
Cadmium		1
Chromium	(hex)	5
	(total)	100
Copper		100
Cobalt		100
Cyanide		5
Fluoride		150
Lead		10
Manganese		500
Mercury		0.1
Nickel		100
Nitrites		100
Selenium		5
Silver		1
Surfactants		100
Zinc		500

Note: The table specifies the elutriation test acceptance criteria for wastes subject to an elutriation test. The elutriation test method is the EP (Extraction Procedure) TCLP method 8080.

TABLE E4

CLOSED CUP FLASH POINT TEST

This table specifies those wastes which must be subject to a closed cup flash point test to determine if the waste has a flash point greater than or equal to 61°C and/or a low combustibility.

(1) Paints
(2 Adhesives
(3) Glues
(4) Resins
(5) Waxes
(6) Polymers
(7) Latexes
(8) Tars and bituminous wastes
(9) Solvent recovery residues
(10) Contaminated soils (exceeding Table E2 values)

TABLE E5

PROHIBITED WASTES

(1) Arsenic and arsenic compounds (except in low level contaminated soils up to the permissible elutriable fraction or maximum concentration).

(2) Beryllium and beryllium compounds.

(3) Biocides.

(4) Chloride sludges and residues.

(5) Chlorinated hydrocarbon wastes.

(6) Distillation residues.

(7) Explosive wastes.

(8) Grease trap and interceptor residues and sludges.

(9) Highly reactive wastes such as carbides, phosphorus sludges, alkali metals, oxidizing and reducing agents.

(10) Hydrocarbon based solvent residues and sludges.

(11) Isocynate compounds (excluding solid inert polymeric materials).

(12) Methylacrylate compounds (excluding solid inert polymeric materials).

(13) Oils and oil interceptor sludges.

(14) Pharmaceutical substances.

(15) Pesticides.

(16) Phenolic compounds (excluding solid inert polymeric materials and low level contaminated soils up to the maximum concentration prescribed by the Health Department of WA.

(17) Polybrominated biphenyl and related materials and equipment containing polybrominated biphenyls and related materials.

(18) Polychlorinated biphenyls and related materials and equipment containing polychlorinated biphenyls and related materials.

(19) Prescribed biomedical wastes.

(20) Radioactive wastes.

(21) Saline residues and sludges.

(22) Surfactants and detergents.

(23) Wastes containing greater than 200 grams per cubic metre of free cyanide.

(24) Wastes having a closed cup flash point less than 61 degrees Celsius*.

(25) Wastes which, when subject to an elutriation test approved by the Authority, produced an elutriant which exceeds the values prescribed by the Health Department of WA.

Note: * Wastes which will be subject to closed cup flash point testing are listed in Table E4.

The stages for development and operation of the landfill are as follows. Each stage is to comprise a number of individual waste disposal cells.

Stage 1 - Valley fill encompassing the existing Pioneer quarry stockpile area (portion of Lot 8) and farmland on Pt. Lot 3. The expected lifetime of this stage is 8-10 years.

Stage 2 - Infill of the existing Bristile shale pit on Pt. Lot 6. The expected lifetime is 5-6 years.

Stage 3 - Infill of the existing (and expanding) Pioneer Concrete hard rock quarry on Lot 8. This final stage has an expected lifetime in excess of 15 years.

To conserve landfill space and assist in the community goal of waste minimization, Pioneer-BFI Waste Services proposes to establish an on-site facility at the Southern Landfill for composting garden wastes and other suitable vegetation. Establishment of the composting facility will be subject to demand as dictated by the nature of the wastes which are supplied to the landfill for disposal. If it is feasible to establish a composting facility, Pioneer-BFI Waste Services will submit a detailed management plan to the EPA and Health Department of Western Australia for approval, prior to construction of the facility. Consequently, operation of the composting facility is not addressed in this current version of the Operations Management Plan for the Southern Landfill.

E2.2 Operational Objectives

With the development of the Southern Landfill, Pioneer-BFI Waste Services proposes to service primarily commercial and special industrial waste producers. The goal of the Pioneer-BFI Waste Services' waste management strategy is to establish an alternative to municipality-operated waste disposal facilities which is both financially realistic and environmentally responsible.

The operational objectives are to:

- design and construct a landfill facility which incorporates measures to prevent potential environmental impacts, and sufficient operational flexibility to enable effective response to any problems which may arise; and

- adopt and implement management practices that are to ensure effective control over all aspects of the landfill operation with the potential to produce adverse environmental impacts.

The landfill is to be operated and managed in strict accordance with accepted modern sanitary landfill practices, and in compliance with the Health Department of Western Australia's guidelines and Pioneer-BFI Waste Services' own environmental and landfill policies.

E2.3 Facility Development

E2.3.1 Site Preparation

- Excavation is to be completed in areas required for the initial stages of landfill development prior to cell construction in the respective stages. Preparatory to installation of the compacted clay seal, additional material will be removed to provide sufficient quantities of stable inert fill for later use as construction and cover materials for the landfill. As part of this process, the final surface of the excavated area is to be graded to allow gravity drainage across each of the landfill cells.

- Pit walls (Stages 2 and 3) constructed during the quarrying operations are to be modified if required during site preparation to provide a safer slope and to aid runoff control.

- Following vegetation clearance from each of the first and second waste disposal cells, the walls and floor of the first cell is to be shaped during which excess material suitable for the daily covering of refuse is to be stockpiled in a convenient location on the second cell.

- As part of site development, the following access road improvements are to be undertaken:

  - a 7 m wide sealed pavement is to be extended from Pioneer Concrete's access road to the gatehouse;

  - an upgrade of the intersection of South Western Highway and the site access road, including acceleration and deceleration lanes; and

  - sign posting along South Western Highway.

E2.3.2 Buffer Zones

- A vegetated buffer zone is to be maintained around the perimeter of the landfill site, being a minimum of 50 m in width.

- All buffer zones around the landfill are to be vegetated, with the exception of the firebreak/access track around the entire site, adjacent to the perimeter fence.

- The existing on-site vegetation is to be retained within the buffer zone wherever practical to provide site screening. Additional vegetation is to be established within the buffer for screening as required.

- A site landscaping plan is to be developed to achieve the following objectives:

  - initial planting is to be undertaken between the landfill and neighbouring properties in the planting season before or immediately following the start of site development earthworks, whichever is the earlier; and

  - integration of the landscaping with the longer term Post-Closure Plan.

- The landscaping plans are to be submitted to the Shire of Serpentine-Jarrahdale for approval within six months of the granting of all necessary approvals to commence landfilling operations.

- All initial plantings are to be maintained at all times, and any losses replaced immediately, to the satisfaction of the Shire of Serpentine-Jarrahdale.

E2.3.3 Site Security

- A 1.8 m high wire mesh fence is to be erected along the boundaries of the site adjacent to the landfill facilities.

- Lockable gates are to be installed at all points of access to the site, including the quarry access.

- Site operating personnel will be present during all operating hours, and the site will also be subject to after hours surveillance.

E2.3.4 Cell Construction and Sealing

- The landfill stages are to be developed progressively as a series of sealed cells within which refuse is to be deposited, compacted and covered. The first cell of Stage 1 is to be sized to accommodate two years' refuse, subsequent cells for all stages are to be sized to accommodate approximately one year's refuse, thereby allowing closure and capping before the deposited material reaches field capacity and generates leachate.

- The proposed lining system is to be a multilayer design comprised of:

  - a 1 m thick compacted clay liner with a permeability not exceeding 1 x 10^{-9} m/s and a gypsum content of less than 1%; and

  - a 300 mm sand or gravel drainage blanket to be placed above the liner to provide protection against cracking of the clay liner.

- The clay is to be compacted in thin layers (no more than 300 mm loose thickness) and density and moisture content are to be controlled by continuous compaction testing. A Quality Assurance/Quality Control assessment report is to be prepared by independent geotechnical consultants for each section of liner constructed.

- If adequate supplies of clay suitable for construction of the 1 m thick basal liner cannot be located, a composite clay/synthetic barrier membrane liner is to be utilized as the landfill basal seal.

- An alternative lining system is high density polyethylene (HDPE) membrane and clay as a composite. For example, 2 mm HDPE membrane could be used in conjunction with a 600 mm thick compacted clay foundation layer (permeability of 10^{-8} m/s) to provide additional containment and attenuation capacity. A 300 mm thick protective layer of coarse sand would be placed over the HDPE membrane to protect it from puncture. In the event that a suitable clay source is not readily available and a barrier membrane liner is to be used, a further report specifying the liner system to be installed would by submitted to the EPA and the Health Department of Western Australia (Health Department) for endorsement.

E2.3.5 Peripheral Embankment Construction

- A clay starter embankment of 2 m height is to be constructed around the perimeter of the liner to prevent leachate and stormwater leaving the active cell. The starter embankment is to be constructed in a similar manner to the clay liner.

- Any area of clay liner or embankment constructed substantially in advance of the landfill operation (2 to 6 months depending on seasonal conditions), from clays susceptible to cracking, are to be watered as necessary to control variation in moisture content.

- Landfill cells are to be progressively constructed over the 12 month period of their use, by regularly raising the perimeter embankments and interposing layers of refuse with clean fill material.

E2.3.6 Leachate Collection

- The leachate collection system is to consist of 150 mm diameter slotted agricultural pipe, sand and filter cloth. The leachate drainage collection system is to be installed in conjunction with construction of the clay liner, with the liner being graded to ensure that leachate will flow to the collection drains. The drainage system is to comprise a 300 mm thick drainage blanket, overlying the basal clay liner, in which the drainage pipe is to be installed.

- Collected leachate is to gravitate to a central double-lined sump located on the perimeter of the currently active landfill stage. The sump is to be constructed at the same time as the clay liner, thereby ensuring that all runoff will accumulate in the sump. A HDPE liner is to be installed in the sump and covered with gravel screenings.

- From the sump, leachate is to be pumped to a leachate treatment tank for storage and recirculation back into and onto the active landfill cell. Recycling of leachate is to be via a slotted pipe trickle irrigation system.

- Sediment is to be periodically removed from the leachate tank for secure disposal. While the Southern landfill is active, the sediment is to be disposed of in the active landfill cell.

- Following decommissioning of the landfill, collected leachate is to be transferred to tanker trucks for off-site disposal. Sediment removed from the leachate tanks is to be disposed off-site at an approved secure disposal facility.

E2.3.7 Stormwater Management System

- The stormwater management system is to consist of:

  – an external network of contour drains to be constructed up-gradient of the landfill development to divert drainage around the landfill; and

- an internal system of drains to capture stormwater runoff generated within the site, other than that which has come in contact with the active waste disposal area. The discharges are to be diverted to a sedimentation pond, where sediment loading of the water will be reduced prior to release to the natural downstream drainage system.

- All surface water runoff within an active cell is to be treated as leachate and to be drained to the leachate collection system.

E2.4 Facility Operation

E2.4.1 Acceptance, Placement and Compaction of Refuse

- An assessment procedure that determines the acceptability (or otherwise) of various classes and types of industrial waste at this facility is to be submitted to the Health Department and the EPA for approval. Only industrial waste that meets the acceptability requirements is to be disposed of at the landfill. Forming part of the screening program are to be elutriation and flash point testing and the installation of radiation detection equipment.

- Facilities for detailed screening of wastes are to be provided at the entrance to the site to ensure that the suitability of incoming wastes of industrial origin. Detailed logs of transactions are to be maintained, identifying source and ownership of waste.

- Particularly odorous refuse is only to be accepted at the landfill by prior arrangement and such material is to be covered immediately.

- Refuse is to be progressively placed and compacted into thin layers of approximately 0.3 m compacted depth, in lifts of 2 m in height. Compaction (using a dedicated refuse compacting machine) will ensure maximum refuse density (~ 800 kg/m^3), minimize potential subsidence of the rehabilitated site, and maximize storage volume available and strength of the completed cell against shear failure of the finished outer slopes.

- Cover material is to be placed daily over the compacted refuse to minimize refuse exposure and hence problems associated with wind-blown litter, odours and availability of food for scavenging animals. Cover material is to be sourced from on-site overburden stockpiles generated by quarrying operations and preparatory site earthworks.

- Intermediate cover is to be applied to the top of the active landfill, and to surfaces which are to be exposed to the environment for periods greater than six weeks, in layers of not less than 300 mm thickness.

E2.4.2 Cell Completion

- When each cell is completely filled, it is to be capped with an engineered barrier system as follows:

  - 300 mm minimum layer of low permeability clay over the intermediate cover;

  - 300 mm layer of sub-soil; and

  - 100 mm minimum layer of topsoil suitable for vegetation establishment.

- The final layer of refuse and the composite covering layers are to be designed and constructed to achieve a predetermined crossfall to enhance surface drainage and safeguard against erosion.

- Cells are to be progressively rehabilitated following closure, capping and covering. Shallow rooted native vegetation (species selection being based on advice from the Department of Conservation and Land Management (CALM) and the Shire of Serpentine-Jarrahdale) is to be established on the individual cells as soon as practicable after closure.

E2.4.3 Landfill Gas Control

- The rate of gas production is to be maximized by recirculating collected leachate through a slotted pipe trickle irrigation system.

- Prior to the commencement of tipping operations, a methane gas management plan which addresses monitoring, collection, disposal and potential beneficial uses of landfill gas is to be prepared to the satisfaction of the EPA and the Health Department.

- Initially, gas is to be disposed of by flaring. When monitoring results indicate that action to manage landfill gas emissions is warranted, the methane gas management plan is to be implemented to the satisfaction of the EPA, on advice from the Health Department.

E2.4.4 Wheel Cleaning Facilities

- A wheel cleaning drive-through is to be installed on site, comprising a concrete trough with 300 mm depth of water to dislodge any debris from vehicle tyres. The length of the trough is to be sufficient to accommodate the largest vehicle likely to use the landfill.

- Solid material collected in the trough is to be regularly removed and disposed of in the active landfill cell. Contaminated water in the drive-through trough is to be treated as leachate.

E2.4.5 Dust Control

- A water tanker is to be permanently stationed on site and employed for light watering of internal access roads and trafficked areas for dust control.

- The active tipping area is to be routinely dampened to lay dust.

- Overburden and cover material stockpiles are to be stabilized with temporary cover vegetation, mulching and other suitable techniques to suppress dust generation.

E2.4.6 Noise Control

- All vehicles and machines operating at the landfill site, which are under the control of BFI-Pioneer Waste Services, are to be fitted with effective exhaust system silencers.

- Daily hours of operation of the landfill are to be limited to between 0600 and 1800 hours Monday to Saturday and 1000 and 1600 hours on Sunday.

E2.4.7 Litter Control

- In the event that littering along access routes to the landfill site becomes a problem, prosecution of offenders under the provisions of the Litter Act is to be pursued.

- Any landfill-related litter occurring along the site access routes within a 2 km radius of the site is to be regularly removed.

- Portable litter control screens are to be placed in the vicinity of the active tipping face to intercept any material blown from the tipping face.

- Any litter blown from the tipping face and intercepted by the portable screens, the site security fence or perimeter vegetation is to be routinely collected and returned to the tipping face.

E2.4.8 Pest Control

- As part of normal operational practices, any large appliances, crates, etc., placed in the active tipping area are to be specifically crushed before covering with refuse and cover material, and that any tyres dumped, unless shredded or split, are to be spread out and carefully covered.

- Supplementary control measures directed towards specific pest species are to be implemented on an as-required basis in conjunction with and to the satisfaction of the EPA, Water Authority of Western Australia (Water Authority), CALM, the Shire of Serpentine-Jarrahdale or other relevant regulatory authorities.

E2.5 Contingency Planning

- A contingency plan for emergency situations is to be submitted, for approval from the Shire of Serpentine-Jarrahdale, after consultation with the Shire of Serpentine-Jarrahdale, the EPA, the Health Department, the Water Authority and CALM.

- From the outset of the landfill operation, site operational and management practices are to exclude utilisation of fire except for the controlled flaring of landfill gas.

- Adequate manpower and machinery resources (including a water tanker) to combat any fires which may occur within the landfill site are to be maintained on-site during operating hours.

- Any unforeseen contingency associated with the landfill, and which is producing a demonstrable and unacceptable off-site impact, is to be dealt with in consultation with the EPA, Health Department, the Shire of Serpentine-Jarrahdale, and to the satisfaction of the Minister for the Environment as appropriate.

E2.6 Environmental Monitoring

E2.6.1 Water Resources

- A series of dedicated groundwater monitoring bores, to specifications acceptable to the EPA and Water Authority, are to be installed. It is anticipated that monitor bores will be installed

at about 100 m intervals along sections of the site boundary down hydraulic gradient from areas used for landfilling.

- On commissioning of each monitor bore and prior to the commencement of tipping, groundwater is to be sampled and analysed for a range of potential contaminants to provided background information on groundwater quality. Parameters determined are to include pH, salinity (as TDS), redox potential, major ions, nutrients, total organic carbon, and heavy metals to the satisfaction of the EPA on advice from the Chemistry Centre and the Water Authority.

- A programme of regular sampling from the monitor bores is to be implemented. This programme will be determined by the site hydrogeological conditions, although, initially, sampling on a three monthly basis is envisaged. Water samples collected are to be analysed for a select range of parameters. These are to include pH, salinity (as TDS), zinc, total organic carbon, five day biochemical oxygen demand, ammonia-nitrogen, and total alkalinity to the satisfaction of the EPA on advice from the Chemistry Centre and the Water Authority.

- Privately owned bores on selected properties in the vicinity of the landfill, are also to be sampled initially on an annual basis. Samples are to be analysed for a range of parameters, including pH, salinity (as TDS), and ammonia-nitrogen, to the satisfaction of the EPA on advice from the Chemistry Centre and the Water Authority.

- Borewater samples are to be collected and analysed in accordance with recognized standard procedures, and to the satisfaction of the EPA and Water Authority.

- If monitoring indicates that groundwater quality is being effected to an unacceptable degree, as determined by the EPA, a strategy is to be prepared for clean-up of groundwater contamination, to the satisfaction of the EPA on advice from the Water Authority.

- The strategy for clean-up of groundwater contamination is to be implemented to the satisfaction of the EPA on advice from the Water Authority.

- Should groundwater analyses indicate contamination by landfill leachate, further sampling and analysis for a more extensive range of parameters is to be immediately undertaken, in consultation with, and to the satisfaction of, the EPA and Water Authority.

- Any complaint about a deterioration in groundwater quality reasonably attributable to the landfill operation is to be immediately investigated, in consultation with, and to the satisfaction of, the EPA and Water Authority.

- A programme is to be implemented to regularly sample water in the sedimentation pond, into which groundwater collected by the landfill underdrain, flows. Water samples collected are to be analysed for the same parameters as for samples taken from the groundwater monitoring wells, to the satisfaction of the EPA on advice from the Chemistry Centre and the Water Authority.

- As soon as leachate is detected in the leachate collection sump, and thereafter in conjunction with the groundwater monitoring programme, samples are to be collected and analysed for comparison with anticipated leachate chemistry. Continuing sampling and analysis is to be co-ordinated with the groundwater monitoring programme, and analytical results are to be included in the periodic performance reports.

E2.6.2 Other Environmental Aspects

- From the outset of the landfill operation, a complaints register is to be established and maintained in which details of any complaints about the landfill operation, from local residents within the Serpentine-Jarrahdale municipality, are to be recorded.

- The activity of Silver Gulls at the landfill site is to be monitored from the outset of landfilling operations, in consultation with, and to the satisfaction of, CALM.

- Following the installation of the landfill gas extraction system, landfill gas flow rates are to be monitored at six monthly intervals. Results are to be forwarded directly to the EPA and are also to be incorporated into the periodic performance reports.

E2.7 Performance Reporting

- Annual performance reports are to be prepared and submitted to the EPA, the Health Department and the Shire of Serpentine-Jarrahdale within three months following each anniversary of the commencement of the landfilling operation. These reports are to address:

  – the stage that has been reached in the various operational and management programmes being implemented;

- results from monitoring programmes implemented, including the complaints register, and the response to any complaints received;

- modifications to the various programmes that have been implemented in response to monitoring results; and

- any unforeseen or extraordinary events associated with the landfill that adversely affected off-site environmental quality (and the response to that event) occurring during the preceding 12 months.

- The final report submitted during a reporting period is to provide a detailed review of performance over the entire period and of any modifications to operational and management programmes intended.

- At the same time the periodic performance reports are submitted to the EPA, the Health Department and Shire of Serpentine-Jarrahdale, the reports are also to be made available to relevant community organisations within the Shire of Serpentine-Jarrahdale.

- Any unforeseen or extraordinary events associated with the landfill that adversely affect off-site environmental quality, and the response to any such event, are to be reported immediately to the EPA, the Health Department, and the Shire of Serpentine-Jarrahdale.

E2.8 Post-Closure Management

- Pioneer-BFI Waste Services is to be responsible for construction, operation, decommissioning and post-closure management of the site until such time as the waste has fully degraded (a minimum period of 15 years), to the satisfaction of the EPA.

- Within two years after the date of commencement of construction, a draft decommissioning and post-closure management plan is to be prepared and submitted, to the satisfaction of the EPA.

- At least two years prior to closure, the final decommissioning and post-closure management plan is to be prepared and submitted, to the satisfaction of the EPA.

- The final approved decommissioning and post-closure management plan is to be implemented to the satisfaction of the EPA.

- Post-closure maintenance is to include the following:
  - regular inspection of the rehabilitated surface to monitor the integrity of the landfill capping system;
  - continued collection, treatment and disposal of leachate and landfill gas;
  - continued monitoring of groundwater wells;
  - regular inspection of the stormwater drainage system to ensure unrestricted flow of water; and
  - regular cleaning of leachate collection underdrainage system to remove any obstructions.