CITY OF ROCKINGHAM

LANDFILL FACILITY

COCKBURN SOUND LOCATION 2170

MILLAR ROAD BALDIVIS

PUBLIC ENVIRONMENTAL

REVIEW

VOLUME 1 OF 2

oodward-Clyde

CITY OF ROCKINGHAM

2381/1

MAY 1991

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PUBLIC ENVIRONMENTAL

REVIEW

VOLUME 1 OF 2

AGC Woodward-Clyde

PUBLIC ENVIRONMENTAL REVIEW
FOR DEVELOPMENT OF A LANDFILL FACILITY AT COCKBURN SOUND LOCATION 2170 MILLAR ROAD BALDIVIS

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

The Public Environmental Review (PER) for the proposed landfill has been prepared by the City of Rockingham in accordance with Western Australian Government procedures. The report will be available for comment for 8 weeks, beginning on Saturday 1 June 1991 and finishing on Friday 26 July 1991.

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 the City of Rockingham 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; and
- 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: Friday 26 July 1991
SUBMISSIONS SHOULD BE ADDRESSED TO:

The Chairman
Environmental Protection Authority
1 Mount Street
PERTH WA 6000

Attention: Mr Ron Van Delft

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EXECUTIVE SUMMARY

1 Background

The City of Rockingham (the Proponent) currently operates a landfill facility at Ennis Avenue in East Rockingham. This facility has reached capacity.

The Proponent has been endeavouring to identify a suitable alternative landfill site since 1986, and this process has led to the selection of Cockburn Sound Location 2170, Millar Road Baldivis (Loc. 2170).

The Proposal to establish a landfill facility at Loc. 2170 is being formally assessed by the Environmental Protection Authority (EPA) at Public Environmental Review (PER) level. The PER is to also provide information to satisfy the Health Department's requirements for a proposal and management plan for the establishment and operation of a waste disposal facility.

2 Waste Management Strategy

The broad goals of the Proponent's waste disposal management strategy are:

- to achieve closure of the Ennis Avenue landfill as a priority; and
- to establish an alternative waste disposal facility which is both financially realistic for the municipality and is environmentally responsible.

The specific objectives of the Proponent's waste disposal 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.

Loc. 2170 has been identified by the Proponent as an alternative site for its landfill facility through a lengthy site selection process which has included liaison with the relevant State Government regulatory authorities. Based on this liaison, the Proponent believes that Loc. 2170 is regarded as a potentially acceptable site for a landfill.

In formulating the proposal for Loc. 2170, the Proponent has implemented a wide community consultation programme. This programme was designed to firstly obtain information on issues of interest and/or concern to the community, so these issues could be specifically addressed and secondly, to provide feedback to the community about the proposal.

A range of issues was raised during the consultation process (varying from absolute opposition to the proposal to particular operational and management questions) and, where practicable, these have been addressed through the specific site planning and development strategies, and operational and management programmes intended.

3 Alternative Waste Management Options

The Proponent has an urgent need to resolve its future waste disposal requirements. The existing Ennis Avenue landfill site requires urgent closure but this cannot occur until an alternative facility is in place.

Although initiatives such as recycling and resource recovery will form an increasingly prominent part of future waste management practices, realistically, landfilling will continue to be an important component of municipal waste disposal operations within the Perth Metropolitan Region. Clearly, however, improvements in the selection of landfill sites, and in the planning and management of landfill facilities will be necessary. The regionalization of municipal waste disposal operations is an important consideration in this context.

The Proponent has undertaken several studies which have led to the identification of Loc. 2170 as a suitable alternative to the existing Ennis Avenue landfill site. Loc. 2170 provides an opportunity to establish a secure landfill that will satisfy the Proponent's immediate and longer-term waste disposal requirements and which could also satisfy regional needs.

The Proponent therefore regards the establishment of a landfill at Loc. 2170 as a realistic and appropriate strategy for resolving its future waste management and disposal needs. The site would service the waste disposal requirements of the City of Rockingham in the immediate future, and would be a suitable regional facility as the landfill sites of other Local Government Authorities in the south-west sector of the metropolitan region reach capacity.

4 Existing Environment

Within the City of Rockingham municipal district, only the Tamala Limestone Formation provides conditions that are potentially suitable for the siting of landfill facilities. Loc. 2170 is situated on a ridge within the Tamala Limestone Formation, about 2 km east of Lake Cooloongup. It is immediately east of Western Mining Corporation Limited's (WMC) tailings disposal site.

The Tamala Limestone Formation is the most significant shallow aquifer in the region, although the leakage of liquor containing ammonium sulphate from the WMC site has produced a significant contaminant plume (extending to Lake Cooloongup) within the aquifer. Shallow groundwater beneath Loc. 2170 is of generally good quality (near neutral, fresh and with low levels of nutrients, heavy metals and organic carbon). However, down-hydraulic gradient from Loc. 2170 (i.e. north-west, west and south-west), shallow groundwater quality is more variable, with higher salinity and inorganic nitrogen levels as a result of the ammonium sulphate plume and fertilizer application from market gardening activities.

Approximately 30% of Loc. 2170 has been excavated for limestone and sand and the extractive operation will continue until all basic raw material resources have been removed. As a result, effectively the entire site will be disturbed. That portion of the site not already excavated retains a combination of tall closed mixed shrubland, tuart woodland and banksia woodland. The remnant vegetation would provide habitats for a range of fauna, including grey kangaroo and brush wallaby, and numerous bird and reptile species. Introduced species such as rabbits and foxes are also likely.

The area surrounding Loc. 2170 contains two areas subject to System 6 Red Book recommendations (Lake Cooloongup and Leda). Rural uses predominate, although industrial influences (e.g. tailings disposal, extractive industry, and the railway line) are apparent. No sites of archaeological, anthropological or historic significance occur within Loc. 2170.

5 Description of the Proposal

In developing the proposal for Loc. 2170, the over-riding objective has been to minimize the potential for adverse effects often associated with landfilling operations. While there are many specific measures that would need to be implemented in achieving this objective, essential principles that need to be satisfied are:

- minimizing the extent of the active tipping face;
- sealing of areas in which refuse is to be deposited and capping of those areas when filled to capacity;
- collection and disposal of leachates generated;
- frequent compaction and covering of deposited refuse; and
- rehabilitation of the site in accordance with a predetermined end use.

The proposed landfill includes provision of an on-site transfer station. This will avoid the need for direct public access to the tipping face, thereby enabling the extent of the active tipping face to be minimized. If public access to the active tipping face can be excluded, its extent can be limited to the area necessary for safe operation of the machinery to be used (approximately 100 m^2 at any given time during operation).

Areas receiving refuse will be sealed, the intention being to install a one metre thick compacted clay liner, and capped (using a composite barrier membrane) and covered on completion.

Other aspects of the proposed landfill operation which will facilitate realization of the abovementioned principles are:

- an underdrainage system will be constructed in each cell to collect leachate from the base of the landfill and gravity drain to sumps for pumping to membrane lined evaporation ponds (leachate will also be irrigated over the active landfill to increase evaporation);

- refuse will be pushed and compacted into thin layers (compacted depth of about 0.5 m) using a purpose specific machine following deposition, with compacted material being regularly covered by placement of 200 mm of clean material to provide an effective cover of at least 100 mm; and

- finished contours (following capping and final covering) and revegetation programmes will reflect the interim and ultimate end uses identified for the site (bushland park and light industry respectively).

Other important design, development and operational features of the proposed landfill include:

- Cellular formation - refuse will be deposited in a series of sealed landfill cells which will be capped and covered on completion.

- Buffer zones - will be maintained around the entire site. Within the buffer zones, a 3 m high soil bund will be progressively constructed to effectively screen the landfill operations from adjoining properties and roads. The natural vegetation will be retained within the buffer zone wherever practical, thereby providing additional screening of the site. Additional vegetation will be established within the buffer as required, and on the bund to provide further screening of the site.

- Placement and compaction of refuse - refuse will be progressively placed and compacted into thin layers (of approximately 500 mm compacted depth, and regularly covered (at 3-4 hourly intervals).

- Cell completion - as soon as practicable following closure, capping and covering of individual landfill cells, shallow rooted native vegetation will be established.

- Gas collection - landfill gas monitoring bores will be installed within each completed landfill cell, and gas flow rates will be monitored to determine the need and timing for further measures to manage gas emissions.

6 Environment Impacts

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

- Water Resources
  In view of the reduced vertical separation to the water table (as a result of limestone and sand excavation), and the comparatively high permeability of the in situ sands and limestone, there is a risk that landfill leachates could cause groundwater contamination if appropriate leachate management initiatives were not implemented.

- 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.

- 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.

- 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.

- Dust
  As a result of the prior extractive operation, virtually all of Loc. 2170 will have been disturbed in advance of landfilling. Although restabilization of disturbed areas will be required, the potential for dust generation will remain, as establishment of the landfill will necessitate further disturbance of previously excavated areas, both during the initial construction phase and ongoing operation of the facility.

- 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. Obviously, if allowed to proliferate, these species could move off-site, to the detriment of the surrounding human and biophysical environments. Although flies, mice, rats and feral animals could become a problem at the proposed landfill, the most probable pest species that will need to be addressed will be the Australian Silver Gull (*Larus nouvaehollandiae*).

- Landfill Gas
  Landfill gas consists predominantly of methane and carbon dioxide (major greenhouse gases), along with minor proportions of other gaseous hydrocarbons. Although landfills are not major contributors to the greenhouse effect in an overall sense, 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.

- Fire
  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.

- Social Impacts
  Virtually all potential impacts identified could detract from the amenity of the general area and, therefore, represent possible social impacts. A reduction in property values is another form of social impact that could arise from the proposal.

7 Environmental Management and Monitoring

Management and monitoring programmes addressing all identified potential impacts have been incorporated into the landfill proposal for Loc. 2170. In addition, these programmes also include the submission of periodic performance reports, contingency planning, and management of the site following closure of the landfill.

In developing the management and monitoring programmes, the Proponent has recognized the importance of ongoing community involvement with the project. Although adverse off-site environmental impacts as a result of the landfill would not be 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 the Proponent's response thereto) to be independently scrutinized. Through this mechanism, the community will be able to influence operational practices in areas of legitimate concern.

The Proponent also recognizes the importance of planning towards an identified enduse. Loc. 2170 is within an area to be designated for future light industrial development and the Proponent accepts that such is an appropriate ultimate enduse for the site. Although landfilling of Loc. 2170 will constrain future light industrial development (in terms of when and how such could occur), it will not preclude this form of reuse. The landfill proposal for Loc. 2170 has, in fact, been planned to minimize the degree of constraint imposed upon light industrial redevelopment of the site.

Necessarily, however, there will be a lengthy lag between completion of landfilling operations and the availability of the site for light industrial redevelopment. During this interim period, the site will be maintained as a bushland park. Vegetation planting programmes undertaken during site establishment and operation, and progressive rehabilitation of the completed landfill cells will be consistent with the interim bushland park theme.

Finally, and very importantly with a project of this nature, the Proponent specifically acknowledges that its environmental management and monitoring responsibilities extend beyond the operational life of the proposed landfill. As the Proponent will be the owner of the site, its best interests will obviously not be served by leaving the site in a derelict or otherwise environmentally unsound condition. Ensuring that the site is available for redevelopment within the shortest possible time frame will, however, be in the Proponent's (and the community's) best interests. This objective will only be achieved if the Proponent discharges its ongoing responsibilities effectively following cessation of the landfill operation.

8 Timing

The Proponent recognizes that the environmental impact assessment process is lengthy, and that environmental clearance for the proposed landfill, if granted, is unlikely to be finalized before the third quarter of this year. 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 October/November period of this year, with completion towards the end of the first quarter of 1992.

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
- management following closure.

If the proposed landfill receives environmental clearance, 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 landfill at Loc. 2170 can be addressed by design principles, and ongoing operational practices and specific management measures. The Proponent 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 as an undesirable impact upon the human environment.

While the Baldivis locality is, ostensibly, a rural setting, established land uses 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 have, therefore, been considered in this context. While the proposed landfill will probably be seen as likely to produce adverse social impacts, the potential for such impacts is not great and can be further reduced by the management programmes proposed. Additionally, the complaints register to be maintained by the Proponent, and the submission of periodic performance reports (another commitment provided by the Proponent) 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 the site will already have been comprehensively modified through the extractive industry operation. The potential for off-site biophysical impacts will also be low because of the management programmes intended.

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

The proposal incorporates effective programmes to address these impacts.

The Proponent is working with other Local Government Authorities in the south-western sector of the Perth Metropolitan Region towards establishment of a Regional Waste Disposal Council and strategy; it recognizes the desirability of alternative forms of waste management and disposal (as evidenced by its commitment to recycling) but must take cognisance of economic realities; and the proposal for Loc. 2170 incorporates comprehensive design, operational and management initiatives to safeguard environmental values.

Should the landfill proposal proceed, the Proponent will instigate thorough monitoring commitments. 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, the Proponent has consulted widely with the local communities and has endeavoured to respond to any 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, the Proponent believes such change has been demonstrated to be manageable and unlikely to produce any unacceptably adverse environmental impacts.

1 INTRODUCTION

The City of Rockingham is proposing to establish a sanitary landfill facility at Cockburn Sound Location 2170, Millar Road Baldivis (Loc. 2170). The proposal is being formally assessed by the Environmental Protection Authority (EPA) at Public Environmental Review (PER) level. The EPA has liaised with the Health Department in issuing guidelines for the PER. As a result, the PER is to also provide information to satisfy the Department's requirements for a proposal and management plan for the establishment and operation of a waste disposal facility.

Accordingly, this document constitutes both the PER and proposal and management plan for the proposed landfill at Loc. 2170. This Chapter of the document provides background information about the proposal.

1.1 Proponent

Details of the Proponent are as follows:

Name: City of Rockingham

Address: Council Avenue
ROCKINGHAM WA 6168

Postal Address: PO Box 42
ROCKINGHAM WA 6168

Telephone No.: (09) 528 0333

Facsimile No.: (09) 592 1705

1.2 Need for the Proposal

The City of Rockingham (the Proponent) currently operates a landfill facility at Ennis Avenue in East Rockingham. This facility has virtually reached capacity. Current refuse disposal operations involve the placement of waste in areas previously regarded as completed and having received a final soil cover. The Proponent recognizes this practice to be undesirable, as the landfill surface is being raised above the originally intended final contours, and because of the difficulties for site access and management being caused by the limited capacity and space available.

The Proponent has been endeavouring to identify a suitable alternative landfill site since 1986. Several studies were undertaken, culminating in the preparation of a management plan for the operation of a landfill within Lots 290 and 291 Kerosene Lane, Baldivis (Sinclair Knight and Partners, 1989). However, although reaching an advanced stage, this proposal eventually lapsed.

The proposal to establish a landfill facility at Loc. 2170 is, therefore, a response to the urgent need for closure of the Ennis Avenue landfill and development of a more appropriate facility. The Proponent currently has approval from the Health Department to continue operation of the Ennis Avenue site until 30 June 1991 and has provided the Department with a progress report on its proposals for waste disposal beyond this date.

1.3 Statutory Requirements and Approval Procedures

In Western Australia, specific approval from the Health Department is necessary before a site can be used for municipal waste disposal. This approval is in the form of gazettal of the site for waste disposal purposes pursuant to Section 119 of the Health Act, 1911 - 1984. Various other clearances are also necessary for establishment of a waste disposal facility. The principal requirements in this instance are environmental clearance under the Environmental Protection Act, 1986, and development approvals under the Metropolitan Region Town Planning Scheme Act, 1959.

The Health Department's Discussion Paper for A Metropolitan Waste Strategy requires that applications for the establishment of waste disposal facilities must be supported by a proposal and management plan prepared in accordance with guidelines included in the discussion paper (Health Department, 1988). This document then normally forms the basis upon which the Health Department and other State Government agencies consider the application submitted. However, in the case of the proposal for Loc. 2170, the EPA has already 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.

Having made this decision, the EPA would normally provide guidelines for the PER document. However, in this instance there has been close liaison between the Health Department and the EPA concerning project documentation. Joint guidelines have been provided to the Proponent and a single document that will satisfy the requirements of both the Health Department and the EPA is required. This document responds to those requirements.

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.

1.4 Purpose and Structure of the Public Environmental Review Document

As outlined in the preceding section, the guidelines for the PER have been produced jointly by the EPA and the Health Department, the objective being that the document should satisfy the requirements of both agencies. Accordingly, the PER will need to provide descriptive information on:

- the proposal;
- prevailing environmental conditions;
- anticipated environmental impacts; and
- proposals for managing anticipated impacts.

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

- Introduction
  - information about the Proponent, the need for the proposed landfill, and the statutory requirements applying to the project.

- Waste Management Strategy
  - a review of the Proponent's general waste disposal management strategy.

- Alternative Waste Management Options
  - a review of alternatives to the proposed landfill, including justification for the proposal.

- Existing Environment
  - descriptive information regarding prevailing environmental conditions.

- 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 of 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.

. PER Guidelines.

Several appendices, providing supplementary technical information relating to the proposal, are presented as a separate volume. These include an "operations manual" for the proposed landfill. The manual consolidates information relating to operational practices to be implemented at the landfill.

2 WASTE MANAGEMENT STRATEGY

2.1 General Philosophy

As indicated in Section 1.2, the Proponent's existing Ennis Avenue landfill requires urgent closure. The capacity of the site has effectively been exhausted, access for the public and site operators is restricted, and the opportunity for effective site management is constrained.

Obviously, however, closure of the Ennis Avenue site is dependent on the availability of an alternative disposal facility to satisfy the Proponent's needs.

In assessing the waste management options available to it (refer to Chapter 3), the Proponent acknowledges the benefits of alternative technologies such as sophisticated recycling, resource recovery and waste reprocessing schemes. However, practical and financial constraints limit the Proponent's capacity to pursue these options.

Another landfill is the only realistic option available to the Proponent as the basis for future waste disposal operations. Nevertheless, the City of Rockingham recognizes that stringent management will be required at future landfills to minimize potential environmental impacts.

Accordingly, the broad goals of the Proponent's waste disposal management strategy can be stated as:

- to achieve closure of the Ennis Avenue landfill as a priority; and
- to establish an alternative waste disposal facility which is both financially realistic for the municipality and is environmentally responsible.

A protracted process of investigations has led to the selection of Loc. 2170 as the proposed site for the Proponent's future waste disposal (landfill) facility.

2.2 Statutory Procedures

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.

2.3 Liaison

The Proponent is a member of the South-West Zone Refuse Disposal Committee which also comprises representatives from the following Local Government Authorities:

- City of Canning
- City of Cockburn
- City of Fremantle
- City of Melville
- Town of East Fremantle
- Town of Kwinana.

Through the South-West Zone Committee, all member Local Government Authorities are aware of the Proponent's intentions for Loc. 2170. In addition, the Proponent has liaised directly with the Town of Kwinana regarding the proposed landfill. Discussions between the two Local Government Authorities have addressed issues relating both to management and utilization of the site.

Local industry, and commercial bulk waste operators, are also aware of the landfill proposal for Loc. 2170. Commercial operators are presently excluded from the Proponent's Ennis Avenue landfill, because of its limited further capacity. Establishment of a landfill at Loc. 2170 will effectively increase the waste disposal options available to commercial operators and industry within the Rockingham Kwinana region.

2.4 Objectives

2.4.1 Compliance with State Government Notification

The Health Department's Discussion Paper for a Metropolitan Waste Strategy emphasises the importance of regionalization of municipal waste management facilities. The Proponent recognizes the benefits of regionalization and, during negotiations with the Health Department concerning establishment of a new landfill, has indicated its willingness to accommodate other Local Government Authorities.

The most recent correspondence from the Health Department to the Proponent (undated, but received by the City of Rockingham on 19 December 1990) in connection with the proposal for Loc. 2170 contains the following statement:

> *"I support the action of your City in taking steps to establish an alternative site to that at Ennis Road (sic). I am also pleased to acknowledge your written agreement to allow other local authorities and industry access to the alternative site, Millar Road, Baldivis, as it is the Department's view that this site should be established as a regional landfill in the context of the Metropolitan Waste Strategy.*

For this reason the Department has to have regard for the number of landfills in the South-West Zone. As you are aware it has recently approved a regional landfill in the Zone in the expectation that this will be able to cater for the Zone's waste disposal needs in the medium to long-term future. However considering the growth rates of the Rockingham district this Department believes a satisfactory case can be made out for another regional site being established in that area."

2.4.2 Other Objectives

Goals of the Proponent's waste management strategy are to secure closure of the Ennis Avenue site and 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 these influences are in fact to be minimized. 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 the Proponent's waste management strategy can be stated as:

- 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.

2.5 Community Involvement

Previous initiatives by the Proponent to secure an alternative landfill site, and the recent introduction of a 240 litre mobile bin service and a house to house recycling service, have ensured a high level of awareness on waste disposal and management issues within the overall community.

Further, a specific community involvement programme has been implemented as part of the process of preparing the required documentation for the proposed landfill at Loc. 2170. This programme has included:

- consultation with the Baldivis Action Committee during the formative stage of the proposal, to identify issues or concerns thereby enabling their consideration during preparation of the proposal;

- similar consultation with residents within the immediate environs of Loc. 2170;
- follow up interaction with the Baldivis Action Committee and local residents to demonstrate how the issues and concerns raised have been addressed;
- a public meeting to provide residents of the Leda locality within the Town of Kwinana 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;
- an open forum within the Rockingham municipality to provide an opportunity for residents to obtain information about the proposal for Loc. 2170; and
- a meeting with members of an action committee formed by Leda residents to explain the proposal to them.

Undoubtedly, residents in the vicinity of Loc. 2170 do not regard the proposed landfill as desirable, and they raised a number of concerns during the 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:

- site security (in terms of illegal dumping of hazardous/toxic substances);
- alternative forms of waste disposal;
- stability of the underlying geological formations;
- waste segregation within the landfill;
- buffer distances;
- impacts on flora and fauna within Loc. 2170;
- compliance with undertakings given by the Proponent;
- contingency planning;
- hours of operation;
- monitoring of private bores;
- inadequacy of historical consultation processes on waste disposal matters;
- compensation for adverse affectation attributable to the landfill;
- earthquakes; and

- spontaneous combustion.

During the public meeting with Leda residents, a number of the above-mentioned issues was also raised. However, opinion at the meeting focussed on absolute opposition to the proposed landfill rather than any of these (or other) issues in particular.

The Proponent was also criticized for not consulting the Kwinana community during the site selection process, and there was also criticism of the Town of Kwinana for not ensuring that the Leda community was apprised of the selection of Loc. 2170 as the site for the proposed landfill.

A perception that the proposed landfill was a *fait accompli* was also apparent at the meeting with Leda residents.

The specific issues raised during the community consultation process have been addressed (either specifically or generally) through the management and monitoring strategies proposed (refer to Chapter 7).

The outright opposition from Leda is, clearly, a legitimate stance for residents to adopt. However, beyond acknowledging the existence of this opposition, the only realistic response the Proponent can provide is to demonstrate how any specific issues that were raised during articulation of the opposition will be addressed. As already indicated, this is done in Chapter 7. The follow up meeting with the Leda residents' action group enabled information on the proposal to be provided to the local community, thereby enhancing residents' understanding of the project.

Investigations into alternative sites for the proposed landfill have extended over a number of years, therefore making effective community consultation difficult. However, with the benefit of hindsight, the Proponent does recognize that more effective community consultation during the site selection process could have been beneficial. Realistically, however, the opportunity for such consultation is no longer available. The Proponent does, nevertheless, recognize 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.

The perception that the proposal for Loc. 2170 is a *fait accompli* is clearly incorrect. The PER document is part of the decision-making-process applying to the proposal and a number of statutory clearances and approvals (as outlined in Sections 1.3 and 2.2) will be needed before the proposal could proceed.

In addition to the community consultation undertaken by the Proponent during preparation of the PER document, the City of Rockingham is also committed to providing the opportunity for continued public involvement following establishment of the proposed landfill.

Management commitments provided by the Proponent include the maintenance of a public complaints register. The register will provide a mechanism by which members of the community can record their views on perceived problems or operational and management deficiencies associated with the landfill. The Proponent is also committed to submitting periodic

reports including monitoring information and documenting operational and management experience at the landfill to the relevant regulatory authorities. Such reports will need to address any public complaints received, thereby ensuring that the complaints, and the Proponent's response to them, are subject to scrutiny by the regulatory authorities. Accordingly, the complaints register will effectively provide the community with an avenue for ongoing involvement with monitoring of the landfill which includes external review (i.e. by the regulatory authorities) of the Proponent's response to any complaints submitted. The Proponent is also committed to making copies of the periodic reports available to local community organizations, thereby enabling scrutiny of these documents by those most affected by the landfill operation.

2.6 Recycling

The Proponent introduced a fortnightly house to house recycling service within all residential areas of its municipal district on 5 November 1990. The Council has let a two year contract (with a two year extension option) which provides for the collection of the following materials:

- aluminium cans, aluminium foil trays, bottles, flagons, all glass containers, clean rags, and plastic cool drink and milk bottles (to be placed in a recycling bag provided by the contractor);
- newspapers and cardboard (bundled), used engine oil (in sealed screw top containers, to a maximum of 20 litres), and car batteries; and
- scrap metal and white goods.

Scrap metals and white goods are collected by prior arrangement with the contractor, while all other materials are collected on a fortnightly basis.

Other recycling facilities are also available throughout the community (e.g. commercial aluminium can collection points, bins for the deposition of glass bottles and containers, newspapers and used clothing for welfare organizations). Provision is also made for the separation of metals, white goods, waste oil and car bodies at the existing Ennis Avenue landfill site.

The Proponent is committed to maintaining and enhancing recycling initiatives within its municipal district. The proposed landfill facility will specifically accommodate current recycling initiatives and will provide sufficient space to accommodate the introduction of further initiatives.

Receptacles will be provided on-site for deposition of the full range of recyclable materials. The separation of nickel-cadmium and mercury batteries from the general waste stream is a particular initiative being considered by the Proponent in this context. In addition, a specific car body storage area will be established.

A separate area has also been allocated for composting activities and the Proponent is considering the possibility of introducing a composting programming as an adjunct to the landfill facility. Materials composted could include organic wastes produced from the municipal parks and gardens

operations (including chipped tree prunings) and other sources of non-contaminated organic wastes (e.g. bulk lawn clippings from commercial operators). Although decisions concerning the composting operation have not been finalized the Proponent recognizes that the actual composting pad would need to be sealed and drained, to enable the collection of leachate. Once these decisions have been finalized, detailed proposals for the composting operation will be submitted to the EPA and Health Department for consideration.

Inclusion of an on-site transfer station as intended will also facilitate recycling initiatives, for example through the recovery by supervisory staff of recyclable materials prior to deposition in the bulk bins.

3 ALTERNATIVE WASTE MANAGEMENT OPTIONS

3.1 Alternatives

In Western Australia, Local Government Authorities retain responsibility for the collection and disposal of domestic refuse within their respective municipal districts. In the Perth Metropolitan Region, Local Government Authorities have been formed into regional groupings (Councils and Zone Committees) for waste disposal purposes.

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 utilizing these technologies is generally regarded as beyond the resources of even the regional groupings of Local Government Authorities that have been formed in Perth.

At this time, there is no formal metropolitan waste management strategy for the Perth region, although the Health Department's 1988 Discussion Paper For A Metropolitan Waste Strategy does provide guidance in this regard. The discussion paper clearly shows that landfilling is regarded as a fundamental component of future waste management and disposal practices within the Perth Metropolitan Region.

It is evident that the disposal of municipal waste by landfilling has produced unacceptable environmental impacts in some instances. Such have occurred basically because waste disposal sites have been poorly located and because they have not been operated in accordance with strict sanitary landfill practices.

A properly located, designed, operated and managed landfill represents an environmentally sound form of waste management that is within the financial resources of Local Government.

Realistically, therefore, an alternative landfill is the only option available to the Proponent in terms of its future waste disposal operations. However, the City of Rockingham recognizes that any proposal to establish an alternative landfill will need to incorporate stringent operational and management practices, and it is committed to satisfying this requirement.

Within the City of Rockingham's municipal district, the availability of sites suitable for sanitary landfill development is restricted by the prevailing geological conditions. These are discussed in more detail in Chapter 4. Basically, however, the municipal district contains three principal soil-landform associations occurring in a west-east sequence. In order of increasing distance from the coast, these are the Safety Bay Sands, the Tamala Limestone Formation and the Guildford Formation. Due to shallow water tables in areas of Safety Bay Sand and Guildford Formation, and

susceptibility to inundation in areas of Guildford Formation, the siting of landfills in these areas is environmentally unacceptable. Neither of these constraints apply within the Tamala Limestone Formation which occupies a north-south corridor of land approximately 3 km in width with its western boundary between one and 8 km inland from the coast.

Planning studies undertaken for the Proponent (Maunsell and Partners, 1986, 1987, 1988) examined the suitability of four sites within the Rockingham municipal district and in the Tamala Limestone Formation, for development of sanitary landfill facilities. The sites examined were:

- Lot 655 Eighty Road, Baldivis;
- Lot 1 Baldivis Road, Baldivis;
- Lots 290 and 291 Kerosene Lane, Baldivis; and
- Loc. 2170 Millar Road, Baldivis.

The location of these sites is shown on Figure 1.

Lot 655 Eighty Road is a Crown reserve (Reserve 28597) gazetted as a rubbish disposal site and vested in the City of Rockingham. The site is undeveloped and retains mainly undisturbed native vegetation. This site was, however, deemed unsuitable for landfill development because of the necessary disturbance of native vegetation, its proximity to residential dwellings, the absence of existing excavation, and the possibility of groundwater contamination (Maunsell and Partners, 1986).

Lot 1 Baldivis Road is privately owned and has previously been quarried for sand. The site is currently used for rural residential purposes. Although the capacity of the site would be limited to only a few years at current waste generation rates, it would have potential for interim use pending development of a longer term facility. However, use of this site was considered to be economic only if it would not require lining (Maunsell and Partners, 1988). An unlined site in this area would be unlikely to be environmentally acceptable, even on an interim basis and this option was, therefore, not pursued.

Lots 290 and 291 Kerosene Lane are privately owned. Part of the site contains a largely disused limestone quarry. Mainly because landfilling could have commenced almost immediately due to the advanced state of excavation, the site comprising Lots 290 and 291 was initially preferred over Loc. 2170 although the latter was regarded as a more appropriate, long-term option (Maunsell and Partners, 1988). A proposal was submitted to the Health Department for development of the site as an unlined landfill (Sinclair Knight and Partners, 1989). However, because of concerns about impacts on groundwater quality and the proximity of the site to existing groundwater users, and as the site was not owned by the City of Rockingham, the proposal was not finalized.

Loc. 2170 has been owned by the Industrial Lands Development Authority (ILDA) since 1977, and is currently being quarried for limestone and sand by WA Limestone. The Proponent is negotiating purchase of the site from ILDA. The potential of Loc. 2170 for waste disposal was previously considered to be restricted by the limited extent of on-site excavation (Maunsell and Partners, 1988). However, the extent of excavation has increased since 1988 and assuming sale of the site to the Proponent and re-licensing of the quarrying operation under the City of Rockingham's

Extractive Industry By-laws, co-ordination of the quarrying and landfill activities will now be possible. Accordingly, the previously perceived constraint no longer applies. With this issue resolved, the advantages of Loc. 2170 over the Kerosene Lane site, including greater distance from residential dwellings and groundwater users, and greater capacity, make this site the preferred location for the Proponent's waste disposal activities.

The Proponent has been negotiating with the Health Department concerning the use of Loc. 2170 for refuse disposal for some time now. Recent correspondence from the Department confirms the appropriateness of pursuing Loc. 2170 as an alternative (i.e. to the existing Ennis Avenue site) location for the Proponent's waste disposal operations.

3.2 Regional Context

The Health Department's Discussion Paper For A Metropolitan Waste Strategy establishes that the responsibility for solid waste collection and disposal should remain with Local Government. The discussion paper also emphasises 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.

As already indicated, the Proponent has been endeavouring to secure a new landfill site for a number of years. In this regard, action towards gaining approval for Lots 290 and 291 Kerosene Lane (immediately south of Loc. 2170) as a landfill site reached an advanced stage. The Kerosene Lane site was identified in the Health Department's discussion paper as a potential regional site and, in March 1989, the Acting Director of Public Health wrote to the Proponent stating the following in relation to the landfill proposal for Lots 290 and 291 -

> "*Since approval in principle has already been given, gazettal procedures for this site are now in progress. To enable these procedures to be completed, I would be pleased to receive your advice that Council will allow other local authorities and industry access to the site in accordance with the Guidelines for Host/Guest Agreements (copy enclosed), or any subsequent agreement acceptable to the parties concerned and to this Department.*
>
> *Should this arrangement be acceptable to Council, I would request that the capital works requirements for the site be commenced as soon as possible so that the site can be ready to be made operational without delay.*"

The City of Rockingham responded in May 1989 indicating its acceptance that other Local Government Authorities would be able to use the site (subject to normal financial arrangements). Approvals for the Kerosene Lane site were not, however, finalized.

The Proponent recognizes the desirability of regionalizing waste disposal and is an active member of the South West Zone Refuse Disposal Committee. Participating Local Government Authorities agree on the formation of a formal Regional Waste Management Council. However, a number of issues will need to be finalized before the Regional Council can be established and accordingly, a regional waste disposal strategy will not be developed (i.e. by the Regional Council) for an appreciable time.

Of the Local Government Authorities comprising the South West Zone Committee, all but Fremantle and East Fremantle have operating landfill facilities. These Local Government Authorities use the City of Canning and City of Melville facilities respectively. The life expectancy of the landfills operated by the South West Zone members varies. For example, the Proponent's existing site at Ennis Avenue has minimal remaining capacity, while the recently established Henderson site in the City of Cockburn has substantial capacity (particularly taking future extensions into account). The life expectancy of the Town of Kwinana landfill site is currently estimated to be between 5 and 15 years.

The acceptability of the existing operations also varies and advice from the Health Department suggests that short-term rationalisation of landfill facilities in the south west sector of the Perth Metropolitan Region will be pursued. This rationalization will, obviously, form part of the process of developing a regional waste disposal strategy for the South West Zone.

Although such a strategy has yet to be developed, the recently established Henderson landfill will obviously be an important part of the strategy. In fact, the Health Department's discussion paper indicates that the Henderson site should function as a regional facility to service the majority of the Local Government Authorities comprising the South West Zone, with a second regional facility being established to service the most southerly Local Government Authorities within the Zone (i.e. the Town of Kwinana and City of Rockingham), in recognition of the high growth rates in these municipalities. As indicated in Section 2.4.1, recent correspondence from the Health Department further acknowledges the need for a second regional facility to service the south western sector of the region.

The question of where this second facility should be located is, obviously, pivotal to the regional strategy for the South West Zone. The Proponent realizes that the proposal for a landfill at Loc. 2170 could pre-empt the regional strategy. Nevertheless, the Proponent recognizes that the site provides the opportunity to establish a further strategically located, secure landfill that would satisfy its own immediate and long-term waste disposal needs and could also satisfy the long-term waste disposal needs of adjacent Local Government Authorities. The Proponent recognizes that, if established, a landfill at Loc. 2170 would need to be available to external users and as such, the site could represent an appropriate basis for the second regional facility to service the South West Zone Local Government Authorities.

3.3 Conclusion

The Proponent has an urgent need to resolve its future waste disposal requirements. The existing Ennis Avenue landfill site requires urgent closure but this cannot occur until an alternative facility is in place.

Although initiatives such as recycling and resource recovery will form an increasingly prominent part of future waste management practices, realistically, landfilling will continue to be an important component of municipal waste disposal operations within the Perth Metropolitan Region. Clearly, however, improvements in the selection of landfill sites, and in the planning and management of landfill facilities will be necessary. The regionalization of municipal waste disposal operations is an important consideration in this context.

The Proponent has undertaken several studies which have led to the identification of Loc. 2170 as a suitable alternative to the existing Ennis Avenue landfill site. Loc. 2170 provides an opportunity to establish a secure landfill that will satisfy the Proponent's immediate and longer-term waste disposal requirements and which could also satisfy regional needs.

The Proponent therefore regards the establishment of a landfill at Loc. 2170 as a realistic and appropriate strategy for resolving its future waste management and disposal needs. The site would service the waste disposal requirements of the City of Rockingham in the immediate future, and would be a suitable regional facility as the landfill sites of other Local Government Authorities in the south-west sector of the metropolitan region reach capacity.

4 EXISTING ENVIRONMENT

4.1 Geology and Soils

Six general geologic units occur within the Rockingham area. These are:

- *Safety Bay Sand*- comprises low coastal sand dunes, of recent eolian origin. Soils of this unit correspond to the Quindalup soil association of Bettenay et al. (1960). These are deep pale cream coloured calcareous sands.

- *Tamala Limestone Formation*- comprises high dunes of eolian calcarenite and associated orange/yellow ferruginised quartz sand. Soils of this unit correspond to the Karrakatta and Cottesloe soil associations of Bettenay et al. (1960). Soil profiles vary from a shallow veneer of sand overlying calcarenite (Cottesloe association) to deep yellow sands with calcarenite at depth or absent (Karrakatta association). Generally the presence of calcarenite decreases in a west-east direction as a result of a longer leaching history for the eastern dunes, and accessions of wind-blown sands.

- *Guildford Formation*- comprises alluvial clay and sand deposits within an essential flat landscape. Soils of this unit correspond to the Serpentine River and Guildford soil associations of Bettenay et al. (1960). The Serpentine River association occurs to the east of the Tamala Limestone Formation and contains poorly drained clay soils. Further eastwards the Guildford association contains predominantly duplex soils consisting of a shallow (0.1 to 0.5 m) sandy surface horizon overlying a mottled kaolinitic sandy clay subsoil.

- *Bassendean Sand* - comprises eolian dunes of highly leached grey quartz sands frequently with weak organic or iron organic hardpans. The corresponding soil association of Bettenay et al. (1960) has the same name.

- *Lagoonal Deposits* - comprise dark greyish brown silts and minor clays, shells, shell fragments, and recemented limestone. Soils of this unit correspond to the undifferential deposits of the Vasse soil association of Bettenay et al. (1960).

- *Alluvial River Deposits* - comprise mid to dark grey, soft, water saturated clay with variable organic content. This unit has no corresponding soil association according to Bettenay et al. (1960) but corresponds to the peaty swamps of the Herdsman soil association as mapped by Churchward and McArthur (1979).

The occurrence of these geologic units is shown on Figure 2. Loc. 2170 lies within the Tamala Limestone Formation which occurs as a north-south orientated ridge, 3 to 5 km in width. Safety Bay Sand occurs to the west of the Tamala Limestone Formation and extending to the coast. Lakes Cooloongup and Walyungup occur at the boundary between the Tamala Limestone and Safety Bay Sand formations.

The original land surface of Loc. 2170 comprised two north-south trending dunes of 25 to 35 m Australian Height Datum (AHD) elevation, separated by a swale of approximately 15 m AHD elevation. The western dune is predominantly limestone with a thin surface sand horizon. The eastern dune is predominantly sand, with limestone occurring at depths of greater than 20 m below surface level.

Both limestone and sand are being quarried within Loc. 2170, and quarrying operations are producing a finished floor level of about 4 m AHD.

4.2 Groundwater Systems

4.2.1 Hydrogeology

The near-surface geological sequence of Loc. 2170 and the Lake Cooloongup area comprises sediments of Cretaceous and Quaternary age. A generalized cross-section of the hydrogeology through the limestone aquifer and Lake Cooloongup is shown on Figure 3.

The Tamala (Coastal) Limestone is by far the most significant shallow aquifer in the region. The Osborne Formation brown clay directly underlies these limestone beds and forms a very low permeability base to the shallow groundwater system.

The limestone ridge on which Loc. 2170 is located outcrops as a north-south trending ridge approximately 3 to 5 km wide lying to the east of Lake Cooloongup. Lithological logs of monitor bores constructed by Western Mining Corporation Limited (WMC) adjacent to Loc. 2170 and by the Proponent within Loc. 2170, indicate that the base of the limestone aquifer is probably cavernous in nature. Solution channels at the aquifer base appear to affect groundwater flow within the aquifer, and may exert a considerable effect on localized preferred directions of groundwater flow. Additionally, the limestone aquifer is expected to be heterogeneous in nature meaning that significant changes in the hydraulic properties are likely over short distances.

Towards the margin of Lake Cooloongup, the Safety Bay Sand overlaps the limestone. These sands extend under the lake and thicken considerably further west. On the eastern margin of Lake Cooloongup, a thin wedge of "Cooloongup sand" occurs between the Tamala Limestone and Safety Bay Sand formations.

The only other geological unit of importance in the area are the marls developed over the base of Lake Cooloongup and comprising calcareous silts, clays and mudstone. Although their distribution is not well known, they are believed to vary from 1 m to 7 m in thickness and be of low permeability.

This marl will restrict groundwater - lakewater interaction with the exception of periods of high lake or groundwater levels when interaction of waters could occur at the margins of the lake where the shoreline is not overlain by lake marls.

The WMC tailings pond located within Cockburn Sound Location 2209 (Loc. 2209), immediately to the west of Loc. 2170, exerts a major influence on groundwater quality. In 1979 a leak of liquor (containing ammonium sulphate) was detected during a routine maintenance inspection. The resultant ammonium sulphate plume has been the subject of considerable investigation, showing that it has migrated a short distance east of the pond (to the western boundary of Loc. 2170), and to a considerable distance west of the pond (the plume is thought to underlie the eastern fringes of Lake Cooloongup). To minimize detrimental effects of the plume on Lake Cooloongup and fringing vegetation, WMC plans to dewater and rehabilitate the tailings pond and recover and treat contaminated groundwater (WMC, 1990).

4.2.2 Groundwater Levels

As part of its tailings pond monitoring programme, WMC has recorded water levels from four monitor bores located within the western portion of Loc. 2170 over the years 1980 to 1988. In addition, as part of the hydrogeological investigations for the present study, two monitor bores were installed along the eastern boundary of Loc. 2170 in November 1990 (bore reference numbers B3 and B4 - refer to Figure 4).

The maximum groundwater level recorded in the WMC bores (WMC reference numbers 2170 - 1, 2, 3 and 4) is approximately 2.5 m AHD and occurs during late winter/spring (WMC, 1988). It should be noted that WMC bores 2170 - 1, 3 and 4 no longer exist, having been displaced by quarrying activities and roadworks. The November 1990 groundwater levels recorded in monitor bores B3 and B4 were approximately 4.6 m AHD. Using the maximum variation in water level observed for the WMC bores, and applying this to bores B3 and B4, a maximum groundwater level of 5.0 m AHD is anticipated along the eastern margin of Loc. 2170.

Relatively high groundwater gradients occur towards the west at the end of winter and a near flat water table at the end of summer. Using an assumed aquifer transmissivity of 7 700 m^2/d, an effective porosity of 25%, and an average water table gradient of 1.4×10^{-4}, an aquifer throughflow of about 1 kL per day per metre width of aquifer is estimated.

The regional groundwater flow direction in the vicinity of Loc. 2170 is generally westward. However, of more importance in terms of specific proposals for Loc. 2170 is the localized direction of groundwater flow. This varies between north-west and south-west dependant upon preferential flow paths within the limestone aquifer and local recharge patterns.

The initial landfill staging to the year 2003/4 will be entirely within the western third of the site and within an area roughly defined by the WMC bores. Therefore, it is reasonable to anticipate a maximum ground water level of 2.5 m AHD across this portion of Loc. 2170.

4.2.3 Groundwater Quality

The existing quality of groundwater beneath the Loc. 2170 and adjoining areas was determined by chemical analysis of borewater samples from the following bores:

i) the two monitoring bores (B3, B4) installed within Loc. 2170 for the present study;
ii) WMC monitoring bore 2170 - 2 (B7); and
iii) four off-site production bores (B1, B2, B5, B6) on private properties in the vicinity of Loc. 2170.

Water exposed in a pit in the quarry floor (some 400 m east of the south-western corner of Loc. 2170, and about 70 m north of the property's southern boundary) was also sampled and analysed.

The location of the site monitoring bores, off-site production bores and quarry pit, are shown on Figure 4.

Sampling was undertaken during the first quarter of 1991. The chemical analyses included the determination of major water quality parameters, nutrients and heavy metals. The site monitoring bores B3, B4 and B7 were used to determine the quality of groundwater beneath Loc. 2170. These bores tap the top 10 or so metres of the unconfined aquifer which has a total thickness of about 25 m (refer to Appendix A for soil profile logs). Borewater samples from adjoining areas were taken from production bores located both up-gradient (B1 and B2), and down-gradient (B5 and B6), of the general direction of groundwater flow beneath the study site. Although construction details for the off-site production bores are not known, it is likely that the screened intervals of these bores extend up to several metres into the unconfined aquifer.

Details of the sampling and analytical methods employed are summarized in Appendix A. Water quality data obtained are presented in Table 1.

The surficial groundwater beneath Loc. 2170 is characterized by a pH between 6 and 7, and a salinity (as total dissolved solids TDS) of a few hundred mg/L. The major ion data show that the groundwater corresponds to the 'mixed' sodium chloride-calcium bicarbonate water type (Hem, 1986). This is consistent with the site's calcareous aquifer materials, and is a general feature of groundwaters derived from calcareous formations on the Swan Coastal Plain. Nutrient levels are within the sub-mg/L range, although for B4 borewater the nitrate-nitrogen level is a few mg/L. Total organic carbon levels amount to several mg/L. With the exception of iron and manganese, the levels of heavy metals are below the respective metal detection limits. The level of soluble iron (likely present as mainly ferrous-iron) within the mg/L range for B3 borewater is consistent with the moderately reducing redox potential (Eh) of 0.14 V measured at the time of sample collection. This Eh value is consistent with the ferrous-iron/ferric-iron redox couple for near-neutral groundwaters (Willett, 1983). The groundwater beneath Loc. 2170 have gross-alpha and gross-beta activities below the recommended guideline value of 0.1 Bq/L for drinking water (NHMRC/AWRC, 1987).

TABLE 1

WATER QUALITY DATA

Sampling Location:	Quarry Pit Water	B3 Borewater	B4 Borewater	B7 Borewater	B1 Borewater	B2 Borewater	B5 Borewater	B6 Borewater
Major Water Quality Parameters								
pH	7.0	6.0	6.7	7.8	6.6	6.4	6.8	7.0
Electrical Conductivity	390	320	440	860	1 700	440	850	1 100
Total Dissolved Solids	240	220	250	560	1 100	280	540	690
Sodium, as Na	39	39	40	56	220	30	65	85
Potassium, as K	3.2	2.4	2.9	3.0	6.0	2.0	2.0	5.5
Magnesium, as Mg	4.5	4.5	5.0	8.0	24	6.0	0.50	18
Cadmium, as Ca	27	7.0	30	90	85	50	95	120
Chloride, as Cl	62	41	57	81	400	50	90	140
Bicarbonate, as HCO_3	85	45	85	270	340	160	300	290
Sulphate, as SO_4	10	10	10	20	<10	20	30	100
Fluoride, as F	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.2	<0.1
Silica, as SiO_2	6	14	20	12	8	8	8	8
Nutrients								
Total Phosphorus, as P	<0.05	0.10	0.15	0.75	<0.05	<0.05	<0.05	<0.05
Nitrate Nitrogen, as N	0.20	0.10	3.6	3.8	0.45	2.7	4.3	12
Ammonia Nitrogen, as N	<0.05	<0.05	0.05	0.10	0.75	<0.05	<0.05	2.0
Total Organic Carbon, as C	5.5	3.5	3.4	7.7	16	1.7	0.5	0.7

Note: All values in mg/L, except for pH and electrical conductivity (micro-S/cm)

TABLE 1 (CONT'D)

WATER QUALITY DATA

Sampling Location:	Quarry Pit Water	B3 Borewater	B4 Borewater	B6 Borewater	B1 Borewater	B2 Borewater	B5 Borewater	B6 Borewater
Heavy Metals								
Iron, as Fe	150	2 300	700	<50	3 500	300	<50	<50
Manganese, as Mn	<50	200	500	<50	<50	<50	<50	300
Copper, as Cu	<50	<50	<50	<50	<50	<50	<50	<50
Zinc, as Zn	<50	<50	<50	<50	<50	<50	<50	<50
Cadmium, as Cd	<5	<5	<5	<5	<5	<5	<5	<5
Lead, as Pb	<10	<10	<10	<10	<10	<10	<10	<10
Nickel, as Ni	<50	<50	<50	<50	<50	<50	<50	<50
Chromium, as Cr	<50	<50	<50	<50	<50	<50	<50	<50
Cobalt, as Co	<50	<50	<50	<50	<50	<50	<50	<50
Mercury, as Hg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic, as As	<10	<10	<10	30	<10	<10	<10	<10
Selenium, as Se	<1	<1	<1	<1	<1	<1	<1	<1
Radiological Parameters								
Gross - Alpha Activity	<0.01	0.01	0.04	<0.01	<0.01	0.02	<0.01	<0.01
Gross - Beta Activity	0.15	0.07	0.09	0.35	0.13	0.24	0.05	2.0
Gross - Beta Activity Corrected for ^{40}K	0.06	<0.01	<0.01	0.17	0.07	0.18	<0.01	1.8

Notes: i) Values for all heavy metals in micrograms/L.
ii) All valves in Bg/L; and
iii) Corrected gross-beta activities based on the corresponding stable K valves (in mg/L) and a correction factor of 0.0296.

Groundwaters of the surficial aquifer in areas adjacent to Loc. 2170 are characterized by a pH between 6 and 7, and a salinity (as TDS) up to 1 000 or so mg/L. The groundwaters correspond to the mixed sodium chloride-calcium bicarbonate water type, and are generally characterized by low nutrient levels within the sub-mg/L range. For the B2, B5 and B6 borewaters, however, nitrate-nitrogen (NO_3-N) levels amount to several mg/L. In particular, the nitrate-nitrogen level for B6 borewater exceeds the recommended guideline value for drinking water (NHMRC/AWRC, 1987). This borewater also has an ammonia-nitrogen level within the mg/L range. The groundwaters from areas adjoining Loc. 2170 have gross-alpha and gross-beta activities below, or close to, the recommended drinking water guideline value. However, B6 borewater has a somewhat elevated gross-beta activity.

Summarizing, the surficial groundwater beneath Loc. 2170 is near-neutral and fresh with low levels of nutrients, heavy metals and organic carbon. In contrast, the quality of surficial groundwater down-gradient from Loc. 2170 is more variable, with higher salinity and inorganic nitrogen levels.

4.2.4 Groundwater Use

Private properties to the east, south and west of Loc. 2170 extract groundwater for stock supplies, market garden irrigation and domestic use. Figure 4 shows the location of private production bores. To the north of Loc. 2170 is undeveloped bushland, within which no groundwater extraction occurs. Adjacent to the western boundary of Loc. 2170 is the WMC tailings disposal site within which there are several monitor bores, although these are used only for water level measurement and collection of groundwater samples.

4.3 Climate

Long term average climatic data were obtained for rainfall (Rockingham Post Office), pan evaporation (Perth), wind speed and direction (Mandurah).

Average rainfall and evaporation data are shown in Table 2. The region has a winter rainfall regime with 90% of rainfall occurring in the months from April to October. Rainfall exceeds evaporation in the months from May to August.

Wind analysis data are summarized on Figure 5. Predominant wind direction in the morning (9 am) varies from south easterly to north easterly depending on the season. Afternoon wind direction (3 pm) is predominantly south westerly in all seasons.

4.4 Flora and Fauna

The biological resources of Loc. 2170 have been reviewed through field survey and literature search. The results of this investigation are presented in full in Appendix B. In summary, biological conditions throughout Loc. 2170 are as follows.

TABLE 2

LONG TERM AVERAGE RAINFALL (ROCKINGHAM) AND PAN EVAPORATION (PERTH)

Month	Rainfall (mm)	Pan Evaporation (mm)
Jan	9	338
Feb	12	266
Mar	17	239
Apr	43	144
May	122	99
Jun	180	75
Jul	173	74
Aug	125	81
Sept	72	102
Oct	46	158
Nov	20	201
Dec	10	262
Year	**832**	**2 039**

Approximately 30% of the site is currently occupied by quarrying operations. The remaining portion of the site supports either Tall Shrubland, Tuart (*Eucalyptus gomphocephala*) Woodland or Banksia Woodland.

The western portion of the site contains tall closed mixed shrubland, 3 to 5 m in height and dominated by *Acacia saligna, Banksia* spp. and *Macrozamia riedlei.* Isolated trees occur through this area, including tuarts, jarrah (*Eucalyptus marginata*), marri (*E.calophylla*), and sheoak (*Casuarina fraseriana*). Minor shrub species include *Jacksonia furcellata* and *Hakea prostrata.*

The central portion of the site contains tuart woodland, interspersed with mixed stands of tuart, jarrah and marri. Understorey species of 3 to 5 m in height include *Banksia grandis, B.attenuata, B.menziesii, A.saligna, C.fraseriana, J.furcellata* and *Dryandra sessilis*. A variety of ground cover species occur despite invasion by introduced grass species.

The eastern portion of the site contains mixed banksia open woodland, dominated by *B.attenuata, B.menziesii* and *B.grandis*, interspersed with occasional jarrah and marri trees.

The quality of vegetation beyond the immediate area of disturbance by quarrying is generally good. Vegetation degradation is limited to signs of minor stress in the tuart woodland immediately adjacent to the quarry, evidenced by death of branch tips and invasion of the understorey by introduced grasses.

In assessing the significance of the remnant vegetation within Loc. 2170 to native fauna, the diversity between and within the vegetative formations on the site and adjacent to it is important. In general, however, the tall tuart-jarrah-marri woodland would be important to fauna because it is part of a diminishing ecosystem within the Perth Metropolitan Region. Previous surveys have confirmed that the tuart-jarrah-marri forests of this area support a very diverse fauna, particularly passerine birds (Tingay and Tingay, 1977).

A list of fauna species likely to inhabit undisturbed areas of Loc. 2170 is contained in Appendix B.

4.5 Reserves and EPA Red Book Areas

Reserves and EPA System 6 Red Book areas within the general vicinity of Loc. 2170 are:

- Reserves A18452, A24411 and A22429 encompassed by Red Book Recommendation M103; and
- Reserves C31102 and C33581, encompassed by Red Book Recommendation M104.

(Department of Conservation & Environment, 1983.)

These areas are shown on Figure 6.

Reserves A18452, A24411 and A22429, encompassed by Red Book Recommendation M103, are part of the Lake Cooloongup open space. Reserves A18452, for Recreation and Picnic Ground and A24411, for National Park, are vested in the City of Rockingham. Reserve A22429, for recreation, is unvested. All of these Reserves are also reserved under the Metropolitan Region Scheme for Parks and Recreation. System 6 Recommendation M103 seeks establishment of a Regional Park encompassing Lakes Cooloongup and Walyungup and some adjoining lands, and identifies particular management priorities for the two Lakes. The conservation of flora and fauna is the priority identified for Lake Cooloongup.

Reserves C31102 and C33581, encompassed by Red Book Recommendation M104, occur immediately to the north of Millar Road. Reserve C31102, for Cemetery Site, and C33581, for Parks and Recreation, are both unvested. The area is regarded as having a high conservation value as it encompasses an interface between three soil landform and vegetation associations, and contains a wetland area. The System 6 recommendation seeks the establishment of ways and means of protecting the intrinsic value of the area involved.

4.6 Human Environment

4.6.1 Land Use

In keeping with zonings under both the City of Rockingham's Town Planning Scheme and the Metropolitan Region Scheme, rural land uses predominate in the Baldivis locality although, in the immediate vicinity of Loc. 2170, industrial related activities occur (e.g. extractive industry and tailings disposal). The Kwinana to Jarrahdale railway line immediately north of Millar Road also contributes to the industrial influence encroaching upon the general area.

Allotment sizes in the immediate vicinity vary, although, Loc. 2170 at approximately 100 ha, and Loc. 2209 at approximately 50 ha, are substantially larger than the prevailing lot size. Most nearby properties are used for low intensity rural pursuits or as rural retreats. Some have not been developed. South of Kerosene Lane, however, intensive horticultural activities predominate.

In the broader context, lands east of Baldivis Road are, typically, in broad scale agricultural use, while to the west of Mandurah Road, there is a large wedge of regional Parks and Recreation Reserve encompassing Lake Cooloongup. A portion of this Reserve also extends east of Mandurah Road onto the western flank of the limestone ridge on which Loc. 2170 is situated. North of Millar Road and the Kwinana to Jarrahdale railway is the Leda locality. Land use planning for this area has not been finalized, but it will eventually be allocated to a combination of residential development and open space.

As a reflection of the present land use pattern, population densities in the vicinity of Loc. 2170 are low.

4.6.2 Significant Sites

Aboriginal Sites

Surveys of Loc. 2170 for sites of Aboriginal significance were undertaken in January 1991. Ethnographic and archaeological surveys were undertaken by Messrs Rory O'Connor and Gary Quartermaine respectively. Reports on these surveys are provided in Appendix C.

No sites of ethnographic significance to Aboriginal people have been previously recorded within Loc. 2170, or were identified during the course of the January 1991 survey. Similarly, there are no previously recorded archaeological sites within Loc. 2170, and field surveys did not locate any archaeological material.

Post European Settlement

Loc. 2170 does not contain any sites of historical significance, and is not associated with the Rockingham to Jarrahdale Heritage Trail which traverses the southern sector of the Leda locality.

5 DESCRIPTION OF THE PROPOSAL

5.1 Proposed Site

5.1.1 Ownership

The Proponent is currently negotiating the purchase of Loc. 2170 from ILDA. Under the purchase agreement being negotiated, the City of Rockingham will gain progressive access to the site for landfilling in accordance with an agreed staging plan (refer to Figure 7). The Proponent will have full access to the site from about 2004 onwards.

ILDA will retain control over the basic raw material resources within Loc. 2170, and the arrangement regarding progressive access is to ensure that these materials will be removed prior to landfilling, thereby avoiding their sterilization.

5.1.2 Location

Loc. 2170 has a frontage of about 1.5 km on the southern side of Millar Road in Baldivis, and is situated some 1.7 km east of Mandurah Road and 1.2 km west of Baldivis Road. The site is located approximately 8 km east of the Rockingham town centre and 3.5 km south of the Kwinana town centre.

Figure 8 shows the location of the site, and its position in relation to individual residences and residential areas.

The closest individual residence is approximately 250 m east of the south eastern extremity of Loc. 2170. Other nearby residences (fronting onto Baldivis Road to the south east of the site, and Kerosene Lane south of the site) are upwards of 400 m from the nearest boundary of Loc. 2170.

The nearest existing residential development area is within the Leda locality north of the Kwinana to Jarrahdale railway line, approximately one km north east of Loc. 2170. Further residential development will occur within the Leda locality and although detailed planning of the locality has not yet been completed, the minimum separation between Loc. 2170 and this development will approximate 500 m.

5.1.3 Zoning

Loc. 2170 is currently zoned Rural under the City of Rockingham's Town Planning Scheme No. 1 and the Metropolitan Region Scheme. However, land use zonings in this general area, both at the local and regional scales, are under review.

Structure plans for the Baldivis locality to the south of Loc. 2170, and for the Leda locality north of the Kwinana to Jarrahdale railway, are presently being prepared. Significant features of current proposals for the Baldivis locality in this regard include:

- designation of Loc. 2170 and land to the south and west for light industry;
- retention of the tailings disposal site immediately west of Loc. 2170;
- designation of the land immediately east of Loc. 2170 (through to Baldivis Road) as a regional cemetery;
- establishment of a future urban cell south of Kerosene Lane.

Various development strategies have been put forward for the Leda locality to the north of Millar Road and the adjacent railway line. Finalization of a development strategy for Leda will involve decisions about System 6 Red Book Recommendation M104 for the area immediately north of the railway line and the desirable juxtaposition of residential areas and the south-eastern extremity of the east Rockingham industrial area. Although this strategy has not yet been finalized a significant open space buffer will be retained immediately north of the railway line to satisfy the intent of the System 6 recommendation.

Figure 9 shows the indicative land use proposals for the Baldivis and Leda localities.

5.1.4 Current Site Use

Loc. 2170 is currently being excavated for limestone and sand by WA Limestone under contract to ILDA. Quarrying operations presently occupy approximately 30% of the site and will eventually extend our the entire site apart from perimeter buffer zones. WA Limestone anticipates that extraction of the in situ basic raw materials will have been completed by 2003/4.

5.2 Planning

5.2.1 General

At present, some 30% of Loc. 2170 is affected by quarrying operations. This equates to an area of about 26 ha. It is expected that quarrying operations will have been completed in about 12 years, with virtually all of the site, with the exception of the peripheral buffer zone, having been excavated. On this basis, an area of approximately 85 ha could potentially be available for waste disposal.

Based on current and projected refuse generation rates, Loc. 2170 would provide sufficient capacity to satisfy the Proponent's waste disposal operations for some 30 years. In estimating waste volumes, the total population of both the City of Rockingham and Town of Kwinana have been used, reflecting the possible regional context of the proposed landfill. It is

unlikely, however, that the facility would be used for refuse disposal from the Town of Kwinana in the initial years of operation. Additionally, the estimates only include municipal and inert industrial wastes as are currently being received at the Proponent's existing Ennis Avenue landfill.

At this juncture, the proposal for Loc. 2170 shows only strategies for the development of the site for landfilling for an initial period of approximately 12 years. It is not feasible to state categorically what will happen beyond this time frame. Changes in community attitudes, Government requirements and the status of the site could, for example, influence the rate and/or nature of its continued use for waste disposal.

Nevertheless, if it is assumed that landfilling operations were to continue beyond the 2003/4 time frame, and that the basic approach involving sealed landfill cells would also continue, a possible general sequence of the continued operation is shown on Figure 10. Clearly, however, detailed planning for continuation of the landfilling operation beyond the 2003/4 horizon of the current proposal would need to occur, with such planning reflecting experience gained from the initial site operations.

5.2.2 Waste Streams and Waste Generation

A waste stream survey was conducted at the Proponent's existing Ennis Avenue landfill site over a two week period in October 1990. During the survey, the type of vehicle and its major contents (dominant waste category) were recorded by the supervising staff at the landfill.

Vehicles were classified into the following categories:

- compacter trucks
- open trucks
- two wheel trailers
- four wheel trailers
- cars
- station wagons
- vans
- utilities.

Waste was classified either as garden materials or other waste comprising domestic garbage and non-hazardous industrial wastes. Insufficient data were collected to categorize waste types further.

The average weight of contents of each vehicle type was taken from a study undertaken by the Victorian Environment Protection Authority in 1984-1985 (EPAV 1985 a and b). This study involved recording the weights of waste materials carried by vehicles in the above categories entering nine major landfills within the Greater Melbourne Area. The average weight of contents for each vehicle category is shown in Table 3.

TABLE 3

WASTE STREAM SURVEY

Average Weights Of Vehicle Contents

Waste Carrier Description	Average Weight of Waste Carried (Tonnes)
Compacter Truck	8.35
Open Truck/Bulk Bin	1.77
Two Wheel Trailer	0.28
Four Wheel Trailer	0.74
Car Boot	0.11
Station Wagon	0.23
Van	0.27
Utility	0.14
Tray	0.99

Reference EPAV 1985 a and b

The number of each category of vehicle entering the Ennis Avenue landfill site during the two week survey period is shown in Table 4. Estimated waste volumes were calculated from the average weight of vehicles contents and vehicle numbers. Data for the two week survey period, and an annual projection based on these data, are shown in Table 5.

The total annual volume of waste produced (52 400 tonnes) corresponds to a per capita waste generation rate of 3.5 kg day for the City of Rockingham (population 41 000).

It is recognized that this waste generation rate is higher than the rates used in previous waste disposal studies undertaken within the Rockingham municipal district. For example, Maunsell and Partners, 1986, used a daily per capita rate of 3.0 kg, while Sinclair Knight and Partners, 1989, used a rate of 1.6 - 1.8 kg. It is noted, however, that the rate used in the 1989 study did not include inert waste materials and was apparently based on data drawn from the inner metropolitan Local Government Authorities of Bayswater, Bassendean and Belmont.

TABLE 4

NUMBERS OF DIFFERENT VEHICLE TYPES
ENTERING THE ENNIS AVENUE LANDFILL SITE OVER
A TWO WEEK PERIOD

	Vehicle Type							
	Compacter Truck	**Open Truck**	**2 Wheel Trailer**	**4 Wheel Trailer**	**Car**	**Station Wagon**	**Van**	**Utility**
Number	99	359	935	117	236	133	125	310

TABLE 5

CURRENT WASTE STREAM SURVEY - WASTE PRODUCTION

Time Period	Waste Quantity (Tonnes)		
	Garden Materials	Other Waste	Total
2 Week Survey	520	1 490	2 010
Annual	13 550	38 850	52 400

The figure is, nevertheless, consistent with investigations undertaken for the City of Gosnells' Kelvin Road landfill. These investigations established daily per capita generation rates of 2.1 kg for municipal waste and 1.9 kg for commercial waste respectively, giving a total of 4.0 kg per capita per day (Halpern Glick Maunsell, 1990). Of the commercial waste component, 0.5 kg is attributed to commercially operated compacter trucks, which are currently excluded from the Proponent's Ennis Avenue site. This reduces the total daily per capita waste generation rate from 4.0 kg to 3.5 kg.

In terms of the lower daily per capita generation rates (i.e. 1.6 - 1.8 kg), it is relevant to note that projections of future waste volumes included in the Municipal Waste Management Plan prepared for the Shire of Mundaring (AGC, 1990) were based on a daily per capita generation rate of 1.5 kg. This figure reflected available data, including material from other studies within the Perth Metropolitan Region. However, the Shire's subsequent experience, based on the rate of consumption of landfill airspace, has indicated that the 1.5 kg per capita per day generation rate is appreciably low.

Future waste production has been estimated by multiplying the current per capita generation and rate expected population growth rates. The per capita waste generation rate is assumed to stay constant. In estimating future waste production, conservative population growth rates have been adopted. According to State Planning Commission data, the population of the City of Rockingham is expected to grow at an average rate of 4.3% to the year 2001 (State Planning Commission, 1988). An annual population growth rate of 2% between 2001 and 2011 has been assumed based on recent verbal advice from the City of Rockingham's Planning Department. By comparison, the 1989

study by Sinclair Knight and Partners used an average annual population growth rate of 5.16% to 2010 and 3% thereafter, while June 1990 statistical information produced by the City of Rockingham's Planning Department project annual population growth rates of 7% or marginally greater from 1990 to the target year (2010).

Waste generation rates for the town of Kwinana are estimated assuming the same per capita rate as for the City of Rockingham, and a population growth rate of 0.2% (State Planning Commission, 1988).

It is evident that neither the population growth rate nor the per capita refuse generation rate can be absolutely quantified. Nevertheless, it is considered that, based on the available information, the projected level of waste production presented in Table 6 provides a reasonable indication of likely future waste volumes. However, should experience indicate that the rate of waste production does vary markedly from the projected volumes, the method of operation intended (detailed in the following chapter) is sufficiently flexible to accommodate such variation.

5.3 Proposed Method of Operation

5.3.1 Development Concept and Design Philosophy

The proposed landfill is intended as a secure facility for the disposal of municipal and inert industrial waste utilizing strictly controlled sanitary landfill practices. The landfill has not been designed to receive hazardous or other forms of intractable wastes and, therefore, the exclusion of such wastes constitutes an over-riding operational objective to which the Proponent is committed.

In developing the proposal for Loc. 2170, the over-riding objective has been to minimize the potential for adverse effects often associated with landfilling operations. While there are many specific measures that would need to be implemented in achieving this objective, essential principles that need to be satisfied are:

- minimizing the extent of the active tipping face;
- sealing of areas in which refuse is to be deposited and capping of those areas when filled to capacity;
- collection and disposal of leachates generated;
- frequent compaction and covering of deposited refuse; and
- rehabilitation of the site in accordance with a predetermined end use.

The landfill operation proposed for Loc. 2170 has been planned and designed to comply with each of these principles. It will include an on-site transfer station and a series of sealed landfill cells within which refuse will be placed using the thin layer landfilling technique.

TABLE 6

ESTIMATED FUTURE WASTE PRODUCTION

Year	Estimated Waste Generation					
	Rockingham		Kwinana		Total	
	Tonnes	In situ m^3	Tonnes	In situ m^3	Tonnes	In situ m^3
1991	52 400	74 000	19 700	27 800	72 100	101 800
1992	54 700	77 100	19 700	27 900	74 400	105 000
1993	57 000	80 500	19 800	27 900	76 800	108 400
1994	59 500	83 900	19 800	28 00	79 300	111 900
1995	62 000	87 500	19 900	28 000	81 900	115 600
1996	64 700	91 300	19 900	28 100	84 600	119 400
1997	67 700	95 200	19 900	28 100	87 400	123 400
1998	70 400	99 300	20 000	28 200	90 300	127 500
1999	73 400	103 600	20 000	28 300	93 400	131 900
2000	76 500	108 100	20 100	28 300	96 600	136 400
2001	79 800	112 700	20 100	28 400	99 900	141 100
2002	81 400	115 000	20 100	28 400	101 600	143 400
2003	84 100	117 300	20 200	28 500	103 200	145 700
2004	84 700	119 600	20 200	28 500	104 900	148 100
2005	86 400	122 000	20 300	28 600	106 700	150 600
2006	88 100	124 400	20 300	28 700	108 400	153 100
2007	89 900	126 900	20 300	28 700	110 240	155 600
2008	91 700	129 500	20 400	28 800	112 100	158 200
2009	93 500	132 000	20 400	28 800	114 000	160 900
2010	95 400	134 700	20 500	28 900	115 900	163 600
2011	97 300	137 400	20 500	28 900	117 800	166 300

Note: In situ cubic metres assumes compaction of refuse to 850 kg/m^3 and 20% cover material addition.

The proposed on-site transfer station will obviate the need for direct public access to the tipping face, thereby enabling the extent of the active tipping face to be minimized. If public access to the active tipping face can be excluded, its extent can be limited to the area necessary for safe operation of

the machinery to be used (approximately 100 m^2 at any given time during operation).

The intention is that the on-site transfer station will be established during initial development of the proposed landfill. However, because of logistical and financial considerations, there is some possibility that full development of the proposed landfill operation may need to be staged over a period of up to five years. Staged development of the site over such a period would facilitate the resolution of logistical factors (e.g. relating to establishment of the formal Regional Refuse Disposal Council), and financial considerations (e.g. relating to management of budgeting and funding commitments) associated with the project.

If establishment of the transfer station was deferred as part of a staged development programme, the only practical difference this would make to operational practices is that the active tipping face would need to be extended to provide access for the public. Doubling the active tipping face (to approximately 200 m^2 at any given time) would be sufficient in this regard. If construction of the transfer station is to be deferred, a specific operations and management plan for the active tipping face will be prepared and submitted to the EPA and Health Department for endorsement prior to the commencement of landfilling operations.

The onsite transfer station (including the possibility of staging) is further discussed in Section 5.3.2 (Design Features - *On-site Transfer Station*).

The intention is that the basal seal of landfill cells will be a compacted clay liner of one metre (compacted) thickness. Geotechnical and geochemical testing of clay sourced from the Baldivis locality is underway and it is anticipated that material of suitable specifications will be located. The investigations undertaken indicate that clay to the following specifications would be suitable for the basal sealing of landfill cells:

- Permeability - in situ permeability of 1 x 10^{-7} cm/sec or less when clay is placed and compacted.

- Workability - material must be able to be placed, moisture conditioned and compacted into a stable, competent layer with standard earthworks machinery to achieve the required permeability.

- Mineralogy - the semi-quantitative mineralogy of both the 'whole-material' and 'clay-fraction' must be determined, with the content of gypsum being < 1%.

Depending on the outcome of its own investigations into suitable clay sources, the Proponent recognizes that it may need to seek appropriate clay supplies through the open market system. If this is necessary, the Proponent will call tenders for the supply of clay (as specified) upon receipt of environmental clearances for the project.

The Proponent has also had to consider the possibility that suitable clay for the basal sealing of landfill cells may not be available, either initially or in the longer term. In such an event, a barrier membrane lining system would be used for basal sealing of the landfill cells. If it did become necessary to use a barrier membrane rather than a compacted clay basal liner, the Proponent

would submit a further report, specifying the lining system to be used, to the EPA and Health Department for endorsement prior to commencing construction of the landfill cell/s within which the alternative basal lining system was to be used.

In addition to the basal seal, landfill cells will be capped following completion with a composite barrier membrane. The sealing and capping of the landfill cells is further discussed in Section 5.3.3 (Development and Operational Features - *Cell Lining* and *Cell Completion*).

Other aspects of the proposed landfill operation which will facilitate realization of the abovementioned principles are:

- an underdrainage system will be constructed in each cell to collect leachate from the base of the landfill and gravity drain to sumps for pumping to membrane lined evaporation ponds (leachate will also be irrigated over the active landfill to increase evaporation);

- refuse will be pushed and compacted into thin layers (compacted depth of about 0.5 m) using a purpose specific machine following deposition, with compacted material being regularly covered by placement of 200 mm of clean material to provide an effective cover of at least 100 mm; and

- finished contours (following capping and final covering) and revegetation programmes will reflect the interim and ultimate end uses identified for the site (bushland park and light industry respectively).

5.3.2 Design Features

The proposal for Loc. 2170 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 although, as discussed, construction of the on-site transfer station may need to be deferred for a period of up to five years.

The design features are outlined on Figure 11 and are discussed hereunder.

Cellular Formation

The landfill will be developed progressively as a series of sealed cells within which refuse will be deposited, compacted and covered. Each landfill cell 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.

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).

On-site Transfer Station

To obviate the need for direct public access to the tipping face within the operational landfill cell, the proposal includes provision for an on-site transfer station (refer to Figure 12 for general design features of the transfer station).

The on-site transfer station is an integral part of the proposed landfill and it is stressed that the intention is to establish the transfer station as part of initial site development. Nevertheless, it does need to be recognized that construction of the transfer station might need to be deferred for up to five years, to enable resolution of certain logistical and financial considerations.

The Proponent recognizes that, if construction of the transfer station is to be deferred, appropriate commitments regarding its subsequent establishment, and any consequential modifications to operational practices associated with the absence of the transfer station, will need to be provided. Accordingly, if detailed planning and budgetting for the proposed landfill indicate the need to defer construction of the transfer station, the Proponent will submit a supplementary report to the EPA and Health Department (for consideration and endorsement) explaining consequential modifications to the proposal, including arrangements for subsequent construction of the transfer station and requirements for changed operational practices. This report would be submitted prior to the commencement of site development.

If the transfer was not established during initial site development, the size of the active tipping face would have to be extended (to accommodate direct public access). The abovementioned report would, therefore, include, a detailed plan establishing the specific operational and management practices to be instituted at the tipping face. This plan would contain strategies for separating domestic and other vehicles using the site, controlling the actual dumping of refuse at the active tipping face, and compaction and covering operations along the entire tipping face. While acknowledging that the active tipping face would need to be extended, the basic objectives of the plan would be to minimize the additional area required and ensure that the domestic tipping activities were effectively controlled.

For further discussion of refuse emplacement, compaction and covering operations, refer to Section 5.3.3 (Development and Operational Features - *Placement and Compaction of Refuse*).

Following construction of the transfer station, municipal waste collection vehicles and commercial operators will be directed to the tipping face, while casual, domestic users will be directed to the transfer station. This will reduce the necessary size of the tipping face and allow waste deposition to be better co-ordinated with cover material application.

At the transfer station, refuse will be placed in large bins for periodic removal to the tipping face. Initially, the station will accommodate up to 12 vehicles simultaneously (2 vehicles per each of 6 bins), although provision has been made for doubling of this capacity. The overall transfer station compound will also provide for recycling facilities (e.g. bins for the placement of aluminium cans, glass, paper, cardboard, used oil, car body storage area, and an area in which composting activities could be established). As already indicated, the Proponent is committed to maintaining and enhancing recycling initiatives within its municipal district.

Buffer Zones

Where the site adjoins Millar Road, a 40 m buffer zone will be maintained along the boundary of Loc. 2170. A 20 m buffer will be maintained along all other site boundaries. These distances represent the minimum buffers that will be incorporated into the landfill design and, depending on the localized conditions, the dimensions of the peripheral buffers could, in fact, be extended.

For instance, landfilling operations could be visually prominent in the north-eastern extremity of Loc. 2170, because of landform. Accordingly, in the event that landfilling operations were to extend into this part of the site, and depending on the conditions there following completion of the extractive operation, substantially broader buffers could be necessary to ensure effective screening of the operations. Also, if landfilling operations were to extend into the south-eastern extremity of the site, broader buffers would be necessary to ensure adequate separation from existing residences.

All buffer zones 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.

Within the buffer zone, a 3 m high soil bund will be progressively constructed to effectively screen the landfill operations from adjoining properties and roads. The natural vegetation will be retained within the buffer zone wherever practical, thereby providing additional screening of the site. Additional vegetation will be established within the buffer as required, and on the bund to provide further screening of the site.

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 2 m high wire mesh fence with two strands of barbed wire will be erected along the Millar Road boundary of the site adjacent to the landfill facilities and the initial five landfill cells. The fence will be extended along the western boundary of Loc. 2170 and into the property from Millar Road a sufficient distance to enclose the initial facilities. As development of the site progresses, this fence will be extended to enclose the entire complex. Lockable gates will be installed at all points of access to the site including the quarry access.

The 2 m mesh fence will be placed on the crest of the bund adjoining the landfill operations. It is anticipated this will form an extra litter control barrier on the margins of the site. The natural vegetation remaining in the buffer zone and vegetation established on the bund, will screen the fence and bund from adjoining properties and Millar Road.

In areas associated with the landfilling operation but not initially enclosed by the 2 m mesh fence, a combination of the existing one metre barbed wire fence and a "vehicle trap" will be utilized to prevent vehicular access to the site and minimize illegal dumping. The trap will consist of a cut to fill trench and bund with approximate depth/height differential of 1.5 m. In addition, the access track along the western boundary of Loc. 2170 will be closed by either blockage or a lockable gate.

The presence at City of Rockingham personnel at the landfill during operating hours will, obviously, ensure site security during those hours. The landfill will be subjected to after hours surveillance on the same basis as all other City of Rockingham facilities. Additionally, development proposals for the landfill include construction of a permanent (City of Rockingham) residence adjacent to the transfer station and facilities area. This will enable the Proponent to maintain a permanent after hours presence at the site should such be necessary to supplement security measures.

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

As indicated, limestone and sand are currently being excavated from Loc. 2170. The extractive operation is being undertaken by WA Limestone and will continue for approximately 12 years.

Excavation will be completed in areas required for the initial stages 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 the Proponent and the extractive industry operator (presently WA Limestone), and through conditions attached to the Extractive Industry Licence applying to the operation. In general, however, a minimum separation of 5 m from the highest recorded level of the water table will be maintained upon completion of excavation.

On completion of the quarrying operation, preparation of the site by the Proponent 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 operator 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. The minimum vertical separation between the final graded surface and the water table will be 2 m. Placement of the lining materials will increase this separation to 3 m.

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

Cell Sealing

Two options for sealing the landfill cells have been considered, these being compacted clay and some form of synthetic barrier membrane. For reasons of effectiveness, a clay liner is the preferred option.

Testwork undertaken indicates that clay with suitable geotechnical and geochemical qualities for lining of the landfill cells should be available from local sources. 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 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 150 mm loose thickness) and density and moisture content will be controlled by continuous compaction testing.

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 underdrainage blanket of permeable material will be installed on the upper surface of the basal liner. This will form part of the leachate collection system.

The majority of the clays that are potentially suitable for use in lining the landfill have a high smectite content. These clays will shrink and swell with variation in moisture content, causing cracking of the clay and hence flowpaths for leachate migration. Therefore, on construction of the liner and starter embankment, and installation of the underdrainage blanket, a 300 mm sand or soil cover, compacted and wetted, will be placed to protect the clay liner from moisture content variations.

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 basal liner cannot be located, a synthetic barrier membrane liner would be utilized as the landfill basal seal. Two possible alternative lining systems are high density polyethylene (HDPE) membrane or a composite geotextile fabric/bentonite clay liner.

Two millimetre HDPE membrane could be used in conjuction with a 500 mm underlying compacted clay foundation layer (to provide additional containment and attenuation capacity). The surface of the clay would be graded and all irregularitories that could puncture the HDPE would be removed. The clay foundation would be constructed to the specifications previously discussed for the clay liner with the exception of thickness. A protective layer of sand and crushed limestone of minimum 600 mm thickness would be placed over the HDPE membrane to protect it from puncture.

The composite liner comprises a flexible geotextile fabric bentonite clay sandwich. The sodium bentonite clay has a very low permeability (less than 10^{-7} cm/sec) to various liquids and simulated leachates and has a self-healing ability due to the swelling characteristics of the clay. Base preparation of the site would include a minimum 100 mm sand layer and removal of all projections likely to damage the liner. A minimum 600 mm sand and crushed limestone protective cover would be placed over the liner to prevent damage due to trafficking. A secondary compacted clay liner underlying the geocomposite barrier would need to be constructed to provide additional safety against leachate seepage and attenuation of leachate components.

In the event that a suitable clay source is not readily available and a barrier membrane liner was 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 conjuntion with the barrier membrane liner.

Leachate Collection and Disposal

Low levels of leachate production are anticipated because the active life of the landfill cells would be limited to about 12 months. Information about leachate generation is provided in Appendix D. A leachate underdrainage 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 underdrainage blanket immediately above the basal clay liner (e.g. crushed rock, inert rubble, gravel with a permeability rating of not less than 1×10^{-1} cm/sec), and a series of drains consisting of high strength draincoil pipe encased in aggregate filled trenches of approximately 1 m wide by 0.4 m deep. These trenches will also be lined with filter fabric. The combination of filter fabric and aggregate will minimize the potential blockage of the drains by sludges or refuse. Figure 13 shows a cross-section of the leachate collection drains.

The clay liner will also be graded to promote gravity drainage of leachates to a lined pond located on the perimeter of the currently active cell. The pond will be constructed at the same time as the clay liner, thereby ensuring that all run-off would accumulate in the pond. The design storage volume of the pond will be for a one in 100 year storm event of 24 hours' duration, and a

one in 10 year event of one hour's duration. A PVC liner will be installed in the pond and covered with a protective 200 mm thick levelled sand base. A new pond will be constructed for each landfill cell, with the previous pond being completely drained and backfilled, and the leachate drains from the previous cell connected with the drains in the adjacent newly opened cell, thereby ensuring that any leachate produced from the capped cell will be collected. The PVC liners will not be recycled from one pond to the next.

Leachate collected in the pond will be recycled by pumping through an irrigation system 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. For much of the time, landfilling and, therefore, leachate irrigation will be occurring below the level of surrounding landform and accordingly, wind dispersion of leachate is unlikely to be a problem. Nevertheless, the Proponent recognizes that irrigation activities may need to be controlled to avoid excessive wind dispersion of the liquor. In this regard, if observation indicates excessive dispersion is occurring because of prevailing winds, irrigation will be halted until winds subside.

On completion of limestone quarrying activities within the area covered by the detailed proposals, a permanent leachate evaporation pond will be constructed to service all cells. The permanent pond has been sized on the basis of a water balance which includes incident rainfall during a 90 percentile wet year, plus anticipated rate of leachate generation and evaporation. Sediments will need to be periodically removed from the evaporation pond and, because of their elevated salinity, disposed of in a secure landfill or other form of secure disposal facility. While landfilling continues at Loc. 2170, these sediments could 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. The Proponent recognizes this as an ongoing requirement following closure of the site.

Peripheral Embankment Construction

Once the initial storage capacity within an active landfill cell, provided by the starter embankments, has been utilized, lifter embankments and the bund parallel to the side of the quarry will be constructed.

A PVC liner will be incorporated into each embankment lift to limit rainfall infiltration into the landfill over the period the outer face is exposed (i.e. prior to the construction of the adjacent cell). The liner will be near horizontal but graded to the outside of the cell to allow drainage of the infiltrating rain water away from the refuse.

As shown on Figure 14, the lifter embankments and the side bund will be constructed by the placement of thin layers of earthfill, suitably moisture conditioned and compacted. Material for embankment construction will be sourced from on-site overburden, limestone and sand materials.

As each lift of the embankments is completed, the outer face will be stabilized with vegetation. Drainage paths will be provided to allow incident rainfall to flow to the quarry floor without causing serious erosion of the face.

Airspace between the lifter embankments and the adjacent quarry face will be progressively filled with clean material (see Figure 14). This material will be compacted to a similar degree as the lifter embankments.

Placement and Compaction of Refuse

Refuse will be progressively placed and compacted into thin layers of approximately 0.5 m compacted depth. 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 at frequent (3-4 hourly) intervals over the compacted refuse, to minimize refuse exposure and associated environmental problems such as wind blown litter, odours and availability of food for scavenging animals. The depth of cover material placed will be 200 mm, to provide an effective cover of 100 mm.

Cover material will be sourced from on-site overburden stockpiles remaining from quarrying operations. Additional limestone/sand materials will be available from 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 will be filled to completed height over a period of 12 months. Once filled, the refuse surface will be covered as follows:

- 500 mm minimum layer of selected granular material or solid inert waste;
- 150 mm minimum layer of sand;
- composite barrier membrane;
- 150 mm minimum layer of sand;
- 800 mm layer of compacted granular soil;
- 150 mm minimum layer of topsoil.

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).

Finished contours will not constrain future use of the site for light industry, the long-term enduse identified for Loc. 2170. The interim enduse for Loc. 2170 will be bushland park, and rehabilitation of closed cells will be directed towards this objective. Cells will be progressively rehabilitated following

closure, capping and covering. Shallow rooted native vegetation (species selection being based on advise from the Department of Conservation and Land Management) will be established on the individual cells as soon as practicable following closure.

Surface Water Runoff Disposal

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

Runoff from areas beyond the active cell, including the outer slopes of the active and completed cells, will not contact refuse and will, therefore, be uncontaminated. This water will be directed to the floor of the quarry area and subsequently lost by infiltration to the groundwater system.

Any surface runoff from the capped landfill cells will be contaminant free and accordingly, containment or treatment of this water will not be necessary.

Gas Collection

The rate of gas production will be limited by restricting the amount of water entering the landfill cells. Cells will be capped with a barrier membrane upon completion, and the site drainage system will direct any uncontaminated runoff away from the landfill cells.

Landfill gas monitoring bores will be installed immediately upon closure and capping of each cell. Regular monitoring of these bores will determine the need and timing for the construction of gas collection/production bores.

Road Construction and Maintenance

The main site access from Millar Road will form a loop with separate entry and exit points (refer to Figures 11 and 12). This configuration will help reduce cross traffic movements, as the majority of vehicles will enter the landfill from the west. Marked turning and passing lanes will be provided to assist traffic movement on Millar Road.

A separate access to the WA Limestone quarry will be constructed. The new quarry access will enter Millar Road some 200 m east of the landfill access road.

All roads to be used by the public for access to the landfill site and at the transfer station will be sealed. Table drains will direct all stormwater from the sealed areas to on-site infiltration basins. Roads accessing the landfill cell area will be constructed from unsealed compacted limestone and be at least 6 m wide. A water tanker will be permanently on-site and available for dust suppression on all unsealed roads and other trafficked areas during dry periods or as required.

Wheel Cleaning Facilities

To prevent the tracking of debris and sediment from the unsealed portion of the site into the sealed transfer station/facilities area, a wheel cleaining grid will be installed on the egress track from the active landfill area. This will comprise a lateral grid over a collection sump and will be designed to vibrate

vehicles passing over it, thereby dislodging any debris from tyres which will then collect in the underlying sump. Material collecting in the sump will be regularly removed and disposed of in the active landfill cell. The length of the grid will be sufficient to accommodate the largest vehicle likely to use the landfill.

Seismic Stability

As part of the broader Perth region, the Baldivis 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 Baldivis locality.

Water Supply

Water supplies for use on-site will be drawn from roof catchment of rainfall (for potable supplies) and from an on-site groundwater production bore (for irrigation, vehicle washdown, dust suppression and fire control purposes).

The groundwater bore will probably be located within, or close to, the area designated for site facilities (i.e. transfer station, offices, permanent residence etc.). All requirements of the Water Authority of Western Australia regarding the siting, construction and licensing of the production bore will be complied with.

6 ENVIRONMENTAL IMPACTS

6.1 Introduction

Under the agreement being negotiated between the Proponent and ILDA concerning the purchase of Loc. 2170, the City of Rockingham will gain staged access for landfilling, while the Development Authority will retain control over the in situ basic raw materials. ILDA's objective is to ensure that the available basic raw materials (limestone and sand) will be removed prior to landfilling.

ILDA has contracted WA Limestone to remove the limestone and sand as a commercial operation. Excavation of Loc. 2170 has been underway since the mid-1980s, and the extractive operation will continue until the basic raw materials are exhausted. As a consequence, while about 70% of Loc. 2170 presently supports relatively undisturbed vegetation, virtually the entire site will eventually be heavily modified as a result of the extractive operation.

All areas that will be used for landfilling will be excavated, while much of the remainder of the site to be developed (i.e. the transfer station and facilities area) has been disturbed as a result of the extractive operation. Therefore, the adverse impact of the landfill proposal within Loc. 2170 on landscape and biological resources of the site will be minimal.

Current structure planning for the Baldivis locality designates Loc. 2170 for future light industrial development. Notwithstanding the proposal to use Loc. 2170 for landfilling, light industry is still considered an appropriate ultimate end use for the site. However, there will be an appreciable time lag between completion of landfilling and the availability of the site for light industrial use. The interim use of the site during this period will be bushland open space.

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 of 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

There are no surface water features within Loc. 2170. However, based on available data, the maximum level of the unconfined water table beneath Loc. 2170 is 2.5 m AHD. The vertical separation between natural ground surface and the unconfined water table varies between approximately 10 and 25 m. As virtually all of the site is to be excavated, the depth to the water

table will be reduced. In view of this reduced separation and the comparatively high permeability of the in situ sands and limestone, there is a risk that landfill leachates could cause groundwater contamination if appropriate leachate management initiatives were not implemented.

Groundwater throughflow in the unconfined aquifer (about 1 kL/d per metre width of aquifer) indicates that the concentration of any contaminants entering the groundwater system would be readily reduced by dilution. Some attenuation of contaminants within the leachate would also occur with movement through the underlying geological formations.

The significance of potential impacts on the groundwater system is increased by the proximity of Loc. 2170 to Lake Cooloongup and the Leda wetlands and its location up hydraulic gradient from these features. Additionally, existing contamination from the adjacent WMC tailings pond and the requirement for remedial measures, emphasize the unacceptability of a disperse and attenuate landfill proposal for Loc. 2170. This is explicitly stated in the guidelines provided by the EPA. Consequently, the proposal for Loc. 2170 will need to incorporate adequate safeguards against groundwater contamination from landfill leachates.

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 Loc. 2170 would decrease the potential for odour impacts from the proposed landfill. However, increasing residential development will occur to the north and south of Loc. 2170 (in the Leda and Baldivis localities respectively) 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 Loc. 2170 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 Loc. 2170 reduces the significance of this potential impact, although future residential development will increase the prominence of noise as an issue.

6.2.5 Dust

As a result of the prior extractive operation, virtually all of Loc. 2170 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 on-site transfer station 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, as will the movement of vehicles to and from the site along the presently unsealed eastern portion of Millar Road.

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 present level of dust generated by traffic on the unsealed portion of Millar Road is not apparently having a detrimental effect on the adjacent vegetation. Again, therefore, dust can be regarded as a potential impact upon the human environment.

The significance of dust as a potential impact is not high at present, because of the comparative isolation of Loc. 2170. 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. Obviously, if allowed to proliferate, these species could move off-site, to the detriment of the surrounding human and biophysical environments.

Although flies, mice, rats and feral animals could become a problem at the proposed landfill, 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 Perth Local Government Authority landfill sites (including the City of Rockingham's existing site at Ennis Avenue).

The Shoalwater Islands off-shore from Rockingham are inhabited by over 4 000 pairs of Silver Gulls (the major colony of about 3 000 pairs inhabiting Penguin Island), and the Ennis Avenue landfill is regarded as a major food source for this population (Department of Conservation and Land Management, 1990). Silver Gulls are considered a pest species on the Shoalwater Islands, because they are reducing the breeding success of other bird species, contributing to vegetation change, and inhibiting rehabilitation initiatives in some colony areas.

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 Loc. 2170 and environs represents a significant potential impact arising from the proposed landfill applying to both the biophysical and human environments. Concern over the potential impact of Silver Gulls was a particular issue raised during public consultation.

Although some researchers suggest that there is no evidence to implicate Silver Gulls as a major public health risk (e.g. Iveson, 1976), there is concern that the proposed landfill could attract gulls that would roost on Lake Cooloongup, the Leda wetlands and other nearby water bodies and contribute to their contamination and pose a public health risk through fouling of domestic and secondary water supplies. The continued availability of food to support the present excessive gull colonies inhabiting the

Shoalwater Islands is perceived as another possible undesirable consequence of establishing a landfill at Loc. 2170. The Draft Management Plan for the Shoalwater Islands identifies the need for control of the Islands' gull population.

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 BOD) 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 increasing residential development upwind of the site and the extent of bushland 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 of 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 Loc. 2170 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 3 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 Loc. 2170 will occur because of the ongoing extractive operations.

Nevertheless, probably the most tangible social impact that could be attributed to the establishment of a landfill at Loc. 2170 would be a reduction in property values (this was a clear concern expressed during the consultation process). A recent valuation of Loc. 2170 indicates that a number of influences would attribute some discounting to the unaffected market value of the site. These influences were the nearby tailings disposal site to the west, the designated regional cemetery site to the east, and "the parcel of land to the south which acts as a rubbish disposal site" (a reference to the Kerosene Lane quarry site). The total discount attributed to these three factors was 10%.

Based on this valuation, it is reasonable to conclude that establishing the proposed landfill would influence nearby property values. Specific valuations would be needed to establish the magnitude of this influence, although, based on the earlier advice, a discount of less than 10% would apply (ie as the total discount from the three factors was 10%, the discount attributable to any one of the factors would be less than 10%).

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 Loc. 2170. Such will, however, occur as a result of the extractive operation which has been occurring since the early 1980s 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.

A number of potential environmental impacts arise from the proposed landfill, the most significant of these being groundwater contamination and the effects of pest species (particularly Silver Gulls). Both potential impacts have implications for the nearby Lake Cooloongup and Leda wetlands. Lake Cooloongup is regarded as having a high conservation value, supporting some 13 different vegetation formations, 73 bird species and a variety of other fauna (Department of Conservation and Environment, 1983).

The Leda wetlands form part of a larger area immediately north of the Kwinana to Jarrahdale railway line also considered as having important conservation value, because it represents an interface between several soil, landform and vegetation associations.

The broader environs within which Loc. 2170 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 influences the character and amenity of the general environs. These are the WMC tailings disposal site, the Kwinana to Jarrahdale railway, and the existing sand/limestone extraction operation. Land use proposals for the environs include a regional cemetery, light industry (encompassing Loc. 2170) and residential uses, all of which will produce further changes to the locality.

The area is, therefore, in a state of change, and although the landfill proposal will reinforce this change, its overall significance in this context is difficult to estimate. However, of greatest significance in this regard is the juxtaposition of Loc. 2170 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 Loc. 2170 is to minimize potential environmental impacts, by appropriate design, development strategies, operational and management practices. The specific measures that will ensure the potential impacts discussed in the preceding section will be minimized will now be reviewed. The significance of these potential impacts will also be addressed.

7.2 Water Resources

7.2.1 Predicted Impacts and Management

There are no natural surface water features within or immediately adjacent to Loc. 2170. Additionally, the high permeability of the in situ soils and underlying geological formations will prevent any off-site movement of surface water. Any 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 one metre compacted thickness;
- installation of a leachate collection underdrainage system within each landfill cell which will discharge to a sealed pond from which liquor would be recycled by spray irrigation over the active landfill cell and lost to the environment by evaporation;
- installation of a site drainage system that will divert clean runoff water away from areas receiving refuse for disposal by ground infiltration;
- 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 0.5 m thick) and regular covering of deposited refuse 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 contains a detailed examination of leachate generation within the proposed landfill, and the chemistry of leachates generated. The Appendix also assesses the potential for loss of leachate through the clay seal and the environmental consequences of such loss.

In summary, in the immediate environs of Loc. 2170, there will be a minor increase in groundwater salinity (as total dissolved solids - TDS) and total organic carbon (TOC), although levels will remain comparable with those currently occurring, but a more pronounced increase in ammonia - nitrogen will occur. In down-gradient groundwaters more distant from Loc. 2170, levels of the abovementioned parameters will not materially change.

The implications of the anticipated changes in groundwater chemistry attributable to the proposed landfill essentially relate to remediation proposals for the ammonium sulphate plume from the adjoining tailings pond. Elevated TOC levels could pose problems in WMC's reverse osmosis plant, while elevated ammonia - nitrogen levels could pose problems for a possible groundwater recharge scheme to safeguard vegetation fringing Lake Cooloongup from the effects of nitrogen toxicity.

These issues are discussed in Appendix D, but should experience indicate that the anticipated groundwater TOC and ammonia-nitrogen levels in the immediate vicinity of Loc. 2170 do pose a problem for WMC, then they will need to be resolved conjointly by the Proponent and WMC.

7.2.2 Monitoring

As indicated in Appendix D, there is a need to monitor raw leachate, to confirm its chemical composition. Raw leachate from collection sumps will be sampled and analysed periodically to establish its chemical composition for comparison with anticipated leachate chemistry.

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 50 m along sections of the site boundary down hydraulic gradient of the landfill. On this basis, approximately 30 bores will be required for the western sector of the site. 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 will probably not penetrate very far 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 prefered flow paths, 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 would 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 accord 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 (e.g. five-day biochemical oxygen demand, BOD_5) which have short holding times, 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 would 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 (Appendix D). Should groundwater contamination be indicated by

the determination of such parameter, 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 Loc. 2170, 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 a 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.

Discussions have been held with WMC to determine the potential extent of co-ordination of the groundwater monitoring programmes for the proposed landfill and the adjoining tailings disposal site. However, because of the different contaminant types, it is expected that the degree of co-ordination of the monitoring programmes possible will be limited. Since the monitor in bores used by WMC generally tap the base of the aquifer, common use of bores between Loc. 2170 and the WMC site will therefore be restricted.

7.3 Odours

7.3.1 Predicted Impacts and Management

The impact of odours is very difficult to quantify because people's response to them is essentially 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 should focus on:

- achieving an acceptable separation between the site and areas of human settlement (taking prevailing winds into account);
- 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 Loc. 2170 is 200 m (EPAV, 1989). The nearest existing individual residence is some 250 m from the closest boundary of Loc. 2170, and the separation between the site and existing and future residential areas is substantially greater.

The occurrence of malodours from a landfill can be minimized by:

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

(Department of Environment, 1986.)

These requirements will be satisfied at the proposed landfill as indicated below.

There will be no standing water within the landfill cells. The Western Australian 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, 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 850 kg/m^3 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.

Although the facility will include an on-site transfer station, this is intended to service the casual tipper only. Most domestic putrescible waste (i.e. from the municipal collection service), the decomposition of which generates most malodours, will be deposited directly into the active landfill cell.

7.3.2 Monitoring

As stated above, peoples' reaction to odours is difficult to quantify due to the subjective nature of the human response. Monitoring of odour generation is, therefore, not practicable. Some mechanism to enable the identification of any off-site odour impacts (or other adverse social impacts), is, however, necessary. To this end, the Proponent will maintain a complaints register. This register will also be available to residents from areas such as Leda which are in the vicinity of the landfill site but not within the City of Rockingham. 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;
- control of wind blown material at the tipping face, including the accumulation of debris along the peripheral security fence.

Under the proposal for Loc. 2170, the following measures will be implemented as a routine part of the ongoing operational and management programmes.

Loss of Debris

The Proponent will undertake the following:

- maintain a programme to educate the public 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;

- ensure that any debris along the access routes 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 that is 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;

- although the security fence will be on top of the peripheral bund, it will be screened by vegetation, thereby avoiding visual impact from any material caught in the fence;

- 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 City of Rockingham staff to determine whether littering is occurring, and any public complaints received concerning littering will receive a prompt response. Any material accumulating along the access routes 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.

Recent survey data for the existing Ennis Avenue landfill indicate that the site generates some 2 000 to 3 000 vehicle movements per week (i.e. between 1 000 and 1 500 return trips). Truck traffic comprises about 10% of the total, the remainder being light vehicles. The figures for total movements and truck traffic would, however, be somewhat low, as the Ennis Avenue site has been closed to commercially operated compacter vehicles for some time.

Most traffic accessing the proposed landfill will do so from the west via a number of routes before concentrating on Mandurah Road and, ultimately, Millar Road. Traffic accessing the site from the east will also use various routes before concentrating on Baldivis Road and Millar Road.

Mandurah Road is an established regional route (designated under the Metropolitan Region Scheme as "Other Major Highway"). It carries substantial traffic (about 40 000 vehicles per week in the vicinity of Millar Road based on Main Roads Department traffic counts). Accordingly, the additional traffic that would be attracted to Mandurah Road because of the proposed landfill would be unlikely to have a material effect in terms of increased noise impact along the route.

Although not a regional route, Baldivis Road is an important local distributor, carrying about 20 000 vehicles per week (again based on Main Roads Department information). The extent to which traffic would increase on Baldivis Road as a result of the proposed landfill is difficult to estimate. However, because of the population distribution within the Rockingham municipal district, it is reasonable to conclude that only a small proportion of landfill related traffic would use Baldivis Road. Accordingly, any material effect on properties adjoining Baldivis Road as a result of increased traffic attributable to the landfill would be unlikely.

Millar Road will obviously carry all landfill related traffic. Until recently, Millar Road was an unsealed limestone formation. The western portion (between Mandurah Road and the accessway to WA Limestone's quarry) has recently been sealed, and the City of Rockingham hopes to obtain funding to seal the remainder of the route in 1991/92. The City of Rockingham is also considering the possibility of upgrading the functional status of Millar Road as an east-west link (to reduce traffic flows on rural roads further south which are expected to increase substantially following extension of the Kwinana Freeway to Thomas Road).

Millar Road carries all traffic moving to and from the WA Limestone quarry. Although these movements are variable, at certain times the route carries considerable heavy truck traffic. In addition, the noise environment along Millar Road is dominated by train traffic on the Kwinana to Jarrahdale railway line, although such traffic is, again, intermittent.

Establishment of the landfill at Loc. 2170 will lead to a consistent increase in traffic using Millar Road and, therefore, in noise levels along the route. However, at present there is only one inhabited property on Millar Road (at its western extremity) and, under structure planning proposals for the locality, this could become light industrial land. Accordingly, although traffic and noise on Millar 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 as will specific activities such as the loading and off loading of bins at the transfer station.

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 250 m east of the nearest boundary (i.e. the south eastern extremity) of Loc. 2170, although it is shielded from the site by landform. In practice, the physical separation between this house and the initial stages of the landfill will be significantly greater than the distances mentioned. Other existing and future residential areas (Leda and South Baldivis respectively) are at least 400 m from the nearest boundary of Loc. 2170 and are also screened by landform and vegetation. Accordingly, the degree of noise attenuation afforded by the physical separation between Loc. 2170, existing residences, and existing and future residential areas would at worst, be likely to be towards the higher end of the above range.

The Proponent 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 problematical (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 peripheral bund (3 m in height) plus site revegetation, will further assist in the attenuation of noise from the landfill operation.

The transfer station will be the most exposed component of the proposed landfill operation, and the possibility of noise being transmitted into the surrounding environment therefore exists. Activities in this area will be confined to the movement of vehicles, the loading and off loading of the transfer station bins, and the dumping of refuse into the bins at the station. There may be some intermittent bursts of noise when something hard or heavy is dropped into an empty bin, and the clattering of bins as they are loaded or off loaded by the transporter vehicle. However, the bins and the associated handling area will be below the surroundings and, accordingly, noise will be dampened by the screening effect of the surrounds.

The transfer station is well separated from any existing residences and the Leda residential area and, therefore, although it will contribute to the general noise environment, its impact will not be major.

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 WA Limestone quarrying operation and from the Kwinana to Jarrahdale railway line. Landuse proposals for the general area will further influence its amenity, with the immediate environs of Loc. 2170 assuming an increasingly industrial character. Based on this change in character, and the Assigned Outdoor Neighbourhood Noise Levels scheduled under the Noise Abatement Regulations (Table 7), 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 0800 and 1700 daily.

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

- construction of the peripheral bund to contain on-site noise;
- landscaping the peripheral areas of the site, including the bund, which will help dissipate noise emissions;
- ensuring that all City of Rockingham 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 the Proponent 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 Loc. 2170 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 western portion of Millar Road. Other measures incorporated in the landfill proposal which will ameliorate dust generation are:

TABLE 7

ASSIGNED OUTDOOR NEIGHBOURHOOD NOISE LEVELS
dB(A)

Category	Use of premises at place of reception	Description of neighbourhood in which place of reception is situated	Monday-Friday 0700-1900 hrs	Monday-Friday 1900-2200 hrs Weekends and Public Holidays 0700-2200 hrs	Always 2200-0700 hrs
A	Residential, domestic or private recreational	1. Only or predominantly country, with negligible transportation	40	35	30
		2. Only or predominantly residences with infrequent transportation	45	40	35
B	Residential, educational, hospital or the like	1. Other residences with schools, hospitals and the like or with medium density transportation	50	45	40
		2. Other residences with some commerce or some light industry, or with some places of entertainment or public assembly, or with dense transportation	55	50	45
		3. Predominantly commerce or light industry or places of entertainment or public assembly or with very dense transportation	60	55	50
		4. Predominantly industry, or with extremely dense transportation	65	60	55
C	Commercial, entertainment or public assembly	1. Predominantly residential or with schools, hospitals and the like, or with medium density transportation	50	45	40
		2. Some other commerce or some light industry, or with places of entertainment or public assembly, or with dense transportation	55	50	45
		3. Predominantly commerce or light industry with very dense transportation	60 at any time		
		4. Predominantly industry, or with extremely dense transportation	65 at any time		
D	Industrial	1. Predominantly residential or with schools, hospitals and the like, or with medium density transportation	55	50	45
		2. Predominantly commerce or other light industry, or places of entertainment or public assembly, or with dense transportation	60	55	50
		3. Predominantly other comparable industry, or with very dense transportation	65 at any time		
		4. Predominantly heavy industry	70 at any time		

Source: Noise Abatement (Neighbourhood Annoyance) Regulations 1979.

Site development

- staged construction of a peripheral bund (3 m high) and comprehensive peripheral landscaping where necessary (including of the bund), both of 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 transfer station and facilities area;

- installation of a wheel cleaning grid at the interface of the sealed and unsealed sections of the haul road from the transfer station to the tipping face, 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 to native bushland);

- overburden, cover material etc. stockpiled for future use will be stabilized with temporary cover vegetation, mulching, watering or some other technique;

- 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 Pest Species

7.7.1 Predicted Impacts and Management

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

Normal management practices at the tipping face will minimize host conditions and food for pest species 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;
- any tyres dumped will be spread out and carefully covered.

Various other measures to deter past species 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 the recent 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 generaters to frighten the birds;
- recorded distress calls to both frighten and confuse the birds;
- direct culling.

The Proponent recognizes that supplementary measures to control Silver Gulls at the proposed landfill may be necessary, and is supportive of the recommendations in the Draft Management Plan for the Shoalwater Islands. The Proponent has written to the Department of Conservation and Land Management indicating its willingness to assist in implementing these recommendations.

7.7.2 Monitoring

Monitoring of gull activity at the landfill will entail direct observations and subjective estimates of the numbers involved. The Proponent 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 barrier membrane, the opportunity for active collection of the landfill gas exists, thereby avoiding its uncontrolled release to the atmosphere. Upon completion of each cell, gas monitoring bores will be installed. Regular monitoring of these bores will determine the need and timing for the construction of gas collection/production bores.

The Proponent 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).

As indicated above, the Proponent supports the notion of beneficial use of landfill gas and is willing to participate in the investigation of options in this regard. The Proponent is also willing to assist in investigations into the stimulation of methane production although, at this stage, believes that the management priority for the proposed landfill should be the minimization of leachate (a direct consequence of which will be a reduced rate of landfill gas production).

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.

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 Baldivis locality and will, therefore, help ameliorate social impacts associated with the facility. However, at least in people's perceptions, establishment of the landfill will produce changes that will be considered adverse Accordingly, it will inevitably be regarded as having an undesirable social impact.

Again, however, in assessing the significance of this impact, it is necessary to examine both the present and future landuse context in which Loc. 2170 will be set. As previously indicated, industrial activities and influences are already established within the locality and, under structure planning proposals for the immediate environs, will be reinforced.

7.10.2 Monitoring

The complaints register to be maintained by the Proponent will represent the principal mechanism for monitoring any social impacts associated with the proposed landfill. As any complaints lodged, and the Proponent's 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 the Proponent's response to any complaints received.

7.11 Performance Reporting

While the Proponent believes that the landfill proposal for Loc. 2170 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 that has been 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 the Proponent within three months following the anniversary date of commencement of landfilling operations. The Proponent 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. This report could, for example, provide the basis for renewal of the initial approval for operation of the site.

Necessarily, any unforeseen or extraordinary event that adversely affected off-site environmental quality and the response to that event will be immediately reported by the Proponent 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 Loc. 2170 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.). Further, in the extreme, the cellular approach would enable isolation of any portion of the deposited refuse producing unacceptable leachate losses.

The Proponent 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 the Proponent's response thereto.

Furthermore, as a public authority, the Proponent is clearly identifiable as 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, the Proponent acknowledges that it will need to provide an undertaking to respond to any unforeseen events to the satisfaction of the relevant authorities. The Proponent has already undertaken to immediately advise the regulatory authorities of any unforeseen event and of remedial action implemented in response to the event.

The Proponent provides a further commitment to respond to any contingency in consultation with the EPA and Health Department, and to the satisfaction of the Minister for the Environment.

7.13 Management Following Closure

The Proponent recognizes that its management responsibilities will continue following closure of landfill site. Active management input will continue to be required for a number of years (decades in some instances) in the following directions:

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

Clearly, site monitoring programmes, particularly groundwater sampling and analysis, will be an important aspect of ongoing management following closure.

As the City of Rockingham will be the owner of Loc. 2170 in its entirety, dereliction of the site would obviously not be in the Proponent's best interests. Clearly, the Proponent's best interests will be served by ensuring Loc. 2170 is available for ultimate reuse (i.e. light industrial redevelopment) at the earliest opportunity following cessation of landfilling. This objective can be best facilitated through effective management of the site, both during the operational life of the proposed landfill and following its closure.

Further, as a responsible public authority, the Proponent has a moral obligation to ensure that, if the proposed landfill does proceed, the operation will be brought to an effective conclusion. The Proponent recognizes that this will require a long-term commitment to management of the site following closure of the landfill, and readily provides this commitment.

7.14 Conclusions

The management programmes incorporated in the landfill proposal for Loc. 2170 address all potential environmental impacts normally associated with municipal waste disposal sites. In so doing, the Proponent has also responded to issues raised by the community during consultation undertaken as part of the project.

The Proponent 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 the Proponent's response thereto) to be independently scrutinized. Through the mechanism, the community will be able to influence operational practices in areas of legitimate concern.

The Proponent also recognizes the importance of planning towards an identified enduse. Loc. 2170 is within an area to be designated for future light industrial development and the Proponent accepts that such is an appropriate ultimate enduse for the site. Although landfilling of Loc. 2170 will constrain future light industrial development (in terms of when and how such could occur), it will not preclude this form of reuse. The landfill proposal for Loc. 2170 has, in fact, been planned to minimize the degree of constraint imposed upon light industrial redevelopment of the site.

Necessarily, however, there will be a lengthy lag between completion of landfilling operations and the availability of the site for light industrial redevelopment. During this interim period, the site will be maintained as a bushland park. Vegetation planting programmes undertaken during site establishment and operation, and progressive rehabilitation of the completed landfill cells will be consistent with the interim bushland park theme.

Finally, and very importantly with a project of this nature, the Proponent specifically acknowledges that its environmental management and monitoring responsibilities extend beyond the operational life of the proposed landfill. As the Proponent will be the owner of the site, its best interests will obviously not be served by leaving the site in a derelict or otherwise environmentally unsound condition. Ensuring that the site is available for redevelopment within the shortest possible time frame will, however, be in the Proponent's (and the community's) best interests. This objective will only be achieved if the Proponent discharges its ongoing responsibilities effectively following cessation of the landfill operation.

8 TIMING

As indicated in Sections 1.2 and 2.1, the Proponent's need for a new landfill facility is urgent. The existing Ennis Avenue landfill site is virtually at capacity, but is operating on an interim approval from the Health Department current until 30 June 1991. The Proponent is presently negotiating with the Health Department for an extension of this interim approval. Based on progress of the present proposal, extension of the interim approval is anticipated.

The Proponent's urgent need for a new landfill is not of its own doing, as it has in fact been endeavouring to secure an alternative site for its landfilling operations since 1986. Although an earlier proposal to establish a landfill within Lots 290 and 291 Kerosene Lane immediately south of Loc. 2170 reached an advanced stage in 1989 (the Health Department had indicated its preparedness to approve the proposal) the matter was not finalized. The Proponent's subsequent efforts have been directed towards seeking approval of Loc. 2170 as a landfill site.

The Proponent recognizes that the environmental impact assessment process is lengthy, and that environmental clearance for the proposed landfill, if granted, is unlikely to be finalized before the third quarter of this year.

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 October/November period of this year, with completion towards the end of the first quarter of 1992.

9 COMMITMENTS

The Proponent, the City of Rockingham, provides the following commitments concerning the construction, operation and management of the proposed landfill within Loc. 2170 Millar Road, Baldivis.

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 landfill to the satisfaction of all relevant Government agencies including the following:

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

3) The Proponent is committed to the maintenance and enhancement of waste recycling programmes within its municipal district and will ensure that ongoing practices at the landfill will facilitate the current programmes being implemented and the introduction of additional programmes such as composting.

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

9.2 Design Features

5) The Proponent will progressively develop the landfill as a series of sealed cells, each cell sized to accommodate approximately one year's refuse, in accordance with the staging plan included in the PER (Figure 10).

6) As part of the initial site development, the Proponent will establish an on-site transfer station to obviate the need for direct public access to the tipping face.

7) If detailed planning for the landfill indicates the need to defer construction of the on-site transfer station, the Proponent will submit a supplementary report to the EPA and Health Department explaining consequential changes to the landfill operation, including specific operational and management practices to be implemented at the tipping face and arrangements for subsequent construction of the on-site transfer station. This report would be submitted to the EPA and Health Department prior to commencement of site development, and development would not commence until the EPA and Health Department were satisfied that the modified proposals included in the report were acceptable.

8) The Proponent will maintain a vegetated buffer zone around the perimeter of the landfill site, being a minimum of 40 m in width on the Millar Road boundary and a minimum of 20 m in width on all other boundaries. The buffer zone will be comprehensively landscaped and will contain a perimeter fence, a firebreak track, and a 3 m high earth bund, these features being progressively established during ongoing development of the site.

9) The Proponent will implement site security measures to control vandalism, theft and illegal dumping, including the progressive construction of a 2 m high wire mesh fence with lockable gates around landfill facilities, a trench/bund "vehicle trap" in areas of the site associated with the landfilling operation but not initially enclosed by the 2 m fence, and closure to traffic of the access track along the western boundary of Loc. 2170.

9.3 Development and Operational Features

Site Preparation

10) The Proponent will ensure that, prior to the commencement of construction of the landfill cells, the final excavated quarry surface is graded to allow gravity drainage across each of the landfill cells, while maintaining of minimum 2 m vertical separation between the final excavated surface and the water table.

Cell Sealing

11) During development of landfill cells, the Proponent will ensure that a one metre thick compacted clay liner will be constructed over the excavated surface, giving a minimum 3 m separation above the water table. A 300 mm underdrainage blanket will be installed on the upper surface of the clay liner as part of the process of constructing the liner (refer to Commitment 17).

12) The Proponent will ensure that clay sources used in construction of the landfill cells will meet the following specifications, under both laboratory and field conditions as appropriate:

- in situ permeability of 1 x 10^{-7} cm/sec or less when clay is placed and compacted; and
- gypsum content of less than 1%.

13) The Proponent will ensure that both the excavation of clay for the landfill cell liner, and the construction of the clay liner, will be supervised by suitably qualified geologists or engineers to ensure that only materials that have been tested and found suitable are utilized.

14) The Proponent will ensure that, during development of the landfill cells, the liner will be constructed and compacted in thin layers (no more than 150 mm loose thickness) and density and moisture content will be controlled by continuous compaction testing.

15) The Proponent will ensure that, prior to deposition of refuse within a landfill cell, a starter embankment of 2 m 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.

16) The Proponent will ensure that, on construction of the clay liner (and underdrainage blanket) and starter embankment, a 300 mm sand or soil cover, compacted and wetted, will be placed to provide protection against cracking of the clay material resulting from desiccation. Water application, to control variations in moisture content within any area of clay liner or starter embankment constructed substantially in advance of landfilling will continue as necessary.

17) 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 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 would not commence until the EPA and Health Department were satisfied that the systems proposed were acceptable.

Leachate Collection

18) The Proponent will ensure that a leachate collection system comprising a 300 mm deep permeable (permeability rating of 1×10^{-1} cm/sec or less) underdrainage blanket (placed immediately above the basal clay liner) and a series of drains consisting of high strength drain coil pipe encased in aggregate filled, filter fabric lined trenches will be installed in conjunction with construction of the clay liner. The liner will be graded to ensure flow of leachate to the drains.

19) The Proponent will ensure that leachate collection drains will gravity feed to a pond (lined with PVC covered with a 200 mm protective layer of sand) located on the perimeter of the currently active cell, and constructed at the same time as the clay liner. The design storage volume of the pond will be for a one in 100 year storm event of 24 hours' duration and a one in 10 year event of one hour's duration.

20) The Proponent will ensure that leachate collected will be disposed of by recycling through the refuse by pumping through an irrigation system onto the active landfill cell (only if wind conditions will not cause excessive dispersion of the leachate), and evaporation from the collection pond.

21) The Proponent will ensure that, on decommissioning of a completed landfill cell, the pond serving that cell will be drained and backfilled, and the leachate drains will be connected with the drains in the adjacent newly opened cell allowing continued collection of leachate from finished cells.

22) The Proponent will ensure that, at the earliest opportunity as determined by the progress of the extractive industry operation, a permanent leachate disposal/evaporation pond will be constructed to service all landfill cells. The permanent pond will be of similar construction to the temporary pond (i.e. PVC sealed and covered with a protective layer of sand). On construction of this pond, leachate collection drains from all completed landfill cells will be connected to the pond. Leachate collection drains from all cells developed subsequent to construction of the permanent pond will be connected to the pond from the outset. The permanent leachate disposal/evaporation pond will be sized on the basis of a water balance including incident rainfall during a 90 percentile wet year combined with anticipated rates of leachate generation and evaporation.

23) As part of normal site operational practices, the Proponent will ensure that sediments will be removed from the permanent evaporation pond as required for disposal within the active landfill cell. The Proponent recognizes that the removal of sediments from the pond, and their disposal, will be a continuing requirement following closure of the site. Following closure of the site, disposal of the sediments will occur in a manner satisfactory to the EPA and Health Department.

Peripheral Embankment Construction

24) The Proponent will ensure that, as the initial refuse storage capacity within an active landfill cell (provided by the clay starter embankments) is progressively utilized, lifter embankments and (where relevant) the bund parallel to the quarry wall, will be progressively constructed. The lifter embankments and side bund will be constructed by the placement of thin layers of earthfill, suitably moisture conditioned and compacted. As each lifter embankment is completed, drainage paths will be constructed, and the outer face vegetated to prevent erosion.

25) During progressive development of the operational landfill cell, the Proponent will ensure that a PVC liner will be incorporated into lifter embankment to limit rainfall infiltration into the landfill during the period in which the outer face is exposed prior to construction of the adjacent cell. The PVC liner will be near horizontal but graded to the outside of the cell to allow drainage of infiltrating water away from the emplaced refuse.

Placement and Compaction of Refuse

26) During operation of the site, the Proponent will ensure that refuse will be progressively placed and compacted into thin layers of approximately 500 mm compacted thickness. A dedicated refuse compacting machine will be used to achieve average compacted refuse densities of approximately 850 kg/m^3.

27) During operation of the site, the Proponent will ensure that compacted refuse will be covered with 200 mm of clean material, to provide an effective cover of at least 100 mm, at 3 - 4 hourly intervals.

Cell Completion

28) The Proponent will ensure that, upon completion of refuse deposition, landfill cells will be covered with a layer of granular material, bedding sand (below and above the barrier membrane), a composite barrier membrane of low permeability, further granular material, and a final layer of soil suitable for vegetation establishment.

29) The Proponent will ensure that, as part of ongoing 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 not constrain future use for light industry.

30) 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) will be established and maintained.

Surface Water Runoff

31) 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.

32) The Proponent will ensure that a site drainage system which will direct runoff water from the outer slopes of active landfill cell embankments, and from the surface of completed landfill cells, away from active tipping areas will be progressively installed as the site is developed. As water from this system will not have contacted refuse, it will be uncontaminated and will be disposed of by ground infiltration.

Landfill Gas Collection

33) The Proponent will ensure that, although the rate of gas production will be minimized by restricting the amount of water entering the landfill cells, landfill gas monitoring bores will be installed immediately upon closure and capping of each cell.

Road Construction and Maintenance

34) The Proponent will ensure that the main site access from Millar Road is constructed as a one-way system, with separate entry and exit points to reduce cross traffic movements, and that marked turning and passing lanes will be provided to assist traffic movement on Millar Road.

35) A separate access to the WA Limestone quarry will be constructed by the Proponent in conjunction with initial development of the landfill facility.

36) The Proponent will ensure that, from the outset of the landfill operation, all roads to be used by the public for access to the site, and at the transfer station, will be sealed.

37) The Proponent will ensure that surface runoff from internal roads within the landfill site will not contact refuse and will be directed to on-site infiltration basins.

38) 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

39) As part of the initial site development, the Proponent will ensure that a wheel cleaning grid is installed on the egress from the landfill cell area to dislodge debris and sediment from vehicle wheels. Debris collected in the grid sump will be regularly removed and disposed of within the active landfill cell.

Water Supply

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

9.4 Management of Environmental Impacts

Water Resources

Commitments regarding Cell Sealing and Leachate Collection also pertain.

41) The Proponent will ensure that a site drainage system that will divert clean surface runoff away from areas receiving refuse, for disposal by ground infiltration, will be progressively installed in conjunction with establishment of landfill cells.

42) The Proponent will provide Western Mining Corporation Limited (WMC) with information on total organic carbon and ammonia-nitrogen levels in groundwater samples from monitor bores along the western boundary of Loc. 2170 as soon as practicable following receipt of analytical results. If the levels of these parameters are of concern to WMC, the Proponent will address remedial measures in conjunction with WMC and in consultation with the EPA and Water Authority as appropriate.

Odours

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

43) 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.

44) The Proponent will initiate and maintain a programme to educate the public of obligations under the Litter Act as an adjunct to establishment of the landfill facility.

45) 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.

46) The Proponent will ensure that any landfill related litter along the site access routes is regularly removed.

47) 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.

48) 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.

49) 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.

50) The Proponent will limit the daily hours of operation of the landfill to between 0700 and 1900 hours.

Dust

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

51) 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.

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

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

- the 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.

54) The Proponent will ensure that if a clay lined landfill cell has to be constructed substantially ahead of use and a protective cover layer has been placed to protect the liner from desiccation, the cover material will be stabilized with a temporary cover crop, watering or some other technique.

Pest Species

Commitments regarding Placement and Compaction of Refuse also pertain.

55) 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 will be spread out and carefully covered.

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

Landfill Gas

Commitments regarding Landfill Gas Collection also pertain.

57) The Proponent will liaise with the relevant authorities regarding the beneficial use of landfill gas but envisages that, initially, gas will be disposed of by flaring. When monitoring results indicate that action to manage landfill gas emissions is warranted, the Proponent will determine what this action should be through consultation with the EPA and other relevant authorities.

58) 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.

59) 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.

60) 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.

Social Impacts

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

9.5 Environmental Monitoring

Water Resources

61) 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 50 m intervals along sections of the site boundary down hydraulic gradient from areas used for landfilling.

62) On commissioning of each monitor bore, 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.

63) 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), iron, total organic carbon, five day biochemical oxygen demand, ammonia-nitrogen, and total alkalinity.

64) The Proponent will sample privately owned bores on selected properties in the vicinity of Loc. 2170, initially on an annual basis, and analyze samples for a select range of parameters. These will include pH, salinity (as TDS), and ammonia-nitrogen.

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

66) 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 Water Authority.

67) Any compliant about a deterioration in groundwater quality attributable to the landfill operation will be immediately investigated by the Proponent in consultation with, and to the satisfaction of, the EPA and Water Authority.

68) As soon as leachate is detected in the temporary collection ponds, 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

69) 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 Rockingham and Kwinana municipalities, about the landfill operation will be recorded.

70) From the outset of the landfill operation, access routes to the landfill site will be regularly inspected by City of Rockingham officers to determine whether landfill related littering is occurring along those routes.

71) 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.

72) The Proponent will measure landfill gas flow rates at six monthly intervals following the completion and capping of individual landfill cells. Results will be forwarded directly to the EPA and will also be incorporated into the periodic performance reports.

9.6 Performance Reporting

73) The Proponent will submit annual performance reports to the EPA and Health Department within three months following each anniversary of the commencement of the landfilling operation. These reports will address such matters as:

- the stage that has been 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;
- any unforeseen or extraordinary event associated with the landfill that 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.

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

75) At the same time the periodic performance reports are submitted to the EPA and Health Department, the Proponent will make the reports available to relevant community organizations within both the Rockingham and Kwinana municipal districts.

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

9.7 Contingency Planning

77) 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 and Health Department, and to the satisfaction of the Minister for the Environment as appropriate.

9.8 Management Following Closure

78) 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 Health Department).

10 CONCLUSION

All of the environmental issues and potential impacts associated with the proposed landfill at Loc. 2170 can be addressed by design principles, and ongoing operational practices and specific management measures. The Proponent 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 as 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.

Loc. 2170 and adjoining lands were acquired by ILDA in 1977. In view of ILDA's charter, it is reasonable to conclude that Loc. 2170 (and adjoining lands) were acquired to provide for future industrial development. Further, the present excavation programme at the site has been promoted by ILDA so as to avoid sterilization of the basic raw material resources by future activities. Extractive industry and waste disposal activities (e.g. WMC's nickel refinery tailings disposal site) have been occurring in the Baldivis locality for a considerable time, while the influence of the Kwinana to Jarrahdale railway line upon the surrounding environment is self evident.

In addition, the following future land use proposals for the Baldivis area will also affect the character and amenity of the locality:

- the regional cemetery immediately east of Loc. 2170;
- the wedge of light industrial land which encompasses Loc. 2170 and the lands immediately south; and
- alignment of a regional road link (connecting the future alignments of the Kwinana Freeway extension and the Garden Island Highway) part of which adjoins the southern boundary of Loc. 2170.

In a broader context, residential development within the Leda locality to the north of the Kwinana to Jarrahdale railway and proposals for such development further south along the limestone ridge between Mandurah and Baldivis Roads will produce even further changes in the character and amenity of the locality.

Accordingly, while the Baldivis locality is, ostensibly, a rural setting, established land uses 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 will probably be seen as likely to produce adverse social impacts, the potential for such impacts is not great and can be further reduced by the management

programmes proposed. Additionally, the complaints register to be maintained by the Proponent, and the submission of periodic performance reports (another commitment provided by the Proponent) 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 the site will already have been comprehensively modified through the extractive industry operation. The potential for off-site biophysical impacts will also be low because of the management programmes intended.

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

The risk of groundwater contamination will be reduced 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 by evaporation on-site. Leachate production will be minimal because of the thin layer landfilling practices intended and as each refuse cell will be capped before field capacity is reached. 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.

The thin layer landfilling technique will also reduce the likelihood of scavenging gulls and other pest species being attracted to the site. Nevertheless, the Proponent recognizes that supplementary gull control measures may be needed, and has provided a commitment to support implementation of the recommendations from the Department of Conservation and Land Management relating to the control of Silver Gulls on the Shoalwater Islands. These include measures directed towards the proposed landfill. The Proponent is, therefore, committed to implementing all realistic undertakings that can be provided in respect of gull 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. The Proponent also recognizes that the proposed landfill will be regarded by some as both socially and environmentally undesirable, but is endeavouring to discharge its statutory waste management and disposal obligations in a fully responsible manner.

The Proponent is working with other Local Government Authorities in the south-western sector of the Perth Metropolitan Region towards establishment of a Regional Waste Disposal Council and strategy; it recognizes the desirability of alternative forms of waste management and disposal (as evidenced by its commitment to recycling) but must take cognisance of economic realities; and the proposal for Loc. 2170 incorporates comprehensive design, operational and management initiatives to safeguard environmental values.

Should the landfill proposal procede, the Proponent will instigate thorough monitoring commitments. 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, the Proponent has consulted widely with the local communities and has endeavoured to respond to any 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, the Proponent believes such change has been demonstrated to be manageable and unlikely to produce any unacceptably adverse impacts. The Proponent therefore considers that the proposed landfill at Loc. 2170 should be regarded as environmentally acceptable subject, of course, to the commitments provided.

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12 ABBREVIATIONS AND GLOSSARY

12.1 Abbreviations

AHD	-	Australian Height Datum
Bq/L	-	becquerel per litre
cm/sec	-	centimetres per second
EPA	-	Environmental Protection Authority of Western Australia
ha	-	hectare
HDPE	-	high density polyethylene
ILDA	-	Industrial Lands Development Authority
kL	-	kilolitre
km	-	kilometre
Loc. 2170	-	Cockburn Sound Location 2170, Millar Road Baldivis (the site of the proposed landfill)
Loc. 2209	-	Cockburn Sound Location 2209, Millar Road Baldivis (Western Mining Corporation's tailings disposal site immediately west of Location 2170).
m	-	metre
m^2	-	square metres
mg/L	-	milligrams per litre
mm	-	millimetre
NATA	-	National Association of Testing Authorities
PER	-	Public Environmental Review
PVC	-	polyvinylchloride
WMC	-	Western Mining Corporation Limited
<	-	less than

12.2 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.
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.
Leachate	-	leachate generated within municipal landfills is a complex aqueous mixture comprising soluble and suspended forms of organic and inorganic constituents derived from the decomposition of putrescible refuse.
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	-	The City of Rockingham.

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 (Total Dissolved Solids, TDS)	-	a measure of the content of soluble mineral salts in water or soil; for waters, salinity corresponds to the content of total dissolved solids as determined by evaporative drying.
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 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.

13 PER GUIDELINES

The guidelines issued by the EPA for the proposed landfill were developed in conjunction with the Health Department, the objective being that the PER document should also satisfy the Department's requirements for a proposal and management plan for the establishment and operation of a waste disposal facility.

The guidelines issued are reproduced in full hereunder.

GUIDELINES FOR THE PUBLIC ENVIRONMENTAL REVIEW ON THE PROPOSED WASTE DISPOSAL SITE AT LOT 2170, MILLAR RD , BALDIVIS

These Guidelines identify issues that should be addressed within the Public Environmental Review report (PER). They are not intended to be exhaustive and the proponent may consider that other issues should also be included in the document.

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.

The guidelines have been prepared in consultation with the Health Department of Western Australia in order that the PER meets the Health Departments requirement for a proposal and management plan for the establishment and operation of a waste disposal facility.

The purpose of the PER is to allow all relevant authorities and the public to evaluate the proposal and the possible consequences of the proposed waste disposal facility.

1.0 SUMMARY

The PER should contain 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; and
- conclusions.

2.0 INTRODUCTION

2.1 The Proponent

- name, address, telephone number etc.

2.2 Need for and timing of the proposal.

- reasons for the proposal;
- constraints on current methods of disposal and reasons why not selected;
- objectives of proposal;
- timing of proposal.

2.3 Relevant statutory requirements and approval procedures.

2.4 Purpose and structure of PER.

3.0 ALTERNATIVES

This section should state the basic environmental (including planning), engineering and economic parameters used in the investigation and evaluation of alternative sites. Each site considered should be described at least to provide an appreciation of its salient features.

Factors which should be considered in the above analyses are:

- any inter-relationship between alternative disposal schemes and method and siting of landfill site;
- hydrogeology, proximity to groundwater users, wetlands and water catchments;
- proximity to residential areas;
- soil characteristics;
- access; and
- town planning and land uses.

4.0 DESCRIPTION OF THE PROPOSAL

Some emphasis should be placed on describing landfill design features and operational procedures which minimise environmental impacts.

The description of the proposal should include a discussion of future landfill developments anticipated for the remainder of Lot 2170

4.1 Proposed site.

4.1.1 Ownership and responsibilities

- copy of vesting order or title.
- copy of other relevant agreements relating to use of Lot 2170.

4.1.2 Location

- distance from nearest town boundary
- distance from nearest residential/urban area.
- map or describe distance from nearest residential dwellings.

4.1.3 Zoning

- site zoning or designation; and
- present and future zoning of adjacent areas.

4.2 Proposed method of operation

4.2.1 Site development and design features

- preparatory earthworks removal and excavation;
- design features for leachate and gas control;
- site access and control;
- internal roads construction and maintenance;
- site security and litter control fencing;
- buffer zone development (eg planting of vegetation buffer);
- vehicle washdown facilities; and
- disposal of washdown water.

4.2.2 Planning (provide current estimates for both the proposed local facility and the whole of Lot 2170)

- estimated lifetime of facility;
- estimated volume of waste;
- estimated space available; and
- staging plan.

4.2.3 Operation

- method of operation
  - compaction
  - cover material
  - recycling
- control measures
  - surface water run-off
  - leachate production
  - dust
  - pests
  - fire
  - gas and odour
  - wind blown litter.
  - noise

4.2.4 Waste streams

Describe definite and potential (ie future) waste streams

- types of waste
- quantity of wastes.

4.2.5 Types of waste excluded

- solid
- liquid
- hazardous waste (as defined by the Health Department) should be regarded as a separate issue. Each specific type of hazardous waste should be addressed separately or the site should be designated as unsuitable for the disposal of hazardous wastes.
- instruction for disposal of excluded wastes.

4.2.6 Traffic movement

- access route(s)
- present traffic flow
- anticipated future traffic flow.

4.2.7 Final restoration

- final contours
- proposed after use

5.0 EXISTING ENVIRONMENT

The PER should provide an overall description of the environment and an appraisal of physical and ecological systems likely to be affected by the proposal. It should concentrate on the significant aspects of the environment likely to be impacted by the development. (ie. in particular the processes sustaining the system). Conceptual models or diagrams should be used to illustrate and synthesize the interaction between physical and biological processes that are essential in the maintenance of habitats and resources.

Factors which are likely to be affected by, have an impact on or affect the design and operational requirements of the waste disposal site should be described.

The City of Rockingham should liase with Western Mining Corporation (WMC) and the Authority in regard to proposed groundwater decontamination program and re-siting of the tailings ponds on Lot 2209. The current situation and expected changes in groundwater quality resulting from WMC's proposal should be breifly described in the PER.

5.1 Hydrogeological considerations

- distance between groundwater and waste
- likelihood of prefered pathway flows
- maximum groundwater levels
- groundwater movement direction and pattern
- location of any groundwater withdrawal areas
- location of nearby bores

5.2 Other existing environment features which may be relevant, for example;

- water resources (ground and surface flows)
- flora & fauna
- landform
- reserves & EPA Red Book Areas
- aesthetics
- climate (especially with respect to dominant wind direction & rainfall)
- proximity to housing
- historical, archaeological and ethnographic sites.

6.0 ENVIRONMENTAL IMPACT OF THE PROJECT

This is the most important section of the PER and the discussion should show the overall effect of the proposal on the ecosystem and surroundings during implementation of the project, utilisation of the facility for waste disposal, and during and after rehabilitation. Potential cummilative effects from future landfill operations likely on Lot 2170 should be considered.

The objective is to predict potential impacts on the environment. Impacts should be quantified where possible. Criteria for making assessments of the significance of impacts should be outlined. Compliance with relevant standards such as the (proposed) Metropolitan Waste Strategy should be demonstrated. It may be necessary to determine impacts on individual components of the environment before an overall assessment of the potential impact of the proposal is made.

6.1 Describe how specific components of the proposal will have an effect on the environment . The following components should be considered;

- describe (quantitatively where possible) likely effects of the project on groundwater resources, water courses and drainage systems.
- odour
- litter
- machinery noise
- spread of *Salmonella* by pests (eg Seagulls)
- gas generation (methane and carbon dioxide; relationship to greenhouse effect theory)
- social impacts (land values and transportation)

6.2 Summary of environmental components for which the impact can be minimised by management or sound landfill design.

- proposed collection and disposal of or treatment of collected leachates. An estimate of the quantity and quality (predicted chemical constituents and concentration) of leachate produced and collected should be provided, based on leachate monitoring results from other Swan Coastal Plain refuse disposal sites.
- feasability of methane recovery.

6.3 Summary of unavoidable deleterious effects on the environment (eg vegetation changes, physiographic changes, etc).

7.0 WASTE DISPOSAL MANAGEMENT

7.1 General waste disposal management philosophy.

7.1.1 General philosophy.
7.1.2 Statutory procedures under which the project will be undertaken.
7.1.3 Liaison with other local authorities and private industry regarding the use and management of the facility.

7.2 Specific objectives

7.2.1 Compliance with State Government notification, advice, guidelines, proposals and/or strategies.
7.2.2 Other specific objectives

7.3 Community involvement.

- discuss past and planned community involvement, and community attitudes.

7.4 Any proposed recycling activities.

8.0 ENVIRONMENTAL MANAGEMENT AND MONITORING

The purpose of the management and monitoring programme is to demonstrate amelioration of environmental impacts. Authorities responsible for management, administration, costs and funding including long-term contingencies should be clearly identified. Monitoring results should lead to amendments in the management plan and the manner in which this takes place should be emphasised. Environmental safeguards including contingency planning for untoward and/or infrequent events should be included. Procedures for reporting the results of monitoring and management to appropriate authorities should be given.

8.1 Specific proposals for managing the project to minimise impact on the environment.

For example, rehabilitation and end use, stabilisation of waste disposal area, odour control, litter control, prevention of pollution, capping or lining of site, leachate collection and disposal etc. Ongoing management responsibility following closure of site.

8.2 Proposals for monitoring.

- Discuss adequacy of monitoring bores in relation to site hydrogeology.
- Discuss relationship of monitoring proposals for WMC's bores and monitoring proposals for the detection of chemicals typically found in tip leachates.
- Discuss which typical leachate chemicals are to be monitored, analytical methods, frequency of monitoring and reporting procedures.

8.2.1 Proposed monitoring during use of the site (eg. complaints record etc).
8.2.2 Ongoing monitoring proposals after closure of site to ensure long-term prevention of water pollution and other environmental pollution.

8.3 Proposals for management

- Determine levels of contaminants/pollutants in groundwater which will cause preparation and activation of management proposals to deal with groundwater pollution.

9. PROPOSED TIMETABLE

9.1 Schedule timing for proposal.

9.2 Need for such timing.

10. COMMITMENTS

It is important that specific commitments are given to all components and procedures of the management and monitoring programme. These should be listed and phrased as follows;

The commitment should include (a) **WHO** will do the work, (b) **WHAT** is the nature of the work, (c) **WHEN** the work will be carried out and (d) to **WHOSE SATISFACTION** the work will be carried out, and when appropriate (e) **WHERE** the work will be carried out.

11. CONCLUSION

An assessment of the environmental acceptability of the project in terms of its overall environmental impact and in the context of the proposed management programme should be given.

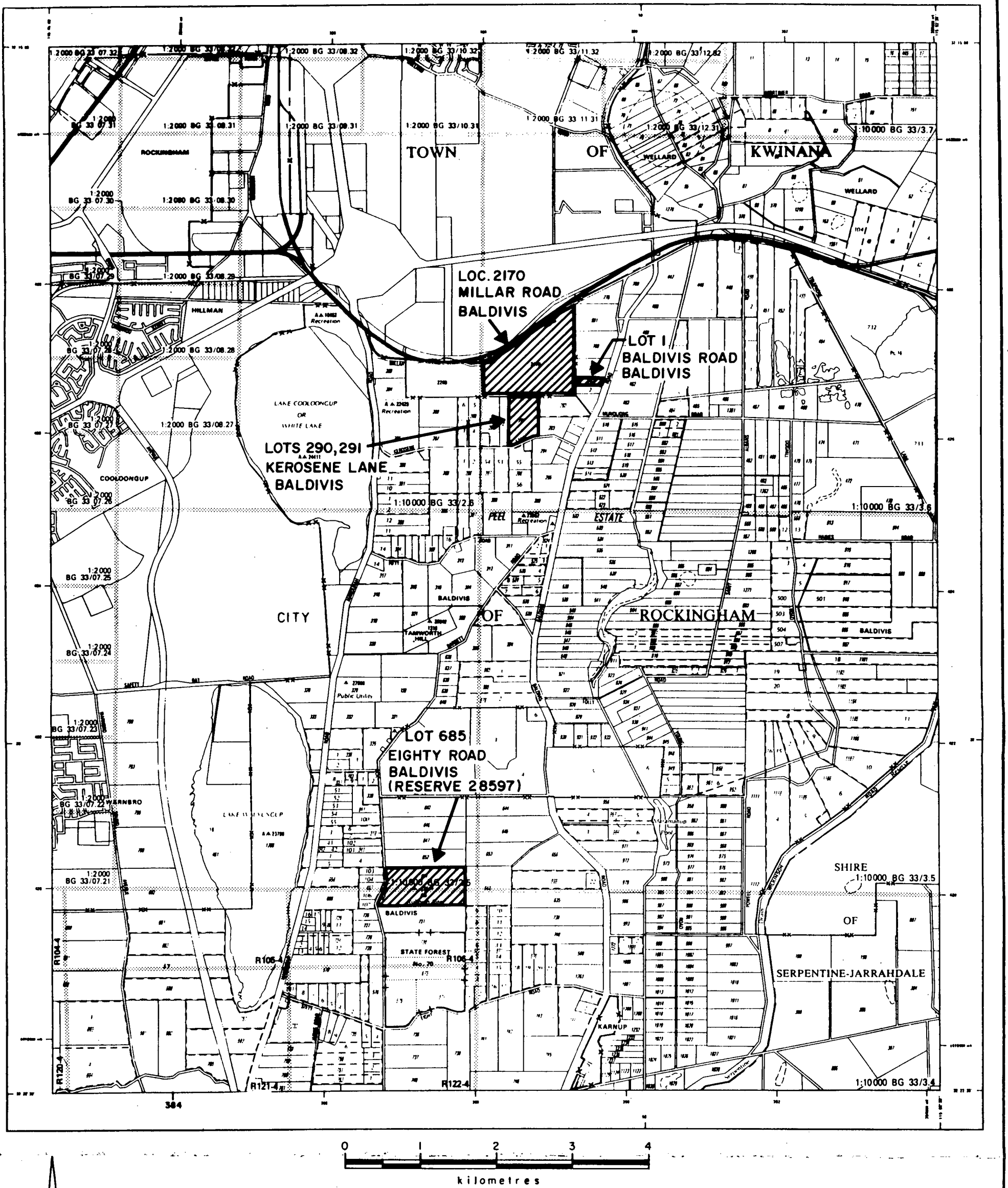
12. REFERENCES

13. GLOSSARY

- Provide definitions of technical terms and abbreviations).

14. PER GUIDELINES

15. APPENDICES



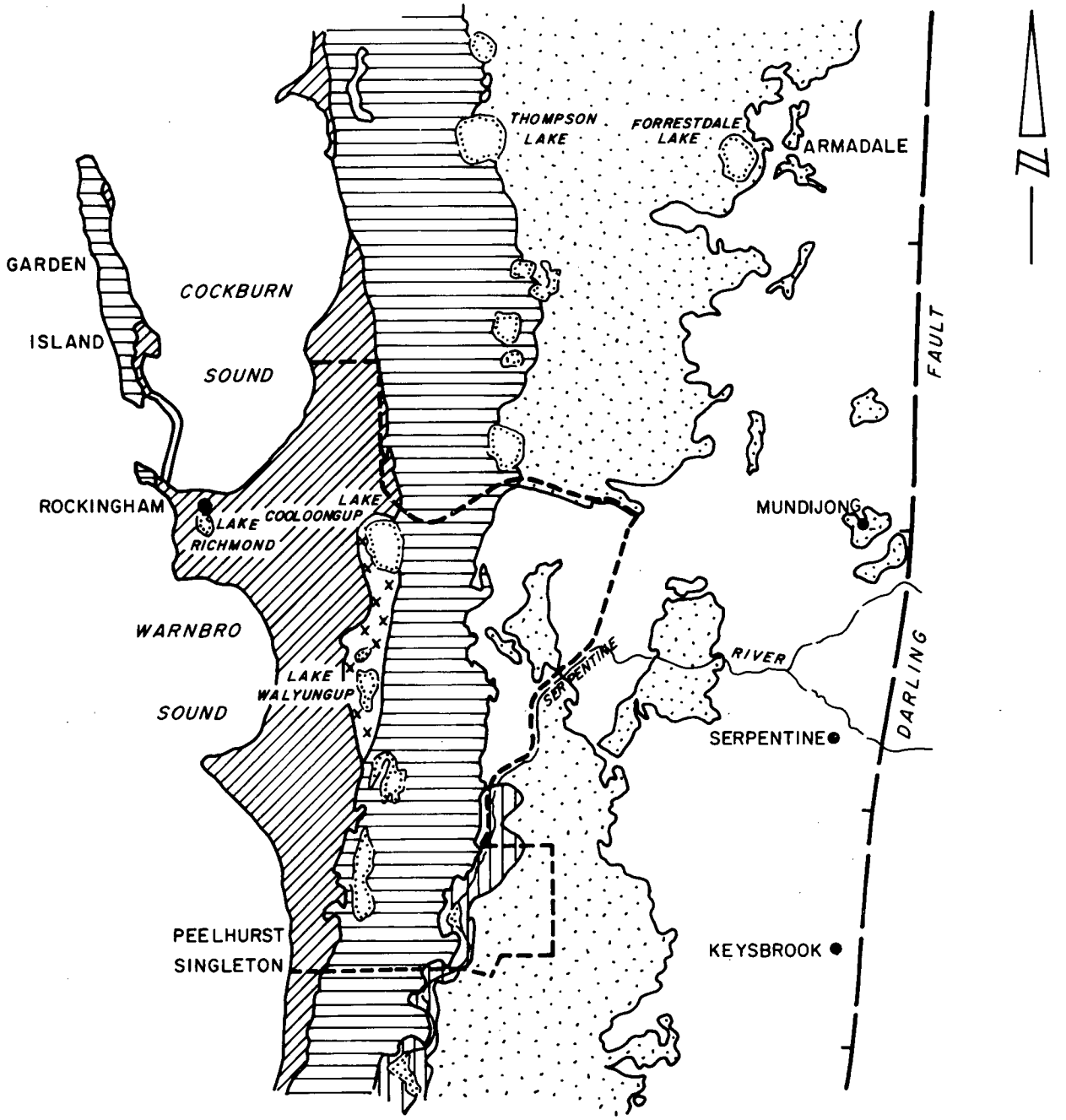
REVISIONS	Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AGC
Woodward–Clyde

CITY OF ROCKINGHAM LANDFILL

ALTERNATIVE LANDFILL SITES

Date April '91 | Dwg. 2381-3 | Fig. 1



LEGEND

- TAMALA LIMESTONE FORMATION
- SAFETY BAY SAND
- BASSENDEAN SAND
- LAGOONAL DEPOSITS
- ALLUVIAL RIVER DEPOSITS
- GUILDFORD FORMATION
- LAKE SYSTEM
- CITY OF ROCKINGHAM LOCAL GOVERNMENT BOUNDARY

SCALE 1 : 250 000

REVISIONS					
Rev.	DESCRIPTION	Drawn Date	Chk'd Date		

AGC Woodward-Clyde

CITY OF ROCKINGHAM LANDFILL

REGIONAL GEOLOGY

Date APR. '91 | Dwg. 2381-4 | Fig. 2

REVISIONS

Rev	DESCRIPTION	Drawn Date	Chkd Date

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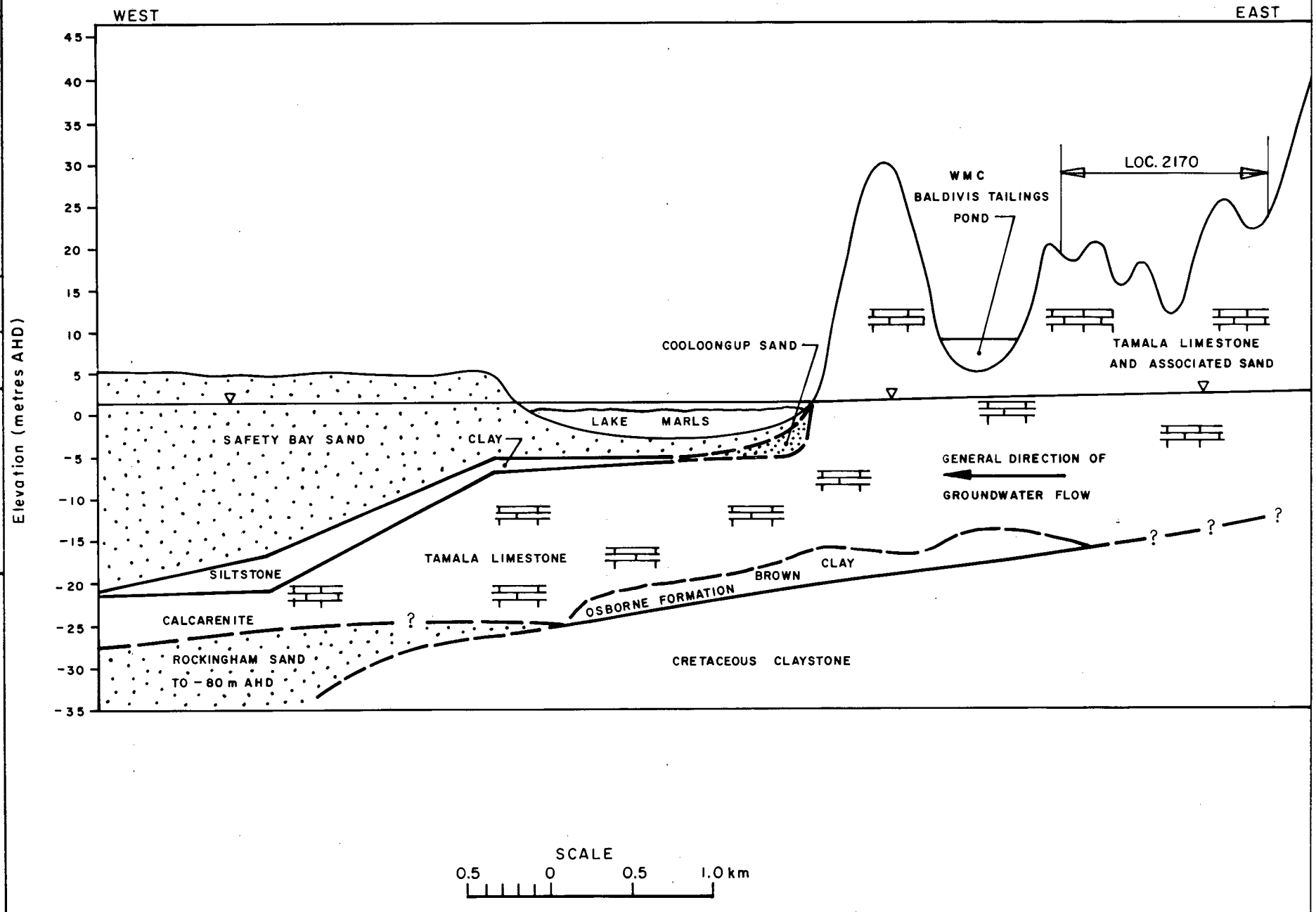
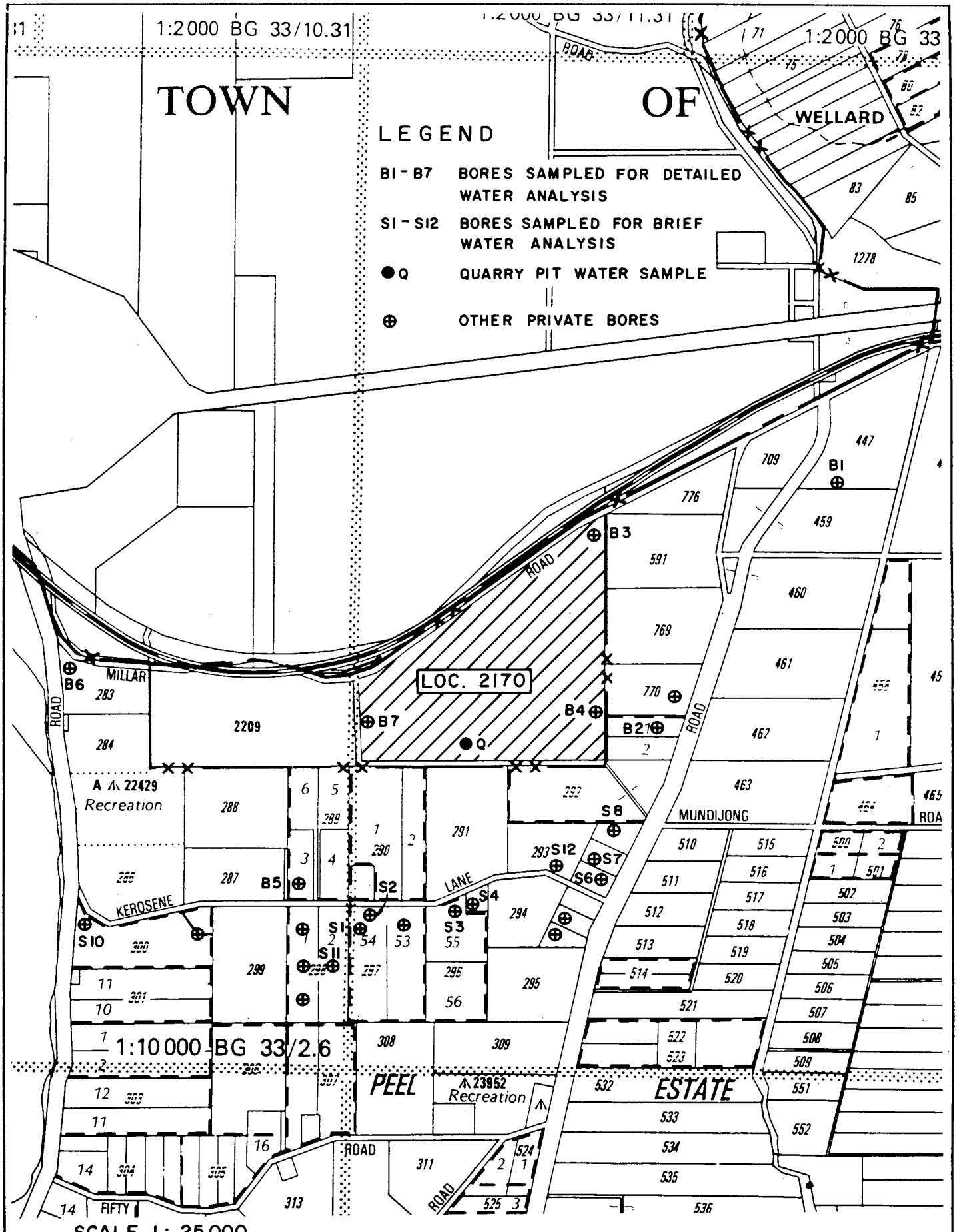
CITY OF ROCKINGHAM
BALDIVIS LANDFILL
LOCAL HYDROGEOLOGY

Date APR. '91 | Dwg. 2381-5 | Fig. 3





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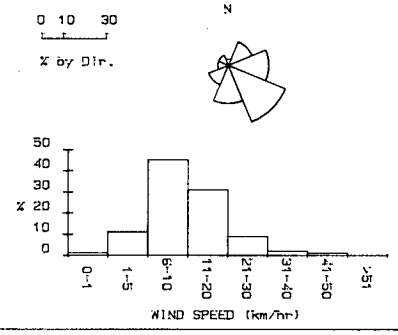
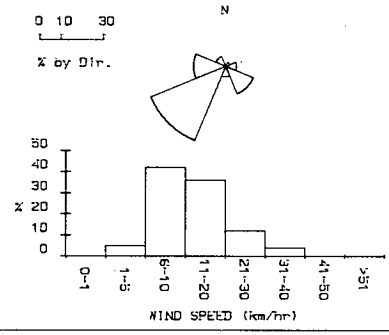
CITY OF ROCKINGHAM LANDFILL
GROUNDWATER SAMPLING
POINTS AND LOCATION
OF NEARBY PRIVATE BORES

Date APR. '91 | Dwg. 2381-6 | Fig. 4

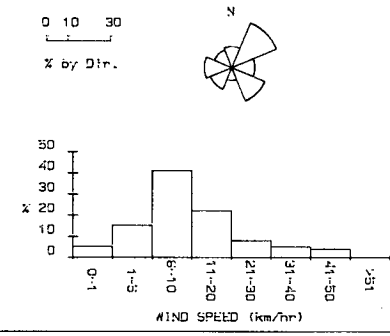
9.00 a.m.	3.00 p.m.	9.00 a.m.	3.00 p.m.

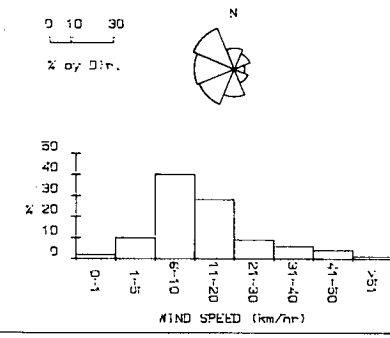
SUMMER



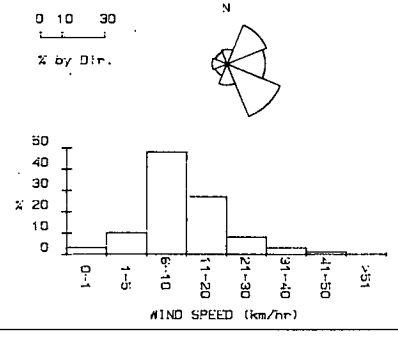


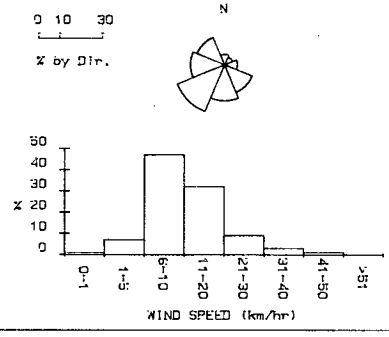
WINTER



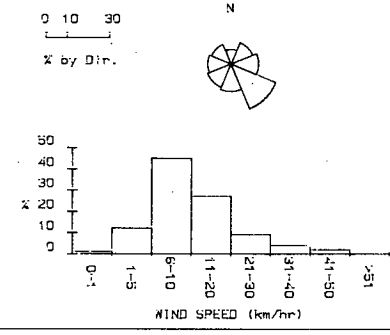


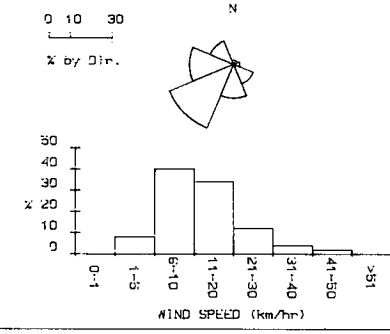
AUTUMN





SPRING





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SURFACE WIND ANALYSIS MANDURAH

Date:	Dwg:	Fig:
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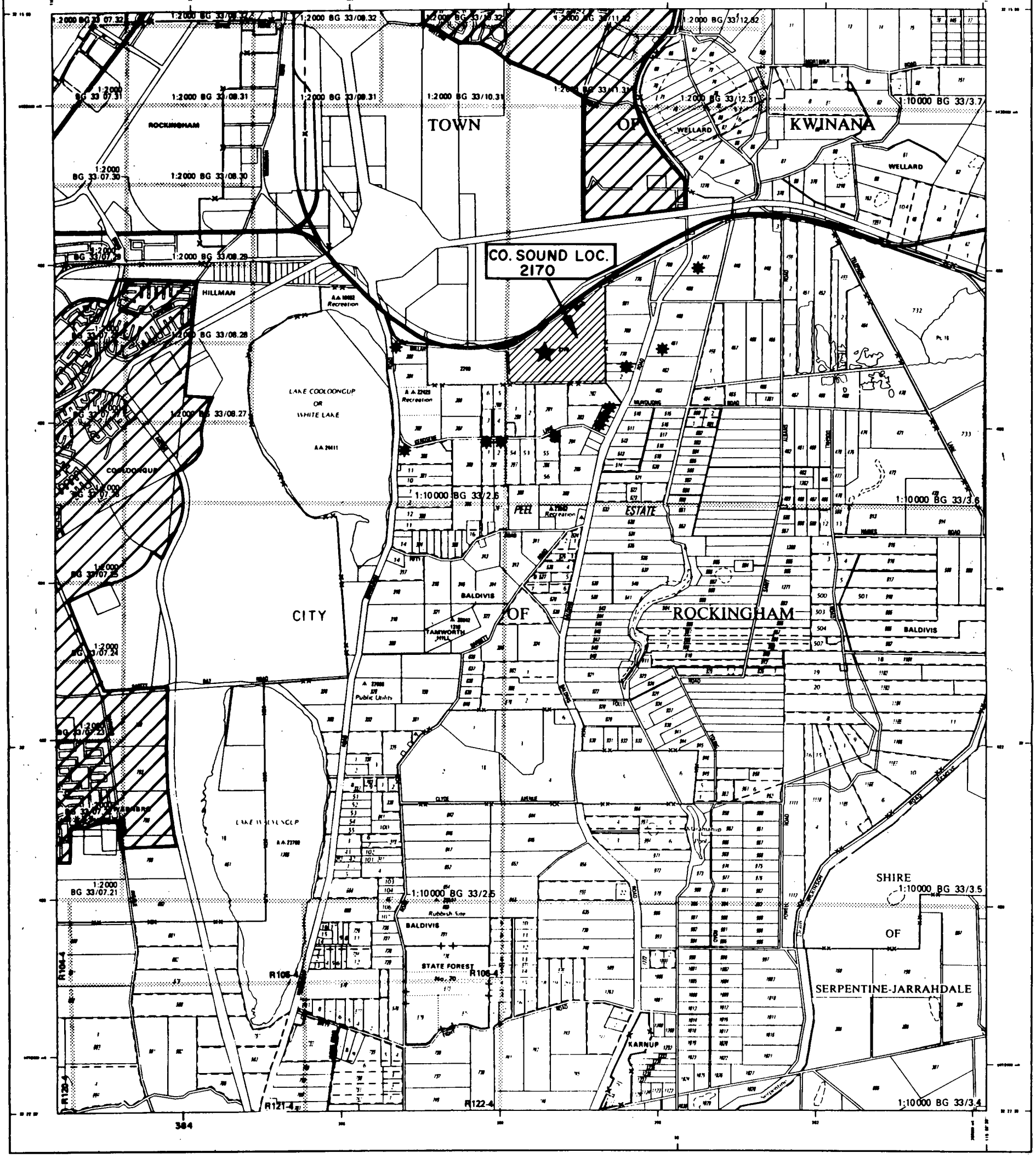

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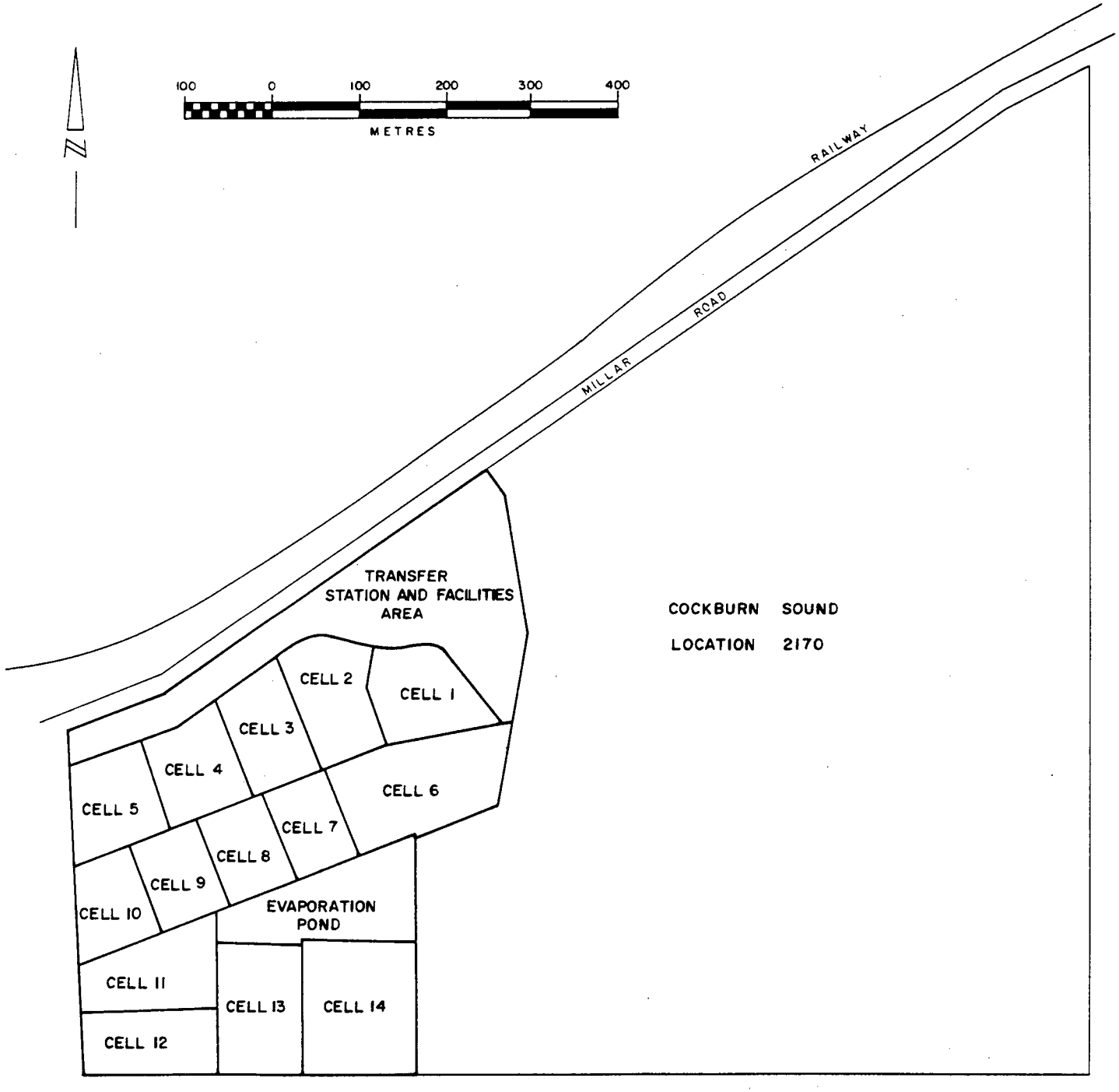
CITY OF ROCKINGHAM LANDFILL

EXISTING NEARBY RESIDENCES AND RESIDENTIAL AREAS

Date April '91 | Dwg. 2381-10 | Fig. 8



STAGE	YEAR
TRANSFER STATION AND FACILITIES AREA	1991 / 92
CELL 1	1991 / 92
CELL 2	
CELL 3	1992 / 93
CELL 4	1993 / 94
CELL 5	1994 / 95
CELL 6	1995 / 96
CELL 7	1996 / 97
CELL 8	1997 / 98
CELL 9	1998 / 99
CELL 10	1999 / 2000
CELL 11	2000/ 01
CELL 12	2001/ 02
CELL 13	2002/ 03
CELL 14	2003/ 04
EVAPORATION POND	NOT LATER THAN 2003/04

AGC WOODWARD - CLYDE

COCKBURN SOUND LOCATION 2170

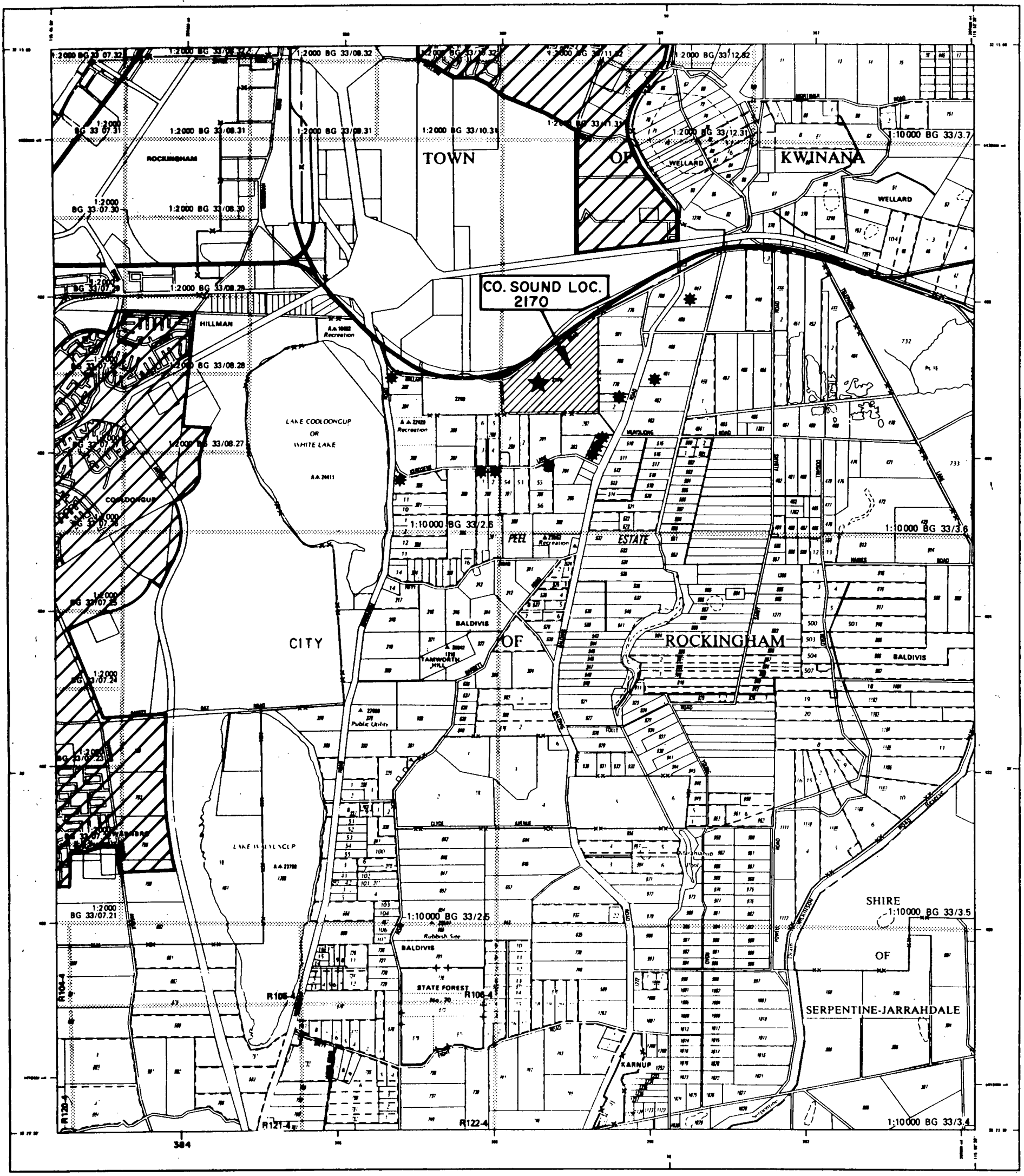
MILLAR ROAD, BALDIVIS

CITY OF ROCKINGHAM

PROPOSED LANDFILL

PROGRESSIVE SITE ACQUISITION

APRIL, 1991	DWG.NO. 2381-9	FIG. 7



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Rev.	DESCRIPTION	Drawn Date	Chk'd Date	

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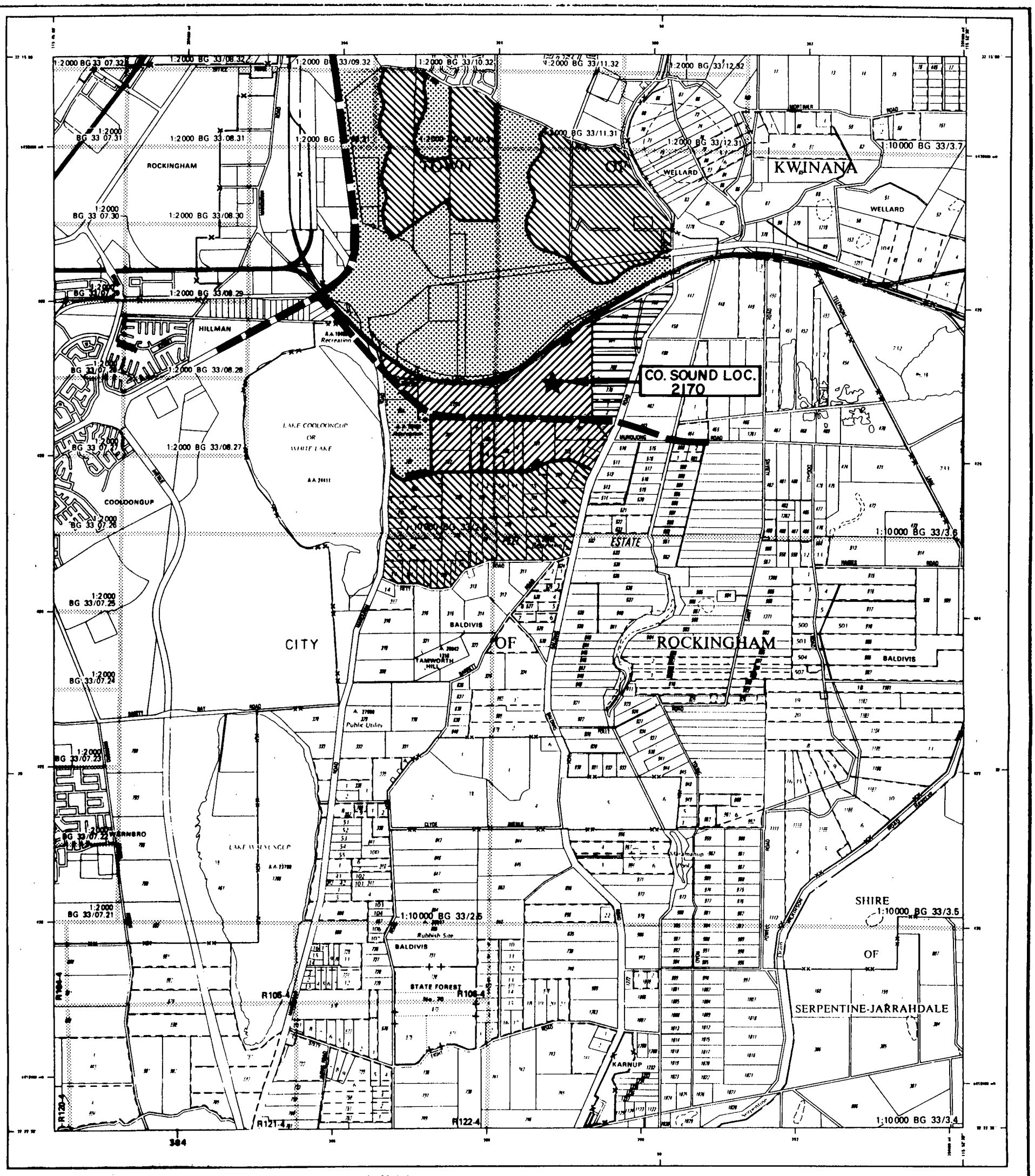
Woodward–Clyde

CITY OF ROCKINGHAM LANDFILL

EXISTING NEARBY RESIDENCES AND RESIDENTIAL AREAS

Date April '91 | Dwg. 2381-10 | Fig. 8



0 1 2 3 4

kilometres

LEGEND

- OPEN SPACE
- LIGHT INDUSTRY
- REGIONAL CEMETERY
- RESIDENTIAL
- REGIONAL ROAD
- ★ CO. SOUND LOC. 2170

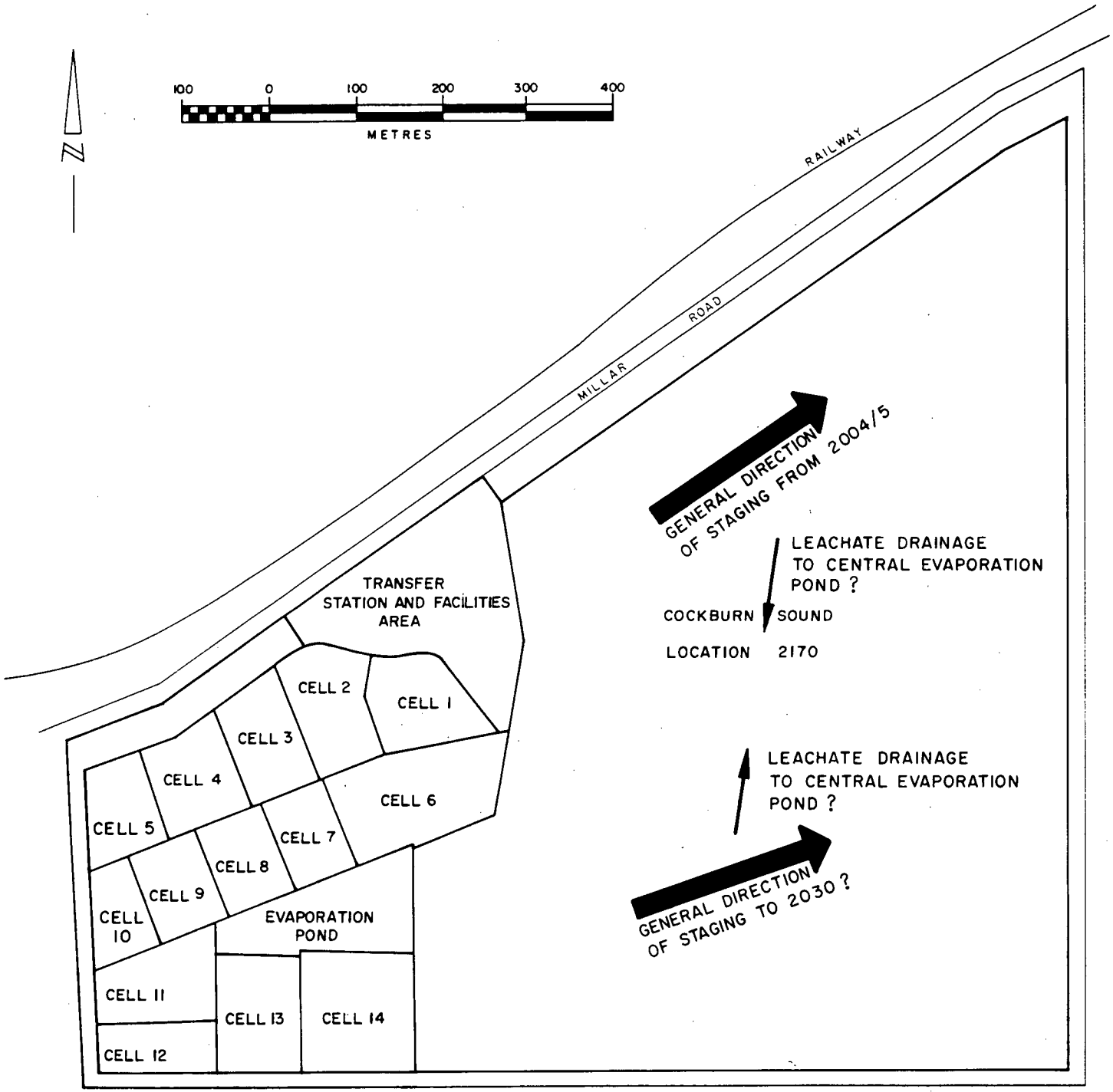
N

REVISIONS				
Rev.	DESCRIPTION	Drawn Date	Chk'd Date	

AGC Woodward–Clyde

CITY OF ROCKINGHAM LANDFILL
INDICATIVE LAND USE PROPOSALS FOR BALDAVIS & LEDA LOCALITIES NEAR CO. SOUND LOC. 2170

Date April '91 | Dwg. 2381-11 | Fig. 9

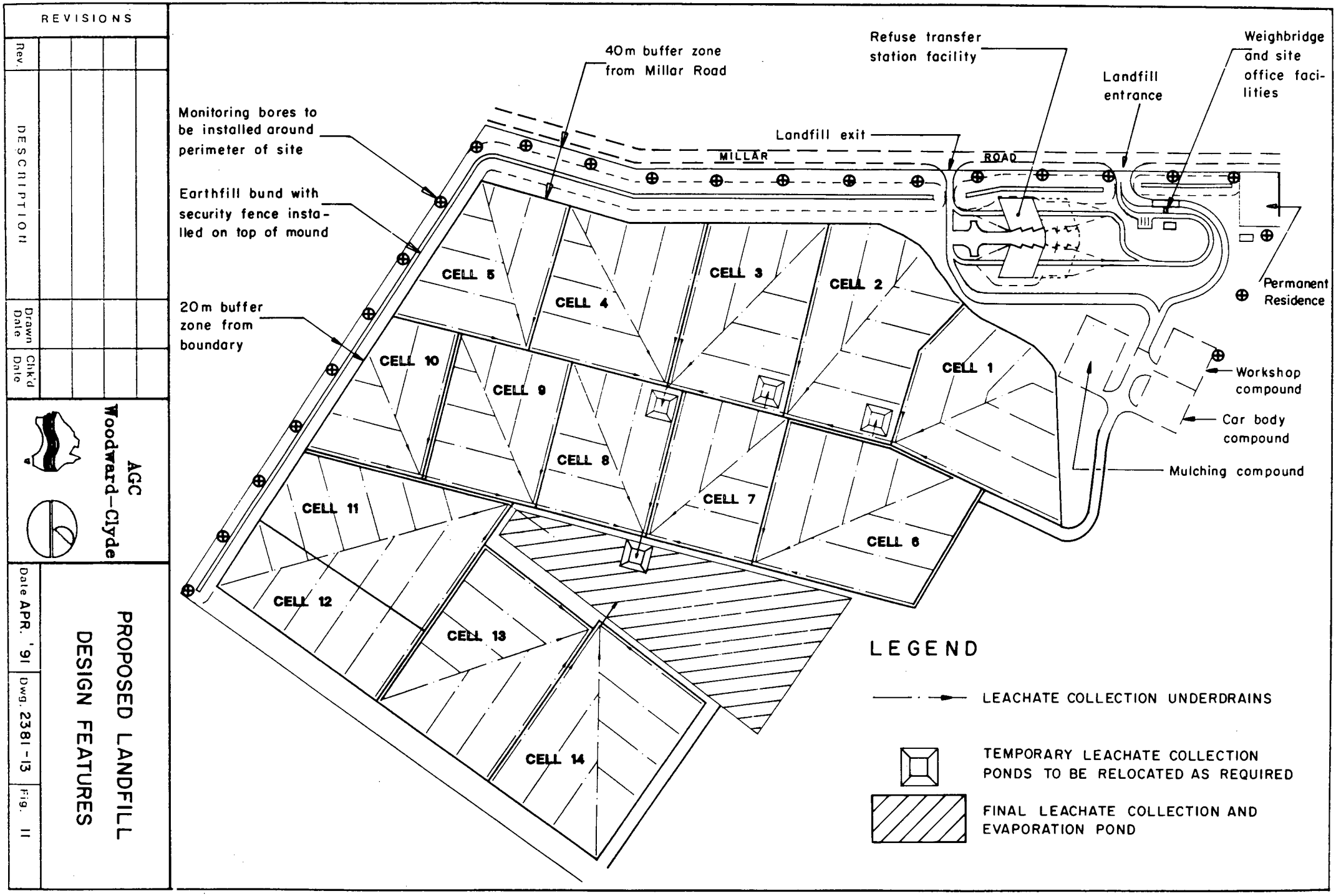


NB: If landfilling extends into eastern portion of Loc. 2170, buffer requirements in the north eastern and south eastern sectors of the site will need to be determined during detailed planning. The current peripheral buffers (ie 40m along Millar Road and 20m elsewhere) may not be adequate in these parts of the site.

AGC WOODWARD - CLYDE

COCKBURN SOUND LOCATION 2170
MILLAR ROAD, BALDIVIS
POSSIBLE SEQUENCE AND TIMING OF LANDFILLING BEYOND 2003/4

APRIL, 1991	DWG. NO. 2381-12	FIG. 10


REVISIONS
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DESCRIPTION
Drawn Date
Chk'd Date
AGC Woodward-Clyde
PROPOSED LANDFILL DESIGN FEATURES
Date APR. '91
Dwg. 2381-13
Fig. 11
40m buffer zone from Millar Road
Refuse transfer station facility
Weighbridge and site office facilities
Landfill entrance
Landfill exit
MILLAR ROAD
Monitoring bores to be installed around perimeter of site
Earthfill bund with security fence installed on top of mound
20m buffer zone from boundary
CELL 1
CELL 2
CELL 3
CELL 4
CELL 5
CELL 6
CELL 7
CELL 8
CELL 9
CELL 10
CELL 11
CELL 12
CELL 13
CELL 14
Permanent Residence
Workshop compound
Car body compound
Mulching compound
LEGEND
LEACHATE COLLECTION UNDERDRAINS
TEMPORARY LEACHATE COLLECTION PONDS TO BE RELOCATED AS REQUIRED
FINAL LEACHATE COLLECTION AND EVAPORATION POND

MILLAR ROAD

EXIT

ENTRY

EARTHEN EMBANKMENT

WEIGHBRIDGE

SITE OFFICE

PERMANENT RESIDENCE

4 5 6 10 11 12

1 2 3 7 8 9

REFUSE LOADING BAY & BIN MOVEMENT AREA

TRANSFER STATION ROOF STRUCTURE OVER REFUSE DISPOSAL AREA

CAR PARK

SITE AMENITIES

RECYCLING AREAS

PRIVATE VEHICLE ACCESS TO TRANSFER STATION

MUNICIPAL AND HEAVY VEHICLE ACCESS TO TIP

INITIAL CONSTRUCTION OF 6 BAYS FOR WASTE DISPOSAL

FUTURE CONSTRUCTION OF 6 BAYS FOR WASTE DISPOSAL

LIMIT OF BITUMEN ROADS

SECURE COMPOUND

CAR BODY DUMP

AREA AVAILABLE FOR FUTURE RECYCLING OPTIONS

APPROXIMATE BOUNDARY OF TRANSFER STATION AREA

TIP ACCESS ROAD

SCALE

0 10 20 30 40

metres

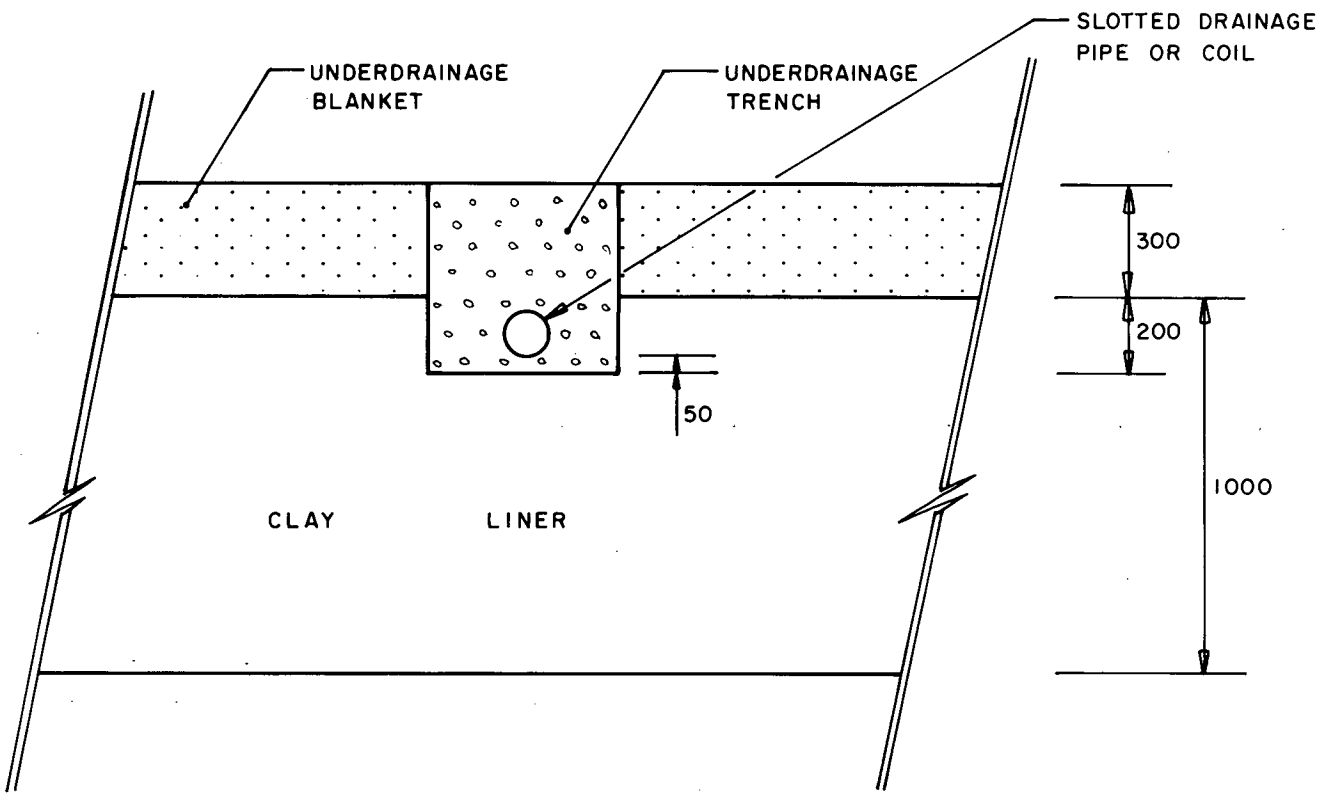
REVISION				
	DESCRIPTION	Drawn Date	Chk'd Date	

AGC Woodward-Clyde

300 ALBANY HIGHWAY, VICTORIA PARK, W.A. 6100. (09) 3624322

TRANSFER STATION
GENERAL DESIGN FEATURES

Date APRIL 1991 | Dwg. 2381 - 14 | Fig. 12



REVISIONS	Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AGC
Woodward-Clyde

CROSS SECTION OF LEACHATE COLLECTION DRAIN

Date APR. '91 | Dwg. 2381-15 | Fig. 13

REVISIONS

Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AGC Woodward-Clyde

TYPICAL CROSS SECTION THROUGH LANDFILL CELL

Date APR. '91 | Dwg. 2381-16 | Fig. 14