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A FUTURE LANDFILL FOR DUNEDIN

REF:38/1/1

DUNEDIN CITY COUNCIL

MEMORANDUM

TO:	**CHIEF EXECUTIVE**
FROM:	DRAINAGE AND REFUSE MANAGER
DATE:	21 APRIL 1993
SUBJECT:	**SOLID WASTE MANAGEMENT STRATEGY - FUTURE LANDFILL**

INTRODUCTION

This report sets out recommendations on Dunedin's future principle landfill site once the present development at Green Island is complete.

BACKGROUND

The method which Council adopts for solid waste disposal is an integral part of its Solid Waste Management Strategy in that once every practical effort has been taken to minimise waste, the remainder must be safely disposed of. This report deals with the issue of which of the alternative sites of Smooth Hill or the Extended Green Island should be chosen as Council's preferred future landfill site.

This could be viewed as 'putting the cart before the horse' in that the landfiling and future landfill site is simply one issue of the total Solid Waste Management Strategy. It is however, a major issue in itself and there is no doubt that a landfill will always be needed in the future.

It is proposed to report to the Works Operations Committee on the 14th June 1993 on the comprehensive Solid Waste Management Strategy.

FUTURE LANDFILL

This report on the Future Landfill draws on the relevant material contained in the Consultant's (Beca Steven) reports entitled:

(1) Refuse Management Strategy for Dunedin City

(2) Environmental Impact Assessment of the Existing Green Island Landfill.

(3) Environmental Impact Assessment of the Smooth Hill Sanitary Landfill.

(4) Environmental Impact Assessment of the Extended Green Island Sanitary Landfill.

together with the public submissions received on all of these documents, a report prepared by D Ogilvie on leachate characterisation and receiving water monitoring and an audit of the consultant's report carried out by Woodward–Clyde as a requirement of the Otago Regional Council.

Copies of the Beca Steven reports have been made available in the Councillor's Lounge since October 1992.

RECOMMENDATIONS OF THE REPORT

The principle recommendations of the report are that the Extended Green Island proposal be Council's preferred option subject to environmental performance measures being met. It is also proposed that the Smooth Hill site be procured now and that zoning changes and designations as appropriate be obtained for both sites to secure long term landfill sites for Dunedin City.

The detailed report is attached.

Trevor Buchanan
DRAINAGE AND REFUSE MANAGER

FUTURE LANDFILL

A. INTRODUCTION

In the search for a new landfill site to succeed the existing Green Island landfill, some 32 possible landfill sites have been reviewed. Each site has been flown over, walked over, and considered ecologically, physically, socially and economically. Finally the two sites of Smooth Hill and the Extended Green Island were selected for detailed evaluation resulting in the Environmental Impact Assessments.

The selection process reduced the number of sites from 32 to 11 for closer review, then down to a short list of five. From this the choice of two sites was achieved as a result of considerable thought and input from the Consultants, the Refuse Working Party (including representatives from environmental, industrial and residential groups), the Tangata Whenua, and individual members of the public, together with input from Regulatory Bodies, Councillors & Council Staff. Consensus was reached on the two sites of Smooth Hill and Extended Green Island being recommended for detailed evaluation and the preparation of Environmental Impact Assessments (E.I.A's). The other 30 sites have been ruled out for various, mainly technical, reasons. This recommendation was subsequently approved by Council on 4 February 1992.

<u>A decision now has to be made as to the preferred site for Dunedin's future landfill and planning procedures commenced to have the site appropriately designated or rezoned.</u>

Public input through public meetings, telephone hot line, written submissions and personal interviews with affected residents have also resulted in, not surprisingly, disparate views. Public responses were encouraged through the distribution of tabloids, pamphlets, direct mailings (over 4,000 to possibly affected residents in Brighton and Green Island) and 5 public meetings. Public submissions closed at the end of February 1993.

A total of 143 submissions were received from individuals and groups and from the summary, the following statistics are apparent:-

Approved the Extended Green Island Site	–	36%
Disapproved the Extended Green Island Site	–	15%
Approved the Smooth Hill Site	–	13%
Disapproved the Smooth Hill Site	–	30%
Disapproved both Sites	–	3%

B. THE ALTERNATIVE SITES – Report Attachments

The following information is attached to this report:

Appendix A	–	Table indicating the Site Selection Process
Appendix B	–	Map of area with landfill sites marked up.
Appendix C	–	A table summarising the basic features of Smooth Hill and the Extended Green Island sites.
Appendix D	–	The Consultant's (Beca's) "Summary & Conclusions" for Smooth Hill.
Appendix E	–	The Consultant's "Summary and Conclusions" for the Extended Green Island Site.
Appendix F	–	The Conclusion for the existing Green Island Landfill.
Appendix G	–	Costings Section from the Extended Green Island E.I.A.
Appendix H	–	Costings Section from the Smooth Hill E.I.A.
Appendix I	–	Summary Table of Public Submissions
Appendix J	–	Brighton and Green Island Direct Mailing Areas
Appendix K	–	Green Island Landfill, Boundaries and Zonings.
Appendix L	–	Solid Waste Management Strategy (Key Issues) and public submission form.
Appendix M	–	Okokia Creek Water Qualiity Review
Appendix N	–	Woodward Clyde Audit of Green Island Leachate Management Proposals.

C. KEY ISSUES

The solid waste disposal method is an integral part of the solid waste strategy. Thus following from a policy of first minimising waste, which is the subject of a separate report, the remainder must be safely disposed of.

The following are key issues relating to the choice of Smooth Hill and the Extended Green Island sites for landfills.

1. Extended Green Island Sanitary Landfill

- The site has been technically assessed as being suitable for the future landfill.

- The proposed mound would be no higher than 15 metres above the existing landfill. The sides of the mound would be gently sloping.

- The extended landfill, operating as a sanitary landfill will have a life of some 25 years at present filling rates.

- The necessary environmental upgrades including leachate control and landscaping will need to proceed at the Green Island landfill whether the future landfill remains at Green Island or goes to Smooth Hill (with possibly a transfer station remaining at Green Island). Funding has been allowed for much of the upgrades in the 1992/93 financial year (some $2.2M of the $2.9M required including a leachate collection system and a bentonite slurry seal wall but excluding a transfer station, landfill gas collection/utilisation, and some land purchase.)

  However as agreement has not yet been reached with respect to various water discharge and extraction rights between the Council, the Otago Regional Council and Submitters, only a pull back of the landfill on the western side adjacent to the Kaikorai Stream to allow construction of the leachate collection system has been completed. Regardless of agreement, design work on the leachate collection system is proposed to commence in May 1993. It is also proposed that landscaping and planting work commence over the 1993 winter.

- The leachate collection system and other environmental upgrades proposed for the existing Green Island landfill will also be satisfactory for the extended landfill. An audit of the proposal carried out by Woodward-Clyde and as required by the Otago Regional Council for the environmental upgrades at the existing Green Island landfill states that "With the proposed leachate collection system in place and operating effectively the above issues (relating to a deeper landfill) are unlikely to significantly increase the risk of leachate movement to the Kaikorai Stream via groundwater flow paths"

- In general terms less than 20% of the pollutional load in the Kaikorai Stream and Kaikorai Estuary comes from the landfills (both Maxwells and Green Island). But 80% of the nutrient ammonia load which helps cause eutrophication of waterways does come from the landfills. The leachate collection system will reduce the pollutional load on the Kaikorai Stream and Estuary particularly in terms of nutrients. However an immediate improvement to the Kaikorai Stream and Estuary will not occur due to existing non-point source discharges from urban and rural run-off and past industrial activity.

  To assist in reducing the strength of the leachate, it can be recycled through the landfill itself by subsurface irrigation. In addition to this it is possible that the leachate from the landfill will require more pre-treatment before discharge to the Green Island wastewater treatment plant.

- The lower Kaikorai Stream and Estuary is a haven and feeding ground for many types of bird species.

- Hazardous and Special wastes will be treated, if accepted, in accordance with C.A.E. (Centre for Advanced Engineering), US EPA and other appropriate guidelines. In many cases we do not accept hazardous substances e.g. Toxic organic compounds.

- Sanitary landfill techniques will further decrease litter, dust, odour, vermin and birds. Controls to date using litter fences, smaller working faces and regular cover have helped. Sealing main access roads will considerably reduce dust and bunds and planting should decrease machinery noise.

- Stormwater control will be carried out using settling ponds.

- Cover material could be obtained from the adjacent hill or purchased as now from local quarries and other sites. Bark, wood waste (not tanalised) and shredded green garden waste could also be used for cover depending on delivered cost.

- If the project is viable collected landfill gas will be utilised in conjunction with possible gas production from the Green Island Wastewater treatment plant. Sufficient gas could be available on a 24 hours basis to produce 1 to 2 Megawatts of power.

  The integration of the two waste processes and the resultant production of gas have the potential of using a valuable resource to power, in part, the operation of the wastewater treatment facilities.

- The extended landfill mound will have a major visual impact but will be softened by landscaping and screen tree planting. The landscaping should be extended to include the Green Island Wastewater treatment plant and both sides of the Kaikorai Stream and Estuary from Green Island to the Estuary Coastal beach. With the right vision we can turn a less than desirable area into a recreational, wildlife and scenic asset.

- Other facilities at the landfill must be made attractive or effectively masked. The use of tree planting and high wind proof netting fences can be used to hide car bodies, scrap steel piles and make more attractive the domestic recycling area.

- At this stage it is considered that a transfer station will not be required. However if a collection type transfer station enhances the sanitary landfill operation then such a transfer station would be proposed. This form of transfer station is about half the cost of a compactor type.

- An archeological survey of the site and adjacent areas should be carried out.

- Monitoring must be thorough and required operational standards met. Monitoring would include – noise, odour, dust and particulate matter, landfill gas quality and location, leachate, stormwater pond turbidity, receiving waters i.e. Kaikorai Stream, Kaikorai Estuary, and the Green Island Wastewater Treatment Plant Sea Outfall.

- For Management and effective monitoring and cost control it is highly desirable to install a weigh-bridge to determine incoming solid waste tonnages accurately. This will be even more of an issue as disposal costs rise from the present $15 per tonne to say $24 per tonne and accurate assessment of disposal fees becomes essential (present fees are assessed on the basis of a visual assessment of volume!).

- Monitor effects on residential areas adjacent to landfill operations.

2. **Smooth Hill**

- The site is technically suitable for a sanitary landfill. Apparent ground surface instability is quite shallow and would be removed as part of the site preparation process.

- The site has a capacity of some 50 years at present filling rates.

- The Consultants state that there is no risk of contamination by leachate at the Brighton Estuary or beach. Currently the Otokia Creek is seriously affected by nutrients from rural run-off and is eutrophic in many sections of its approximately 13 km length.

- A 600mm thick compacted clay liner would be installed complete with a leachate collection system thus containing leachate within the site. It is likely that the leachate would be treated on site but tankering away is a possibility.

- Cover material would be obtained by site stripping.

- Access to the landfill would be by State Highway One. There will be limited access generally and no domestic public access.

- Transfer stations in the Dunedin area would be required. A favoured location is the current Green Island Landfill site. Recycling, car and steel storage and composting could then remain at that site. Any other major transfer station within the City should also provide for extensive recycling.

- Transportation and transfer station costs for solid waste disposal at Smooth Hill will have a major impact on the cost of disposal at this site.

- The cost to the Dunedin community at large will be greater with Smooth Hill than with the Extended Green Island Landfill.

- Sanitary landfill techniques will minimise dust, noise, odour and vermin.

- Access roads should be sealed, certainly on steep inclines. It is possible that a separate haul road to McClaren Gully Road could be developed. The turn off from S.H. 1 must be designed to ensure safe traffic movements on and off the highway.

- The method for transportation of solid waste from Dunedin will be reviewed regularly. Rail from say Burnside to McClarens Gully is still more expensive than truck and trailer road transporters but this remains an option for the future.

- Hazardous and special waste will be treated, if accepted, as per C.A.E. and/or other appropriate guidelines.

- The landfill gas will be collected and flared off. It can be used for producing electricity if viable.

- Stormwater control is obtained by using cut off drains, ponding and promoting regrowth of vegetation on exposed surfaces as soon as possible.

- An archeological survey of the site and adjacent areas should be carried out prior to commencement of any site works.

- Monitoring must be thorough and required operational standards met. Monitor – noise, odour, dust, landfill gas quality, leachate, treatment plant effluent, stormwater pond turbidity, Otokia Creek, and Brighton Estuary.

- For effective management, monitoring and cost control install a weigh-bridge to determine incoming solid waste tonnages accurately and for levying charges.

- Monitor effects on residential areas adjacent to landfill operations.

D. CAPITAL AND OPERATING COSTS

The following is a summary of capital and operating costs.

Landfill Options	Initial Capital Costs	Annual Operating Costs	Landfill Gate
Existing Green Island ▫ 1991/92 Actual costs ▫ Deposition rate 45,000 tonnes/yr ▫ No capital financing charges	-	$0.67M	$14.90/tonne
Existing Green Island ▫ With Environmental Upgrades ▫ Deposition rate 45,000 tonnes/yr ▫ No capital financing charges	$1.9M	$0.95M	$21.10/tonne
Extended Green Island ▫ With Environmental Upgrades ▫ Deposition rate 68,800 tonnes/yr i.e. "all" Dunedin's solid waste ▫ Includes capital finance charges (10%) over 25 years.	$1.9M	$1.30M	$24.00/tonne
Extended Green Island ▫ Environmental Upgrades + Bentonite slurry wall + Transfer station ▫ Deposition Rate 68,800+ tonnes/yr ▫ Includes capital finance charges (10%) over 25 years.	$4.1M	$1.60M	$28.30/tonne
Smooth Hill ▫ With Transfer Station at Green Island. ▫ Deposition rate 68,800+ tonnes/yr ▫ Includes capital finance charges (10%) over 50 years.	$7.2M	$2.90M	$48.85/tonne

For consistency the amounts quoted in the above table, excepting the 1991/92 actual Green Island landfill operating costs, are from the Consultants E.I.A. reports. Modifications will be made to these numbers and to date not indicated in this table are:

- Cost of land purchase at Green Island.

- Landfill gas collection and utilisation systems at Green Island or Smooth Hill. Costs and returns have yet to be derived for proposed generator sets. The likely cost of a gas collection system at Green Island would be around $0.5M.

- More detailed costings extracted from the E.I.A. reports are attached as;

  - Appendix G – Extended Green Island

  - Appendix H – Smooth Hill

- It is possible that a greater degree of leachate treatment will be required than indicated in either the Smooth Hill or Extended Green Island E.I.A's. Leachate characterisation has been carried out to the practical degree possible. The characterisation of the actual leachate will not be known until collected from the leachate collection system. Woodward–Clyde have suggested in their Audit of the Existing Green Island Landfill E.I.A. that "Any discharge consent granted (for leachate) should provide for a monitoring period to check actual site values and a period of time afterwards for suitable pre–treatment facilities to be constructed if required."

E. ALTERNATIVE TECHNOLOGIES TO LANDFILLING

Landfills should be considered as controlled reactors in which biological, biochemical and physical–chemical reactions occur finally resulting in the stabilisation of the waste. It is considered that a 30 year after–care period, from closure of a landfill, is appropriate for stabilisation to be reasonably complete. Monitoring leachate will clearly indicate this process.

The process of waste stabilisation can be speeded up by the following types of processes:

Neutralysis — Pulverisation, pelletising and firing produces a lightweight aggregate. Extensive scrubbing and cleaning of air emissions is required.

Incineration — Using multihearth or fluidised bed (e.g Tahuna) burners to reduce refuse to ash. Municipal wastewater sludge can be co–incinerated with refuse. Extensive scrubbing of products of combustion are required to meet air emission standards.

Biodigestion — The more controlled biological decomposition of solid wastes than landfills using pre–sorting, sieving and shredding prior to feeding the putrecibles to digestors.

All the above processes appear to be more expensive than landfilling at present but these and other processes e.g. Bioaugmentation techniques and Plasma Arc furnaces (for special & hazardous wastes) need to be regularly reviewed to ensure that their 'real' operational costs (including the true cost to the environment) are known and at some point may be overall, more desirable than landfilling. An example of this could be that in the future it may be shown that, or it may be necessary that, municipal wastewater sludge is more cost effectively disposal of by incineration than using other processes. At that point co–incineration of sludge and refuse may be a viable option for Dunedin.

Technology is moving very rapidly in these alternative solid waste disposal methods but for the present, landfilling appears to be the most viable option for Dunedin. Regardless of the process there is still a "remainder" to be disposed of. This is generally landfilled.

F. SOLID WASTE DEPOSITION RATES AND LIFE OF LANDFILLS

1. The current deposition rate in Dunedin is very approximately 0.75 tonne per person per year.

2. The current recycling rate in Dunedin is approximately 18.5%.

3. Deposition rates – the design landfilling or deposition rates for the Smooth Hill site and the Extended Green Island site used in the E.I.A's are as follows:

▪ Deposition rate by volume	– 100,000m³/annum
▪ Deposition rate plus 20% Cover material as per Sanitary Landfill techniques	– 120,000m³/annum.
▪ Compacted Density (In situ at landfill – Beca est.)	– approximately 700kg/m³
▪ Deposition rate by weight (Solid waste only, no cover material).	– 68,800 tonnes/annum

The above deposition rates assume that all solid waste from Green Island, Maxwells, Port Chalmers and North Taieri (now closed) go to Smooth Hill or the Extended Green Island site.

The deposition rates at Green Island for the present situation (excluding Maxwells and Port Chalmers) are taken as follows:

▪ Deposition rate by volume	– 62,500 m³/annum
▪ Deposition rate plus 20% cover material	– 75,000 m³/annum
▪ Compaction Density (Beca est.)	– approximately 700kg/m³
▪ Deposition Rate (Solid waste only, no cover material)	– 45,000 tonnes/annum

The current actual deposition rate at Green Island is somewhat less than the design rate.

- Deposition rate by volume with cover material – 58,400 m^3/annum

This rate has been determined by survey (November 1991–November 1992).

4. Current Landfill Life Remaining

Using current deposition rates, boundary limits, planning designations and conditions the following is the expected landfill life remaining:

Green Island	–	5 years
Maxwells	–	3 years
Port Chalmers	–	10 years
Waikouaiti	–	10 years
Middlemarch	–	10 years +
North Taieri	–	Closed but maintain Planning Designation.
Green Island with Maxwells and Port Chalmers	–	2.5 years

5. Design Landfill Life

Extended Green Island to 15m high mound.	–	25 years
Smooth Hill	–	50 years

(Note that calculations relating to capital costs and financing costs are related to the 25 and 50 years for the Extended Green Island and Smooth Hill sites respectively).

Taking the Green Island Landfill to the Eastern Hill at current levels as per the Pitts Plan	: at 75,000 m^3/annum – 8.5 years
	: at 120,000 m^3/annum – 5.0 years

Taking the Green Island landfill up one three metre lift : at 120,000 m^3/annum – 8.0 years

G. PUBLIC INPUT AND SUBMISSIONS

An outline of the public participation programme commencing November 1991 with the first meeting of the Refuse Working Party, was given in the introduction of this report.

Public submissions were called for in March 1992 and again in November 1992 to February 1993. A summary table of these submissions can be seen in Appendix I.

The following comments can be made with regard to these submissions.

- The majority of submissions were well thought out with clear statements of views held.

- The amount of interest from the public was reasonable (a total of 143 submissions plus good attendance at public meetings) especially in the Green Island and Brighton areas. However this response must be gauged against the number of direct mailings sent out to Green Island and Brighton residents. Allowing for the two city wide mailings (tabloid and pamphlet), the approximately 4,000 "directly" affected residents in the Green Island and Brighton areas received five separate mailings (one direct in March 1992 and two direct in November 1992). In addition the March 1992 submitters (some 116) were direct mailed summaries of the E.I.A. reports and a submission form (as per all direct mailing). The areas direct mailed can be seen on Map, Appendix J.

- In total, 43 submissions were received from Green Island residents and 30 of these referred to landfill location. Of these some 46% approved of the extended Green Island landfill site compared to Smooth Hill and some 54% opposed the site. But concerns regarding odour, noise, wind-blown rubbish, rubbish dropping off vehicles onto Green Island streets and adverse visual effects were raised by residents whether they were for or against the landfill site location.

- Submissions from areas 'other' than Green Island and excepting Brighton's bias, approved of the Green Island site by a relatively high percentage (see table in Appendix I). This group strongly approved waste minimisation and recycling.

- Various Groups and Societies, including environmental groups, tended to disapprove the Green Island site more than approve the Extended Green Island or Smooth Hill. These groups strongly favoured waste minimisation, recycling and alternative technologies for disposing of waste.

- Community Groups tended to be evenly split between for and against Green Island.

Overall, allowing that the analysis of the submissions is not statistically rigorous, it can be a guide only. A higher percentage of submissions favoured the Extended Green Island landfill but there are many in disagreement. Also of importance was environmental controls, and upgrades, landscaping, odour, windblown rubbish, adverse visual effect of the Extended Green Island mound, rubbish from vehicles, higher costs for Smooth Hill than the Extended Green Island and pollution of the Otokia Creek and Brighton Beach. Waste minimisation, recycling, transfer stations and skips, kerbside recycling, more community recycling stations, alternative waste disposal technology, toxic substances and hazardous waste and an increase in Public Education re solid waste were also important issues raised.

Continuing public participation is critical to the existing landfill operation and both the proposed alternative future sites.

The input has to not only be through Councillors and Community Boards but through various interested groups and individuals, Council staff, public meetings, mailings and public education generally.

Liaison Committees are proposed with respect to landscaping, landfill operations and monitoring discharges. It is considered that each group should consist of about five members but able to call on experts in various fields from time to time. The meetings would be on a monthly basis initially then taper off to say four per year. This method worked well and positively regarding odour control at the Tahuna Wastewater Treatment Plant.

H. <u>PLANNING AND PERMITS TO DISCHARGE (OR EXTRACT)</u>

- Licensing of the existing Green Island Landfill (consents to discharge to land) by the Otago Regional Council will be required by 1st October 1994 i.e. the consent issue date. Applications will need to be made at least six months earlier than this date and possibly as early as December 1993. Start of inspections for licences will commence by October 1993.

  The process of licensing, with advertising the application and public submissions, will be similar to other environmental discharge permits to air and to water.

  One of the requirements of a permit or licence will be a landfill management plan. This has been completed for the existing operation only.

- Various discharge permits have been applied for:–

Application W3839: + 3840 & 3841 (See overheads.):

- discharge of leachate to ground water within a bund (leachate control trench).
- taking of ground water within the bund (leachate control trench).
- reviewing aspects of the Green Island Wastewater Treatment Plant discharge with respect to leachate.

Application W3830:

- discharging stormwater to the Kaikorai Stream via retention ponds.

Application W4139:

- extraction of water from the Kaikorai Stream (through the leachate collection system).

Application No.4140:

- realignment of a section of the Kaikorai Stream.

Application

- stormwater diversion.

- Green Island Landfill Site – 1986 District Plan Provisions.

The current site (see attached marked up aerial map Appendix K) is Zoned Industrial B. Landfilling of domestic and tradewaste is a permitted use in the zone with certain provisions e.g. leachate control. The permitted use of landfilling is a precursor to the development of the Kaikorai Estuary for industrial purposes suitable for lighter industrial and commercial use.

If the level of the landfill is to be taken above the current general landfill level, then a rezoning or a designation will be required. The total area including the Maxwells Landfill site will need to be included. In applying for a change of zoning or designation, the ultimate end use will need to be considered and form part of the total proposal. For example, some forms of recreation and wildlife refuge in whole or in part may be appropriate. Any future transfer station linked to Smooth Hill (or Green Island) also needs to be considered at the same time.

- Smooth Hill

  Currently the area is zoned Rural C Zone: Afforestation. For landfilling the zoning will need to be changed, or a designation installed on site. The issue of a buffer zone to preclude residential development would be part of that approval.

I. COMMENTS AND CONCLUSIONS

Waste Minimisation

- Waste minimisation in its various forms is essential for substainability of our resources including land space used up by landfills.

- Recycling is estimated at approximately 18.5% (total Dunedin) not meeting the earlier target set of 20% for 1993/94. The recycling rate needs to be increased targeting a greater amount of green garden waste (and a bigger shredder), direct composting of 'uncontaminated' industrial waste, plastics and paper. It is likely that Council will need to become directly involved with developing markets for both recyclables and products made from recyclables.

- Solid and liquid waste management are very much inter-related. The higher the level of wastewater treatment the more sludge produced and the faster we will fill up landfills unless we dispose of sludge in other ways. Landfilling of wastewater sludge in the medium and long term is not really an option due to limitation in landfill capacity. However in the end costs and environmental protection will control what method of disposal is chosen.

- Public Education on waste minimisation and solid waste generally is vital to an effective waste minimisation programme.

- One way to resolve the wastewater sludge issue and to minimise Solid waste generally is to encourage industry to reduce waste. 'Uncontaminated' waste can be composted directly.

- Hazardous waste disposal may require a separate location altogether (and/or specialised pre-treatment) to Smooth Hill and Green Island. However we believe this to be a regional and national problem and hence other authorities should become involved with this issue.

Public Participation

- There are strong views for and against each of the two landfill alternatives. The decision on which one is chosen will be met with support <u>and</u> opposition. Council can reduce criticism, by improving the landfill operation much further than current improvements have gone. We need to demonstrate that we can operate, on a long term basis, a sanitary landfill with minimal possible intrusion into the surrounding neighbourhood. In the case of Green Island landscaping can also considerable improve the surroundings. Regardless, at the end of the day, there may still be objectors and Council may well have to go right through the planning process including Public Hearings over the landfill issue.

- There is obviously a diverse range of views, perceptions and opinions, with regard to landfills and their operation, which need to be resolved. We believe that the best way to resolve these issues is through Liaison Committees. Review of our operations would be by both the Liaison Committees in conjunction with Council staff and more formally via the discharge permit process with the Otago Regional Council.

- Council's credibility with respect to solid and liquid waste management is paramount.

Environmental Issues

- Upgrading the Kaikorai Stream and Estuary has been in the "too hard basket" for years. There have been some 60 papers and reports written about the landfills, reclamations, industrial site planning and contamination of the Kaikorai Stream and Kaikorai Estuary since 1954.

- As a region, we need to work towards salvaging the Kaikorai Stream and Estuary. However only an estimated 20% of the pollution load on the lower Kaikorai Stream and Estuary is attributable to the Maxwells and Green Island Landfills. The remainder of the pollution is from non–point source rural and urban runoff plus residual contamination of stream and estuary sediments from past industry which often discharged directly into the Kaikorai Stream.

  As it is a regional problem a number of groups must come together to provide a total solution.

- Council has already budgeted for improving the Kaikorai Stream and Estuary environment and has undertaken to carry out the necessary environmental upgrades at Green Island. We now need approval of our proposals by the Otago Regional Council, who will take into account the views of the Submitters before coming to a final decision.

- Council and its consultants have taken a pragmatic approach with regard to hydrogeological studies of the landfill and estuary. Some drilling has been carried out to indicate effectiveness of the leachate collection system. A full hydrogeological study would cost some $500,000 and then the results would not necessarily indicate anything different to that proposed. The cost of the leachate control systems is approximately $1,000,000 not including a Bentomite slurry wall.

- The Woodward–Clyde Audit on the proposal for environmental upgrades at Green Island should be completed within the next two or three weeks. At this point further meetings with Submitters to the discharge permit application for the existing Green Island Landfill can proceed.

- Both Green Island and to the lesser extent Smooth Hill sites have an amenity value after closure of the landfills. This is particularly so where the Green Island site, adjacent wetlands, Kaikorai Stream, Estuary and land bordering the Estuary could be developed into a recreational, wildlife and scenic asset for Green Island residents and the City as a whole.

Landfills

- We have five to eight years left at Green Island depending on the deposition rate. A five year life should be considered.

- The Extended Green Island Landfill required gate charge of say $24 per tonne is about half the Smooth Hill gate charge. Thus it is more cost effective to stay at Green Island. However we need to prove that the environmental upgrades proposed for the existing Green Island Landfill will indeed work as well as we expect. Monitoring of the outcome of the upgrades will occur regularly by the Otago Regional Council (the Licensing Authority), Council staff and Council Staff in conjunction with the proposed Liaison Committees.

- During the above period, as soon as practicable, District Plan Zoning changes or designations should be applied for, both regarding Smooth Hill and the Extended Green Island sites.
  If we can not meet required environmental standards because of such close proximity to residential areas and unexpected difficulties in retrofitting leachate controls then the Green Island site would need to be closed and we would then need to move to Smooth Hill. With a 'greenfields' site at Smooth Hill good sanitary landfill techniques, including leachate control, will be practised from the start.

  Residents are some distance from the Smooth Hill site and residential development adjacent to the Smooth Hill site should be avoided by way of an appropriate buffer zone.

- The various discharge permits already applied for will be required whether we stay or go from Green Island. The after care timeframe is between 20 and 30 years. The leachate control and collection system needs to work for the lifetime of the landfill plus the aftercare period. Pumps and pre–treatment plant (if required – the Green Island Wastewater Treatment plant will have secondary treatment by 1999) will need to be operated and maintained for most of this period.

- It is essential that Council provides tight day to day control on its landfill operation to ensure compliance with environmental standards. The appointment of a full time supervisor for the existing Green Island operation and subsequently the future landfill needs to be considered.

- Maxwells (Fulton Hogan) have indicated both to the Council and the Otago Regional Council that a leachate collection system will be constructed around the perimeter of their own landfill.

- Even if leachate collection systems are installed there is no guarantee that either the Council or Maxwells will be able to remain at the Green Island sites if other environmental or planning issues prevent this.

J. RECOMMENDATIONS

It is recommended that:

1. The Extended Green Island Landfill be the preferred site for a sanitary landfill when the present development is completed with the proviso that the environmental upgrades proposed at the existing Green Island Landfill operate as envisaged.

2. Negotiate with a view to purchase the Smooth Hill site and report back to Council.

3. Proceed, as and when appropriate, to rezone or desingate both the Smooth Hill and the Extended Green Island Landfill sites.

4. When item 3 above is achieved and before the completion of the next level of filling (approximately 3m above the present level) a major review of the effectiveness of the environmental upgrades is undertaken.

5. If the upgrades at Green Island do not meet required and agreed environmental standards following the review in item 4 because of close proximity to residential areas and unexpected difficulties with leachate controls then Green Island be closed and Smooth Hill become Dunedin's Landfill for the next approximately 50 years.

6. Community Liaison Groups be established to provide input to landscaping development of the site, monitoring landfill operations and monitoring environmental performance.

7. Negotiate with a view to landscaping of the Green Island Landfill to include the Kaikorai Estuary area and promote as a regional issue with other groups participating in and sharing the costs of the landscaping.

8. Promote the investigation of a landfill and/or specialised pre–treatment facilities for the disposal of some categories of hazardous waste.

9. Investigate on an on going basis further alternative technologies to landfill disposal techniques.

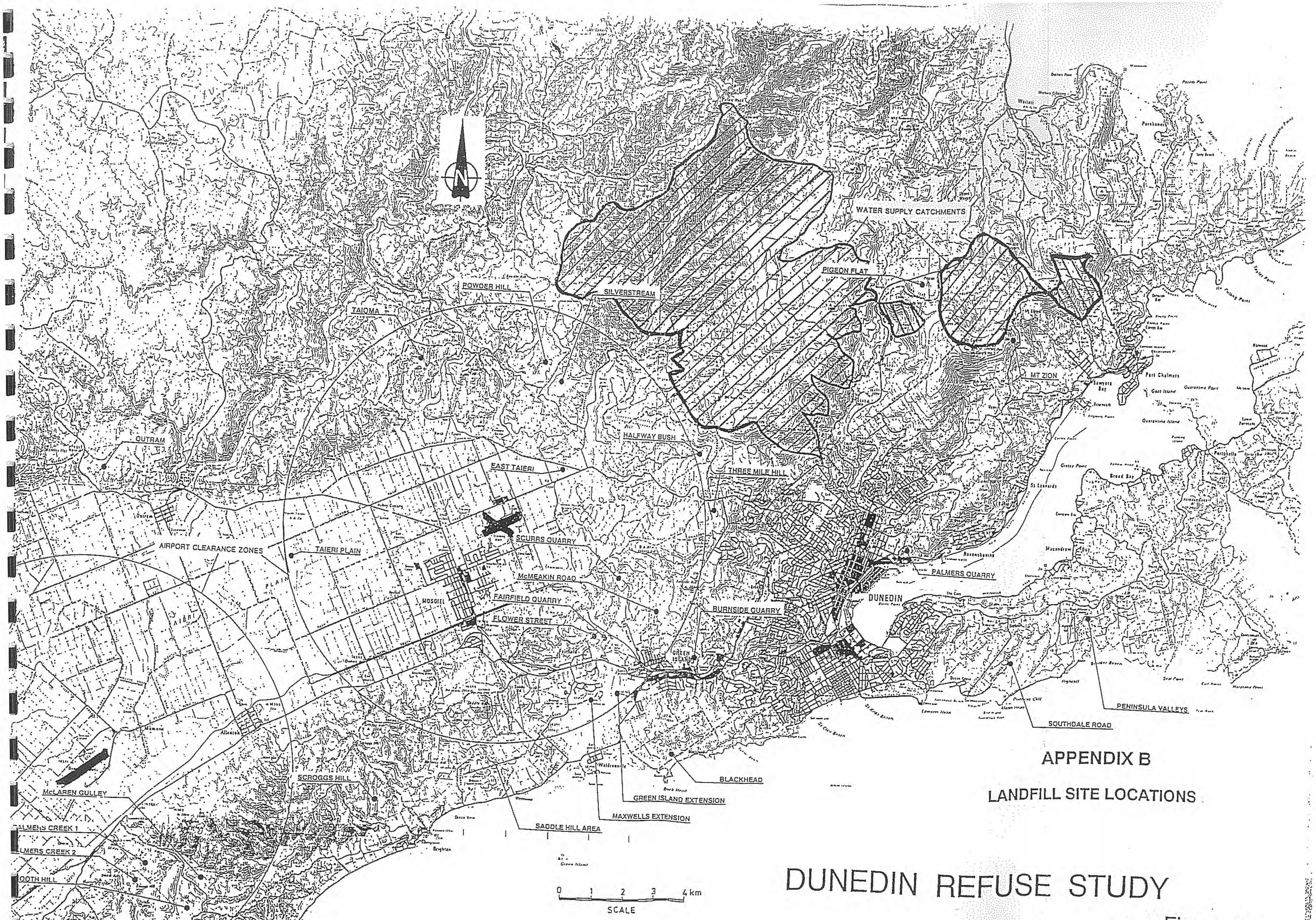
10. Investigate the potential for commercial development of landfill gas in conjunction with the Green Island Wastewater Treatment Plant upgrade.

11. Continue the development of a comprehensive monitoring programme for the Green Island Landfill.

APPENDIX A
SITE SELECTION PROCESS

TABLE I 3.1 : SITE SELECTION PROCESS			
Identification of Potential Sites (32)	**Intermediate List Subjected to Further Investigation (11)**	**Short list evaluated in detail at Working Party and Study Team Meeting on 22 January (5)**	**Sites Recommended for Environmental Impact Assessment (2)**
Southdale Road	Southdale Road		
Blackhead Road			
Halfway Bush	Pigeon Flat (1)		
Three Mile Hill			
Pigeon Flat (2)	Burnside Quarry		
Burnside Marl Quarry			
Fulton Hogan Quarry (Fairfield)	Fulton Hogan Quarry		
Flower Street		Burnside Quarry	
Abbotsford Landslide Area			
Scurrs Quarry	Green Island Extension	Green Island Extension	
McMeakin Road			Green Island Extension
Green Island landfill	Taioma Road	Maxwells Extension	
Taioma Road			Smooth Hill
Milners Road (North Taieri)	Maxwells (Fairfield)	Smooth Hill	
Palmers Quarry			
Sites on the Southern Slopes of Saddle Hill	Powder Hill (1)	Palmers Creek	
Mt Zion Quarry	Smooth Hill (1)		
Maxwells landfill (Fairfield)			
Mill Stream Valley (2)	Palmers Creek		
Powder Hill (2)			
Smooth Hill (2)	Brighton (Scroggs Hill Rd)		
Palmers Creek (2)			
Brighton (Scroggs Hill Road)			
Three Mile Hill (2)			
Outram			

The Burnside Quarry was also recommended as a special waste disposal site.



APPENDIX B

LANDFILL SITE LOCATIONS

DUNEDIN REFUSE STUDY

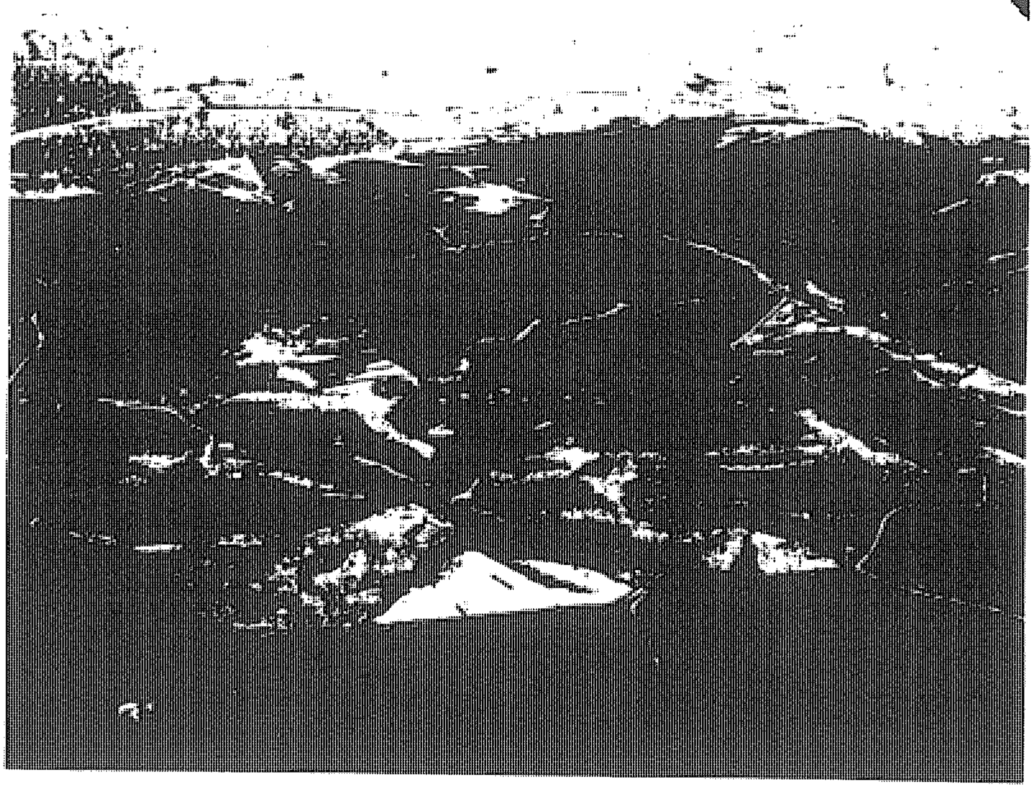
Figure 2.1

APPENDIX C
BASIC SITE FEATURES

TABLE 3.3 : SUMMARY OF SITE INFORMATION		
FACTOR	**SMOOTH HILL**	**EXTENDED GREEN ISLAND**
Zoning:	Farmland owned by Fulton Hogan Ltd Rural C Zone (SPCC).	Existing landfill operated by Dunedin City Council. Industrial B/Coastal Protection and Wildlife Zone (SPCC).
Location:	Southeast of Momona in coastal hills adjacent to Big Stone Road, 30km from Octagon.	Southwest of Green Island at edge of Kaikorai Estuary, 13km from Octagon.
Catchment:	Headwaters of Otokia Stream which travels northwards to discharge to ocean at Brighton.	Direct to Kaikorai Estuary.
Access Route:	South on SH1 and turn off into McLaren Gully Road or new road up Palmers Creek.	From SH1 then Brighton Road.
Surface Features:	Rolling pasture land. Site would be in broad gullies at head of catchment. Some gorse regrowth.	Existing landfill is being completed to an elevation about 108m. Some grass and trees are established but generally the site is barren.
Nearest Residences:	Two houses along McLaren Gully Road otherwise very remote.	100m from eastern boundary of landfill site.
Airfield Proximity:	6km from Momona (just within 6.5km separation zone) but mitigated being on the coast side of airfield.	6.5km from Taieri Airfield but extra separation is created by Chain Hills.
Available Capacity:	6 million cubic metres which could provide 50 years' life.	3 million cubic metres which could provide a 25 year life.
Geology/Hydrogeology:	1.8km from faultline along McLaren Gully Road. Breccia substrata and loess surface soils. Confinement of groundwater not certain but controllable.	Site is underlain by mud sediments then sand layers before mudstone is encountered. Leachate is not confined at present. A perimeter collection trench is proposed.
Cultural/Archaeological:	No site of significance known.	Modified by current activities.
Other Comments:	• Big Stone Road is a recognised logging truck route and an upgraded McLaren Gully Road could divert logging trucks from the Brighton coastal route onto State Highway 1.	Mound would be visible from many viewpoints but impacts could be reduced by forming outer perimeter embankment first and immediately landscaping then infilling "crater" in the centre. This would be done in staged lifts of about 10m height.

BECA

ENVIRONMENTAL IMPACT ASSESSMENT
of the
Proposed Smooth Hill Sanitary Landfill



Prepared for
DUNEDIN CITY COUNCIL
October 1992

11.0 SUMMARY AND CONCLUSIONS

11.1 INTRODUCTION

This EIA assesses the proposal to establish and operate a new sanitary landfill at Smooth Hill to handle all wastes including treated and stabilised special and liquid wastes but not toxic wastes.

PURPOSE OF REPORT

This EIA has been commissioned by the Council for a number of purposes. These purposes include the following:

- to assess all relevant physical, biological, social, cultural, visual and traffic impacts of the proposal, and

- to provide a source document for supporting applications for the discharge permits required for the landfill. This EIA has been prepared to satisfy the requirement for an assessment of "any actual or potential effects that the activity may have on the environment, and the ways in which any adverse effects may be mitigated" as specified in Section 88 of the RMA.

11.2 SITE DESCRIPTION

LOCALITY

The proposed Smooth Hill landfill site is approximately 30 kilometres south-west of the Octagon, Central Dunedin. It is contained within an area of land bounded by State Highway 1 to the west, McLaren Gully Road to the north and Big Stone Road to the south and east. Access to the site could be available from McLaren Gully Road or by the Fulton Hogan private forestry road near Palmers Creek.

The site is located in the headwaters of the Otokia Creek in an area of coastal hills. The Otokia Creek is 13 kilometres in length but also includes a large number of smaller tributaries. It drains the hilly area to the south west of Brighton before becoming an extensive tidal lagoon and flowing into the sea at Brighton. Brighton is a coastal resort community with a population of 1329 people (1991 Census returns).

Land use within the catchment is predominantly forest, grassland and gorse scrub. Surrounding blocks are part of the Otago Coast Forest and planted predominantly with Pinus Radiata.

The land is relatively remote. There are two farm houses on McLaren Gully Road and further houses on Big Stone Road and Christies Gully Road near the Taieri River which are more than 2.5 km from the site.

THE SITE

The site consists of a broad shallow basin incised by several shallow gullies. The gully areas contain wet areas but for much of the year the stream channel in the upper reaches is dry. The site is largely grassland with considerable gorse regrowth, particularly in the gullies, and a few sporadically sited trees.

There are no buildings within the boundaries of the site.

The site is presently a rural holding of approximately 80 hectares and is currently held in four titles. The properties are presently owned by Fulton Hogan Holdings Ltd.

GEOMORPHOLOGY

The site occupies an area of about 80 hectares and is bound to the east, south and southwest by a spur and ridge system (Figure B2). A hill occupies the northwestern corner. Slopes at the site are generally gentle to moderate (7 - 20° with valley side slopes of about 11°).

Both historic (in the order of hundreds of years) and recent continuing shallow slope movement comprising small slides, flows and creep were observed to have occurred within surficial materials (Loess and the upper weathered surface soils derived from the Henley Breccia).

Slickensided clay horizons were observed at the interface between the loess or slope debris and Henley Breccia. Accumulation of water at this interface may have resulted in downslope movement of these materials in response to particularly heavy or prolonged rainfall or earthquake shaking.

SITE HYDROGEOLOGY

The site investigation work to date has provided a sufficient amount of data for a preliminary hydrogeological assessment of the site to be made. Additional site investigation work would be necessary to more fully define the groundwater flow system at the site prior to any resource consent applications for the proposed landfill development.

The following geological considerations are of relevance to the site hydrogeology:

i) The site is underlain by Henley Breccia, comprising breccia and conglomerate interspersed with horizons of carbonaceous mudstone. The breccia is mantled by 1.5 m to 3.75 m of loess and locally, a similar thickness of slope movement debris.

ii) The breccia is rarely jointed.

iii) Perched water tables may exist within the loess and slope movement debris, at the interface between these materials and the Henley Breccia and/or within the Breccia itself.

iv) No faults are known to extend beneath the site.

GROUNDWATER REGIME AT THE SMOOTH HILL SITE

At April 16, 1992 the depth to groundwater in boreholes at the site ranged from approximately 2.5 m in B2, located near the stream on the lower portion of the site, to approximately 56.6 m in B4, located on the ridge top near the eastern boundary of the site. The final equilibrium groundwater levels may be several metres higher than those measured on 16 April. The general direction of groundwater flow at the site appears to be toward the north. This is consistent with the surface water drainage patterns and general topography of the surrounding area.

Based on the geology and topography of the area, a groundwater divide would be expected to exist beneath the ridge tops on the higher elevations of this site. Thus groundwater in the upper portion of the regional groundwater system beneath the site is expected to be primarily derived from recharge occurring within the site itself.

Groundwater discharge may occur in streams at lower elevations within the catchment. Due to the low permeability of the sediments at the site, the volume of groundwater discharging to the streams is not expected to be a significant portion of the stream flow.

The long period of time required for groundwater levels to return to equilibrium in the boreholes indicates that the Henley Breccia at the site has an extremely low permeability. Analysis of the aquifer test data gives permeabilities of 1×10^{-8} m/s to 1×10^{-10} m/s (Table B6, Appendix B). The rate of groundwater movement through the Henley Breccia formation is therefore expected to be extremely slow. The dominant groundwater flow paths are probably through the matrix of the formation rather than through fractures.

SURFACE HYDROLOGY

The Otokia Creek Catchment has a total area of about 27.1 km^2 and drains to the east. The Otokia Creek discharges to the sea at Brighton, through an extensive tidal lagoon, some 14 km south along the coast from St Kilda Beach, Dunedin.

The main channel along Otokia Creek is about 13 km in length with an average slope of about 8%. There are a number of smaller tributaries and two larger ones, McColl Creek and Scrub Creek.

About 1.5 km downstream from the proposed landfill site there exists a flat, meandering wetland in the vicinity of McLaren Gully Road, into which the stream channel disappears.

HABITAT CHARACTERISTICS

Where the creek flows through areas underlain by the Henley Breccia, flow is low and probably fed from perched water tables within the loess/slope movement debris or at the interface of these materials with the Breccia.

In its lower reaches the Otokia Creek enters a medium-sized estuary or lagoon before flowing into the sea through the middle of Brighton township and across Brighton Beach. For much of the time there is no surface flow of water between the estuary and the sea. The estuary is a wildlife area of considerable interest and is also used extensively for recreation. The township of Brighton is an attractive seaside resort and recreational area close to Dunedin. It is popular with both local visitors and tourists.

The Smooth Hill site itself is a broad basin incised by several shallow gullies. The slope varies but is generally not steep. The gully areas are almost always dry, except during heavy rain events.

Landuse in the Otokia Creek catchment is primarily native and exotic forest, grassland and gorse scrub. At the proposed landfill site, the vegetative cover is dominated by grassland with gorse scrub present in the gullies. Soil fertility is low and is classified as suitable for extensive grazing and forestry.

TERRESTRIAL HABITAT

The primary use of adjoining land is for forestry and it is intended that the proposed landfill site be planted in the near future if the landfill does not proceed. There would therefore be an effect on the site habitat even if a landfill was not constructed.

The types of habitats found at Smooth Hill are common throughout the surrounding area and in fact much of the South Island. As a result no unique plant or animal associations are expected.

The closest pocket of native vegetation in the Otokia catchment is approximately 1.5 km from the actual proposed tip site and is a remnant of a mixed podocarp forest. It is mainly secondary growth with the odd large podocarp emerging above the canopy. Several other and more extensive areas of indigenous forest are found on several of the tributaries of the Otokia Creek in the middle area of the catchment.

AQUATIC HABITAT

Aquatic habitat within the boundary of the proposed landfill site at Smooth Hill is virtually nil for much of the year. This is because the Otokia Creek in the upper catchment has no surface flows except during heavy rain.

Outside of the upper catchment, the Otokia Creek has basically three broad types of aquatic habitat - still water (ponds), running freshwater and running estuarine water habitats. However, because flows are often slow the biota present in both freshwater habitats are similar.

Various ponds exist in the Otokia Creek channel, and all are relatively small. The closest pond to the proposed landfill is situated where the creek channel is dammed about halfway between the toe of the proposed landfill and McLaren Gully Road. Two other ponds are present immediately below the road and are similar in size to the upper pond. Both are used for stockwater and duck shooting. These two ponds were not studied in detail but on casual observation they seem to be eutrophic and contain much the same aquatic flora and fauna as the upper pond.

Otokia Creek below McLaren Gully Rd is slow and meandering, except after heavy rain. For the first kilometre below the road it has very little or zero flow. The stream ir the middle and lower sections is generally confined to a narrow (approximately 1 m wide) and relatively deep channel with many pool sections.

The slow meandering nature of the stream, the frequent pools and the wetland type aquatic vegetation all provide a natural settling and filtration action for the materials that enter the stream. As a consequence, the water is generally clear but the concentration of dissolved substances is high (conductivity >30 $ms.m^{-1}$). Because the stream has little flow (around 1-2 l/s in the middle reaches during dry periods) its capacity to assimilate the contaminants that enter it is low. As a result, low dissolved oxygen concentrations occur in the pools (7 mg/l in surface water and 0-2 mg/l in bottom water in April) and diversity of animal life is reduced.

The substrate of the lower reaches of the Otokia Creek near the estuary is characteristically fine sand, silt and mud. The channel widens and deepens in this section and the water is usually more turbid. Plant life is dominated by dead and decaying filamentous algae. Dissolved oxygen concentrations are characteristically low and the bed is anoxic and enriched with sulphides. There is a low diversity of benthic invertebrate life and very few fish species are apparent. Burrowing worms, chironomids (midge larvae), amphipods and snails tend to dominate.

In general the aquatic plant and animal life of the Otokia Creek is typical of that which occurs in slow-moving, spring-fed streams throughout New Zealand. It also provides some habitat for waterfowl but is limited by area. No unique ecological assemblages or species were found or are expected.

The Otokia Estuary or lagoon is a medium-sized body of water situated in the heart of Brighton. It is considered to be an attractive body of water by local residents and visitors and this is enhanced by its close proximity to the Brighton Beach. The estuary attracts a wide range of wetland and water associated birdlife.

Although the estuary has such high value placed on it by both local residents and visitors, it has several severe limitations in terms of the factors affecting its water quality. These include:

(i) **Poor flushing**

The amount of freshwater entering the Brighton estuary from the Otokia Creek is generally very small in comparison to the volume of the estuary. As a consequence, it cannot effectively provide the rapid flows needed to flush out accumulated material. Also, because of the silting up of the mouth, sea water generally only enters the estuary during the monthly spring tides. The only major clean-out occurs, approximately once per year, when heavy rain in the catchment causes the estuary to flood and unblock the channel. For a short period after this the water level in the estuary is lower than normal.

(ii) **Stormwater Entry**

The estuary receives urban stormwater from a large area of Brighton. Urban stormwater is well-known to contain a variety of pollutants including suspended solids, nutrients and heavy metals. The estuary also receives runoff from the developed catchment upstream of the estuary. Some of the contaminants in the runoff will find their way to the estuary.

(iii) **Stock Access to Creek and Estuary**

Stock generally have access to the channel margins of the Otokia Creek and Estuary. In the absence of riparian protection in such a small stream, water quality and stream banks are likely to deteriorate.

(iv) **Channelisation and Drainage**

In its upper reaches, the Otokia Estuary has been extensively channelised and drained. Drainage of the upper reaches is likely to have reduced tidal volume entering the estuary and exacerbated the potential for the mouth to block. The constriction of the channel at the Brighton Rd Bridge is an additional feature that could have reduced flushing.

In summary, the estuary is very poorly flushed and it receives nutrients and other pollutants from both rural and urban runoff. As a consequence, the contaminants that enter it tend to stay in it. Such processes have led to the estuary becoming over-enriched and now it exhibits the classic symptoms of severe eutrophication - organically enriched sulphide sediments, nuisance algal growth and a low diversity of aquatic life. Organically enriched sediments characteristically have an absence of dissolved oxygen in the interstitial water and they release ammonia and sulphides to the water column. In the Brighton Estuary the sediments are very soft, blackened with sulphides, have extensive surface films of bacteria and microalgae and liberate the foul smelling gas hydrogen sulphide.

LANDSCAPE CHARACTERISTICS OF THE LOCALITY

The surrounding landscape character is established by the rolling hills of farmland which is reverting to native scrub and gorse. Much of this poorer quality land has been or is in the process of being converted to commercial forest plantings of Pinus radiata. These will have a substantial impact on the immediate landscape values during the lifespan of the proposed landfill.

The future pine forests will obliterate the present open nature of the surrounding landscape. The trees will provide a strong sense of enclosure to the present vistas; many kilometres of open rolling land will be replaced by abbreviated views within the forest. This is neither good nor bad, rather it will be a different landscape. This is of major significance to the proposed use of the site as the present physical enclosure provided by the surrounding landform will be greatly heightened by the trees as they grow.

The site does not possess any distinctive features which would suggest that it has any significant landscape value. The inner parts of the site are substantially screened from the larger landscape, there are no vegetative features or physical attributes of landscape significance.

TRANSPORT

The route to the site will be along State Highway One, through Fairfield, East Taieri and Allanton to McLaren Gully Road 5.5 km south of Allanton. The distance from the Green Island Landfill is 24 km.

The access into the site runs off SH1 just south (500 metres) of McLaren Gully Road using a forestry access road formed by Fulton Hogan Ltd to serve their forested land to the south of McLaren Gully Road.

SH1 after it leaves Green Island passes through the significantly developed area of Fairfield and then through relatively small developed areas at East Taieri and Allanton. The areas are all located on a major trafficked route where substantial traffic flows are experienced and expected.

MAIN SOUTH RAILWAY

The Main South Railway from Dunedin passes the turnoff from the state Highway One to the Smooth Hill Landfill site adjacent to the small settlement of Otokia. Rail sidings exist at Otokia. The closest rail sidings to the Green Island Landfill are at Burnside.

With the development of the necessary loading and unloading facilities, containers of compacted refuse from transfer stations at Green Island or elsewhere in Dunedin could be taken by rail to Otokia and then by road to the Smooth Hill landfill.

SOCIAL

The predominant land uses adjacent to the Smooth Hill site are pastoral farming and forestry. The number of residents directly affected by the proposed landfill is extremely small. The directly affected population would be two families living on McLaren Gully Road. They are about 1.5 km from the landfill site.

In addition to these few local residents, account should also the taken of the community of Brighton although it is situated some 13 km down the Otokia Creek from Smooth Hill.

MAORI CULTURAL PERSPECTIVE

From information supplied by the Runanga, the site at Smooth Hill appears to be of less importance to the Maori community than the Green Island site. It is the opinion of the Runanga the Smooth Hill and the Otokia Creek would have formed part of the wider network of mahika kai (places of resources), but would have been used much less frequently than the Kaikorai area for gathering resources, such as digging ti root, birding, rats runs and gathering eels from the Otokia Creek. It is possible that cabbage trees on Smooth Hill will have been a source of harvest in summer months.

11.3 PROJECT DESCRIPTION

The actual available airspace in Stages 1, 2 and 3 of the Smooth Hill landfill is 6.4 million cubic metres and therefore the landfill could have a total life of 50 to 60 years. Stage 1 will last 25 years, Stage 2 a further 15 years and Stage 3 has capacity for at least an additional 10 to 15 years.

LANDFILL DEVELOPMENT SEQUENCE

The sequencing of construction of the proposed Smooth Hill sanitary Landfill will be scheduled in a manner designed to minimise environmental impact. Special care in this design shall be given to reducing erosion and limiting the visual impact during construction.

The internal road up to the Smooth Hill site (preferred access) would be constructed as a single lane road with adequate passing bays. In general the present alignment of the forestry access road would be followed. Steeper sections would definitely require sealing - probably with an asphaltic concrete. Good cross-drainage and side channels will be essential to reduce maintenance. The intersection with SH1 will require special attention during design as would any crossing of Palmers Creek.

As soon as possible, the landscaping, screening and planting should be undertaken to an accepted development plan. In particular planting along Big Stone Road around the periphery of the site should be carried out so that the visual impact of the future landfill will be minimised.

The Smooth Hill site comprises three gullies, each being the headwater or top of catchment for its small tributary. These join at the bottom of the site to form the headwater of the Otokia Creek. The landfill development will be staged to minimise the amount of stormwater affecting the operation.

Stage 1 will be confined to the Western gullies only so that runoff from the other gullies will be unaffected. When Stage 1 is complete it will be capped and grassed while Stage 2 is developed and likewise for Stage 3.

The runoff from above the landfill in these three gullies in each stage will be diverted from the body of the landfill so that it does not contribute to the formation of leachate. This could be achieved by a combination of pipes along the stream beds of the gullies to be landfilled and contour drains around the top of the landfill area.

All stormwater contaminated by silt runoff will be diverted to the sedimentation pond for sedimentation and treatment prior to discharge to natural waters.

The sediment pond will service both the initial site development earthworks as well as during the life of the landfill. The upper bund of the sediment pond will form the buttress for the landfill and for the collection of leachate from the fill.

The Stage 1 area shall be opened up for landfilling in confined phases - each providing for six to twelve months of filling only. This will minimise the impacts on the site and the area open at any one time. In all cases the topsoil shall first be removed to stock pile. All contours drains and by-pass and monitoring pipework shall be laid and backfilled. The loess material and any completely weathered upper conglomerate layers shall be removed from the opened-up area of landfill and stock-piled for later use as cover material. At the initial development of Stage 1 and Stage 2 a substantial earthfill buttress will be constructed at the toe of each stage of landfill, keyed into the underlying firm rock to provide stability for the fill mass. Following excavation of the weak surface soils in the steeper areas of the site the excavated surface will be benched to key the fill mass into the underlying firmer conglomerate.

Leachate collection points, pumping stations and perforated pipework shall then be laid over the liner. A gravel drainage layer shall be laid around and over the leachate collection system to maximise pick-up of any liquid produced from the refuse and to provide a back-up path for leachate flow.

LINER CONSTRUCTION

When the loess material has been excavated from the site the underlying conglomerate layers in their natural state will generally provide the low permeability liner for the landfill. However in some areas it is likely that additional low permeability clay will need to be added to provide a sufficient thickness of liner. When fully compacted to provide a 600 mm thick layer, the combined material will provide a liner with an anticipated permeability of less than 10^{-8} metres per second (m/s). A landfill liner must have a permeability less than 10^{-8} m/s to prevent vertical rather than horizontal travel. If clay liner cannot achieve this figure then synthetic liners would be necessary. However the on-site soils at Smooth Hill can achieve this goal. The conglomerate liner will provide a suitable thickness of low permeability material for the absorption of contaminants. Leachate produced from the refuse will travel on top of the liner to the leachate collection system for removal. Around the collection and removal point for the leachate a synthetic liner would be added as an added barrier.

No soil or synthetic liner can be considered totally impermeable to liquid travel. Leachate that enters the liner rather than travelling along the surface to the collection system will be attenuated by ion exchange and absorbed. This "cleansing" of the leachate will be continued as the leachate passes through the breccia and clay layers below the main liner. With an average permeability or travel rate through these soils of 10^{-8} m/s the leachate will take at least another 8 years to penetrate 2.5 metres downward to the minimum groundwater level. Complete attenuation of any contaminants contained in the leachate is likely in this period.

The proposed liner and absorption/attenuation properties of the clays/silts below the liner combined with low regional groundwater table, provide a multiple barrier against any deleterious impacts below the site.

LEACHATE COLLECTION SYSTEM

The soluble constituents of the refuse will be dissolved by the presence of moisture and this fluid which percolates through the landfill is referred to as a leachate. The control of leachate is an important process within the landfill concept.

The liner is the barrier between the refuse and natural environment. The proposed liner for the Smooth Hill landfill will ultimately cover the whole area of the landfill down to the buttress wall at the bottom of each stage and which forms the toe of the landfill. That buttress wall and the integral liner form the low point in the system that will trap the leachate and provide the collection point. At this low point between buttress wall and bottom liner, a network of perforated pipes leading to a collection sump will form the leachate control system. No leachate will escape from this system into the environment. Pump stations will be constructed over the collection sump and all leachate can be withdrawn from the landfill. From the pump stations the leachate will be transferred to a leachate holding tank either for recycling back into the landfill or for transfer back to the City's wastewater treatment plant at Green Island.

The landfill will have a leachate drainage system consisting of 150 mm perforated pipe surrounded by an aggregate drainage material. The aggregate will be wrapped in a geotextile filter fabric to prevent clogging of the aggregate by fines. The pipes will drain into an aggregate-filled trench and sump located immediately upstream of the buttress well. Riser manholes will extend from this sump up the inside wall of the buttress and will surface along the crest of the buttress. Submersible pumps will be lowered into the riser manholes to enable the leachate to be removed from the low point within the landfill and pumped to the holding tank.

LANDFILL GAS MANAGEMENT

Waste encapsulated in a landfill undergoes anaerobic decomposition. The process generates a landfill gas comprised of about 55% methane, 45% carbon dioxide nitrogen, oxygen and other gases. When complete, the Smooth Hill landfill will contain more than 3 million cubic metres of refuse. Consequently the landfill gas (LFG) production potential is appreciable and would reach the point where collection and flaring is required to reduce environmental impacts and utilisation of the gas could be economically viable. Furthermore, any odour associated with the LFG can be reduced by the flaring of the gas.

LANDFILL MANAGEMENT

There are three major elements in the operation of a sanitary landfill:

(i) Proper placement of refuse;

(ii) Effective waste compaction;

(iii) Placement of adequate cover.

Waste placement consists of the refuse vehicles unloading at the face of the active filling area. Once the refuse is unloaded, the compactor pushes the waste into the active filling area spreading the waste into 500 mm to 1 m lifts. Then the compactor proceeds to made 3 to 4 passes over the waste compacting it in place to a target density of around 800 kg/m^3 or greater.

Deposited refuse will be covered at the end of each operational day with not less than 150 mm of compacted soil. As refuse is brought to final grade, the final cover will be applied and vegetated. The final cap will minimize erosion, surface water infiltration, leachate and gas generation.

11.4 SURFACE WATER, LEACHATE AND GAS MANAGEMENT

SURFACE WATER

Due to the nature of a landfill development, reasonably large scale earthworks operations are required, producing large areas of exposed excavation, refuse and landfill cover. Unabated, stormwater runoff will contain high sediment concentration and load.

To achieve stormwater control for the landfill operation at Smooth hill to achieve the above objectives, the following mitigating works will be maintained :

- Operation of the a sedimentation pond at the bottom of each stage of the landfill.
- providing a system of surface drains to safely convey stormwater within the site.
- implementing sound sediment control practices.
- conducting a monitoring programme on the discharge from the sedimentation pond.

LEACHATE

Leachate produced within the landfill by the action of rainfall percolating into the refuse will travel down through the full depth of refuse before travelling horizontally along the low permeability liner. It will be effectively captured by the perforated pipe leachate collection system throughout the site laid in gravel on top of the liner.

LANDFILL GAS MANAGEMENT

A continual programme of monitoring is required to assess the effectiveness of gas migration control measures and to check for gas in ground near the site boundary.

NUISANCE CONTROL

Nuisances at landfills generally fall into the following categories:

- Litter and wind-blown debris
- duct and mud
- vermin, birds and flies
- Odour and air pollution

(i) Litter

All refuse transporters entering the site will be special enclosed transfer vehicles. As such the problem of litter from vehicles will not occur. However one of the most important aspects of ongoing landfill maintenance at Smooth Hill will be litter control. Blowing debris can be minimised by:

- Maintaining a small working face (assisted by having no public access) and depositing refuse at the toe of the face whenever possible.
- Covering portions of the cells as they are filled;

- Cleaning up litter on a daily basis;

- Positioning temporary fencing around the working face to intercept blowing debris;

- Employing temporary labour to regularly clean up the site and check traffic access routes.

(ii) Dust and Mud

All of the roads providing access to the site should be sealed or well metalled. The main internal road which will provide access to the actual place of refuse placement should be kept well metalled.

(iii) Vermin, Birds and Flies

The compaction of refuse deposited at the site by the on-site compactor together with the addition of daily cover makes it difficult for rodents to become established. Although rats and mice may multiply rapidly if allowed access to a food source, daily cover will deny the rodents this food source. Similarly the compaction of incoming refuse and its daily cover will restrict access to a food source by birds. Based on experience at other sanitary landfills, flies are not a problem at a well controlled refuse landfill.

11.5 IMPACTS OF SANITARY LANDFILL OPERATIONS

LAND STABILITY

The proposed Smooth Hill landfill involves filling a series of valleys above the head waters of the Otokia Creek. Investigations have revealed some instability of the near surface soils. Analyses have been carried out to determine the effects on land stability of the proposed fill profiles during construction and for the final ground profile on completion of filling.

Analyses based on information currently available indicate that it is possible to construct a stable landfill at the site. However, further investigation will be required to confirm the soil strengths and extent of these planes of weakness prior to final design.

IMPACTS ON GROUNDWATER QUALITY

The low permeability sediments beneath the site will restrict the infiltration of leachate into the ground and severely limit the rate of movement of any contaminants that enter the groundwater system. Thousands of years would be required for contaminants moving in the groundwater system to travel the 100 m from the fill area to the site boundary. Over this long time period, even the more refractory organic contaminants in leachate would be subject to biological breakdown.

The amount of groundwater recharge occurring at the Smooth Hill site is limited by the extremely low permeability of the underlying sediments. The effect of the landfill development on groundwater quality, levels and flow paths is expected to be minimal.

SURFACE HYDROLOGY IMPACTS

It is expected that there will be some small change in the low and average surface flow regime due to the landfill. But these changes would probably be less than a change in land use zoning from rural to rural / residential. Reduction in peak flood flows from the site could be expected due to flow attenuation achieved by the sedimentation pond.

The main impact of the landfill will be the production of silt laden stormwater from the site. All such stormwater will therefore need to be treated to achieve the predetermined stormwater control criteria. This action is proposed as an integral part of the landfill proposal.

IMPACT ON WATER QUALITY

With good quality control on the design and construction of the sedimentation pond and drainage works together with sound operation practices and monitoring programmes the proposed landfill will not adversely affect the surface water quality within the Otakia Creek Catchment.

BIOLOGICAL IMPACTS

The terrestrial and aquatic habitat within the boundaries of the proposed landfill site at Smooth Hill is considered to be of relatively low ecological value from both a local and regional perspective. Because it is a common and much modified habitat it is not considered to contain any endangered or rare species and is not nationally significant.

Outside of the boundaries of the proposed landfill site at Smooth Hill, the catchment drains into the headwaters of the Otokia Creek. For a distance of at least 1 km below the proposed toe of the landfill there are no surface flows in the stream channel except after heavy rain. Below this upper reach, the stream is slow, meandering and relatively deep, with only minimal flows. In general the stream is enriched, particularly in the bed of pools. Once the stream enters the estuary the quality further deteriorates. This deterioration is, to a large extent, due to the poor flushing characteristics of the estuary and the inputs of nutrients from urban and rural runoff.

All of these features combine, to indicate that the Otokia aquatic environment is already having to cope with more contaminants (primarily nutrients) than it can presently assimilate. It is for these reasons and for general environmental protection that the design of the landfill would ensure complete lining with a low permeability material and collection of the leachate produced within the landfill.

BIRD STRIKE POTENTIAL

A report from Mr T Caithness, an advisor to the Ministry of Transport, is contained in Appendix C. He concluded that the "state of the art sanitary landfills satisfy all reasonable objections from an aviation bird hazard perspective." Gulls are traditionally associated with landfill sites but a sanitary landfill, with bird scare procedures and regular soil covering, can be operated to minimise attraction to the gulls.

A reasonable separation distance exists to the airport and the landfill is not expected to increase the risk of bird strike.

LANDSCAPE IMPACT

The site does not have any significant landscape value. The majority of the site not included in the actual part of the landfill operation would be maintained in pasture. Shelter plantings would be made around the perimeter, screen planting along the Big Stone Road boundary and ornamental planting around the entrance to the landfill.

TRAFFIC IMPACTS

The impact of the covered and sealed transfer vehicles taking refuse from the transfer station to the Smooth Hill site will be minor. The number of heavy vehicles represents an increase of less than 4% in the number of heavy vehicles travelling through the most densely populated area - Fairfield - which already has a relatively high traffic volume.

NOISE IMPACT

The nearest houses to the landfill are 1.4 km distant. A ridgeline to the north of the landfill site intervenes between the houses and the landfill. Consequently noise from the landfill is unlikely to be audible at these houses.

The noise impacts of the transfer vehicles along SH1 are not considered to represent a significant increase in traffic noise.

SOCIAL IMPACTS

In most respects, the actual social impacts of a well managed landfill at Green Island would be greater than at Smooth Hill, while the perceived impacts associated with

Smooth Hill may be seen as more by the Brighton community as more severe and as affecting a wider population. It must be recognised that in social terms, actual and perceived impacts are equally powerful in people's decision making, particularly in the short term.

A variety of mitigation measures are proposed to reduce the social impacts.

- **Traffic Impacts:** It is proposed that refuse trucks will be restricted to SH1 and thereafter access to the site will be through private property.

- **Impact on Property Enjoyment:** There are few residents affected. Proposed litter control fences, application of adequate soil cover and extensive surrounding forests will minimise any impacts.

- **Fire Risk:** Minimum separation distances of 100 m between the landfill and surrounding forest areas will be provided.

- **Leachate Pollution:** Containment of leachate within the site is one of the prime objectives of the landfill design. The possibility of any significant leachate escape past the collection system is remote. Any that did escape would be attenuated in the soil and self-treated in groundwater. There is no risk of contamination at Brighton.

11.6 COSTS OF LANDFILL AND TRANSPORTATION

COST SUMMARY

Based on 56,600 T/yr through Transfer Station and 68,800 T/yr into Landfill

1. Capital Costs

a. Smooth Hill Initial Development		$1.668M
b. Green Island Upgrade		$1.572M
c. Transfer Station		$3.960M
	Initial Capital Cost	**$7.200M**

2. Operating Costs/tonne

a. Smooth Hill Landfill		$16.0
b. Green Island Aftercare		1.0
c. Transfer Station		10.0
d. Refuse Transportation		14.4
e. Maintenance and Environmental Monitoring		1.7
	Total	**$43.1**

Based on the above costs plus ongoing development and maintenance costs over the 50 year life of the Smooth Hill landfill and its aftercare costs, the required gate charge can be assessed. This is the charge per tonne that needs to be made over the life of the landfill to meet all financing and operating costs.

SMOOTH HILL REQUIRED GATE CHARGE IS $48.85

11.7 MEETING COMMUNITY CONCERNS

The range of concerns which have been raised by objectors to the water right applications and by participants in the public consultation programme have been fully covered in this report. The proposed design and management of the Smooth Hill Landfill have been tailored to take account of these concerns. In addition, a range of mitigation measures is proposed to reduce environmental impacts to the minimum possible.

The principal matters of concern and the manner in which these issues have been addressed are summarised below:

Issue	Comment
• potential for discharges to receiving waters.	• leachate collection system proposed for the existing landfill will minimise discharge to natural waters. The very low permeability liner and underlying soils will ensure breakdown and attenuation of any contaminant that may migrate.
• potential for contamination of Estuary at Brighton.	• the liner system site soils are the 13km travel distance from site will mean there is no risk of contamination at Brighton.
• impact on groundwater	• very low permeability soils restrict use of groundwater and will also mean attenuation and breakdown of contaminants before they can enter any groundwater.
• land stability	• relatively shallow slip planes will be overcome by excavation of loess material and keying in to conglomerate below.
• interlocality equity (whether one community should bear the adverse consequences of a facility that serves the whole of Dunedin).	• an issue which is dealt with in the Refuse Management Strategy.
• intergenerational equity (whether the costs and adverse effects of today's wastes should be borne by future generations).	• an issue which is deal with in the Refuse Management Strategy.

• the need to protect the integrity of ecosystems.	• the proposed liner and leachate collection system will provide the necessary safeguard.
• the Brighton Estuary has particular use values, i.e. it is valued for particular functions.	• in spite of its present degraded condition the Estuary has high use values. With the intended protection systems there is no risk to contamination of the Estuary from the landfill.
• visual impact	• the site has little landscape value but the intended perimeter screen planting will ensure the operation has no visual impact.
• litter	• proper site management techniques such as a minimal tip face, consistent covering and provision of litter control fences will effectively prevent this problem.
• odour	• major escapes of landfill gas caused by inadequate soil cover can be eliminated by proposed soil cover practices, and by collection and venting system.
• impact of traffic to site.	• the only route to the site for the transfer vehicles is by SH1 no through Brighton. Access into site will be by internal forestry road not McLaren Gully Road.
• impact on property values and from noise.	• the nearest houses are 1.4km distant and the landfill will not impact on the few houses in the vicinity.
• fire risk to forest.	• Minimum separation distances will be maintained and a fire-lighting pond available.
• Maori cultural impacts.	• Runanga acknowledge that the Smooth Hill site is of less importance and has had less use than Green Island.

11.8 CONCLUSIONS

The significant conclusions of this EIA report:

- The construction of the landfill at the Smooth Hill is technically feasible.
- The site allows for progressive development of the site over the years without incurring a high initial cost.
- The site has a potential capacity of 6.4 million cubic metres giving a life of some 50 years for Dunedin. The landfill would be developed in three stages of 25, 15 and 10 years.

- The site is at the head of the catchment and this stormwater control will not be a problem.

- The site is underlain by very low permeability soils which will provide a very suitable liner of the landfill.

- This liner plus the intended leachate collection system will provide the necessary protection against groundwater contamination.

- The low permeability clay soils will provide an additional barrier against contamination of ground or surface waters by having the capacity to attenuate and breakdown organic contaminants during the very slow (10^{-8}m/sec or 30cms per year) passage through the soil.

- Because of the liner construction, the leachate collection system, the attenuation capability of the soils and the 13km separation distance to Brighton there is no risk of contamination at the Brighton estuary or beach.

- Because the site is so isolated and the access to the site is by a State Highway and internal access is by a State Highway and internal access there will be no traffic, noise, visual or property impact from the operation.

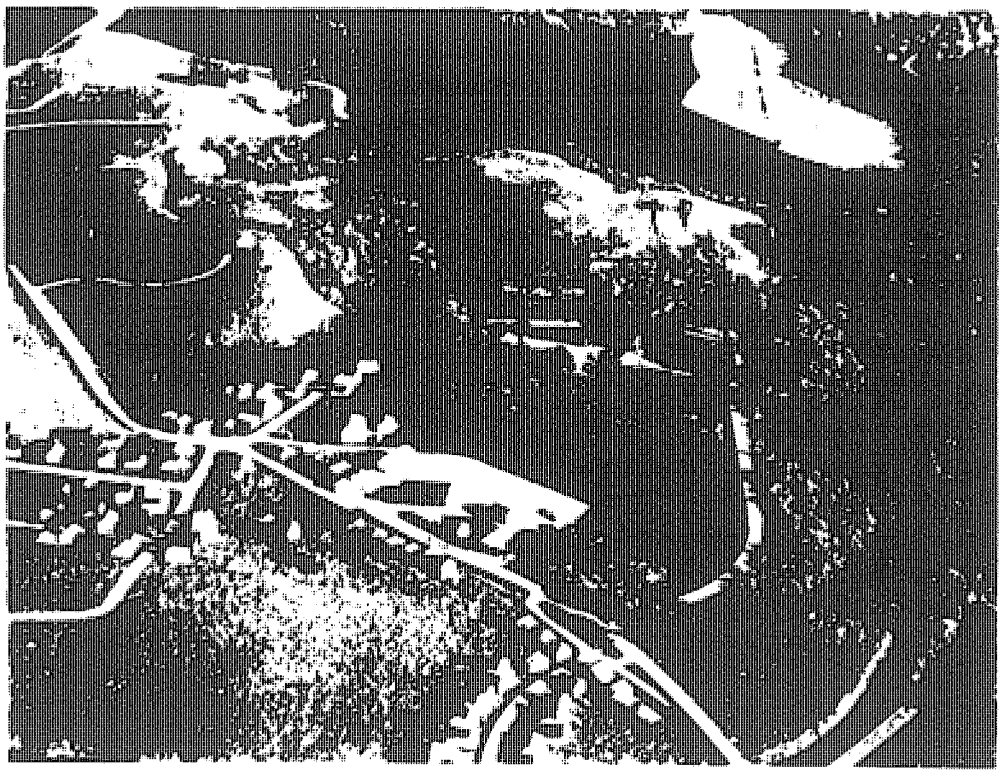
- Development cost for the landfill are reasonable for a new site and operation and management will be economic.

- The capital and operating cost of the necessary transfer station and the high cost of transportation of refuse to the site makes the total operation an expensive one.

- The Required Gate Charge is $48.85/tonne and this is double that for the Extended Green Island landfill.

BECA

ENVIRONMENTAL IMPACT ASSESSMENT
of the
Extended Green Island Sanitary Landfill



Prepared for
DUNEDIN CITY COUNCIL
October 1992

6.0 SUMMARY AND CONCLUSIONS

6.1 SUMMARY OF PROPOSED WORKS

6.1.1 Basis of Extended Landfill

The basis of the proposed works to extend the existing Green Island landfill is to extend only upwards while keeping within the boundaries and confines accepted for the existing landfill. These horizontal limits are described and discussed in the **Existing Green Island Landfill EIA** which preceded this document.

By maintaining the same areal limits to the landfill, the same leachate control and collection system and sediment ponds can be used for the extended landfill as is proposed for the existing landfill.

The intention of this extension to the present landfill is to create a landscaped refuse mound on the site in such a way that the impacts of the proposal are minimised. The mound will rise to a maximum of some 15 metres above the existing landfill, or some 24 metres above the general estuary levels. The created mound will be shaped and contoured with slopes no steeper than 1 in 5 and generally much flatter.

6.1.2 Capacity and Life

This landfill has a volume or nett air space of some 3 million cubic metres and a life of between 25 and 30 years based on the figure of 100,000 m^3 per year of compacted refuse plus 20,000 m^3 per year of cover.

6.1.3 Landfill Development Sequence

The sequence of construction of the landfill is shown on Figures II 1.1 to 1.3.

In developing this sequence the following prevailing conditions are assumed to apply:

a. The leachate control and disposal system put forward and recommended in the **Existing Green Island Landfill EIA** are in place and operating.

b. The stormwater control system and the sediment ponds recommended in that EIA document are in place and operating.

c. That landfilling on the site has reached (or is aimed at reaching) the general levels specified in the Pitts Plan over the whole site. The Extended Landfill therefore is constructed from those levels upwards.

The mound extension commences from a generally flat site (between RLs 107 and 109) over the total landfill area. The basic concept of the mound development is an initial bund - perhaps 3 metres high - around the periphery of the landfill area with the refuse filling then proceeding inside the bund until that whole level is filled. The process is then repeated at the next level. The final layer would be formed into the apex of the mound and, after capping, the mounded landfill would be complete.

The purpose of the initial perimeter bund at each level is three-fold. Firstly it provides a buttress to landfill against, secondly it provides a visual and acoustic barrier for the surrounding areas against the landfill operation and thirdly a windbreak to reduce the possibility of windblown debris.

As the bund was constructed around the site, grassing and planting would take place to a pre-conceived plan. This would not only help to screen the landfill activities but introduce the landscaping concept to the site early and progressively.

The source of cover material must be identified at an early stage. The hill to the south of the site is presumed at this stage to be a source but adequate quantities may not be available within existing Council-owned land and it will be necessary to negotiate to extend those areas.

6.1.4 Leachate Collection and Disposal System

The leachate collection system proposed and fully described in Section 8.4 of the EIA for the **Existing Green Island Landfill** will be utilised for the extended landfill as the plan dimensions will not be increased, only the height of the landfill.

Leachate can be effectively captured around the perimeter of the landfill site due to the nature of the slightly permeable horizontal layers immediately under the site and the impermeable marine sediments and mudstone layers forming the basement strata.

A gravel filled trench around the perimeter, with groundwater pumping from pump stations located at 200 m spacing will be used, with the collected groundwater discharged to the Green Island Wastewater Outfall.

Because the pollutant concentrations are expected to be lower than normal wastewater, it is feasible to discharge the leachate/groundwater collected by the perimeter drains to the Green Island wastewater sewer. Such a discharge would be subject to trade waste controls and monitoring.

The predicted quantity of leachate from the proposed collection system for the Green Island Landfill is 6.5 litres/sec. This flow rate will not increase when the refuse height is increased.

6.1.5 Landfill Gas Management

Waste encapsulated in a landfill undergoes anaerobic decomposition and the process generates a landfill gas comprised of about 55% methane, 45% carbon dioxide. When the height of refuse is increased, the Green Island landfill will contain a substantial volume of refuse. Consequently the landfill gas (LFG) production potential is appreciable and would reach the point where collection and flaring is required to reduce environmental impacts. Utilisation of the gas could be economically viable. Furthermore, any odour associated with the LFG can be reduced by the flaring of the gas.

The gas management system must ensure that the migration of the landfill gas is controlled, the system will reduce 'greenhouse' gas emissions, especially methane, to the atmosphere, and the gas extraction wells will be capable of removing the landfill gas generated through the depth of the waste.

The proposed landfill gas extraction system consists of extraction wells, piping, valving and suction blower. The perimeter wells will serve to form a vacuum net around the filled area, preventing any gas generated within the placed refuse from escaping or migrating offsite.

6.1.6 Surface Hydrology

The refuse mound proposed with the extension of the Green Island Landfill would create side slopes approaching 5H:1V. This would increase the potential for leachate to seep through the cover placed over completed refuse cells to contaminate surface water runoff. This is known as leachate "breakout". To avoid this it is proposed to incorporate an impermeable capping layer on the completed landfill. This would require a 500 mm impermeable clay layer placed over the daily cover once landfilling reaches the final design profile. This would then be overlaid with 150 mm of topsoil. Grass would be established immediately to limit the erosion potential and high sediment loads in the event of rainfall.

During landfilling operations surface drains will direct all stormwater not in contact with the working face of the landfill to the sedimentation ponds. The area being worked will be encircled by a temporary bund and all runoff from within that area will drain to the leachate collection to be discharged to the Green Island treatment plant.

The two sedimentation ponds proposed for the remediation of the existing Green Island landfill as described in **Existing Green Island EIA** would continue to be used during extended landfilling operations at Green Island.

Accumulated sediment will need to be removed from all sediment ponds on a regular basis (probably annually). This would involve dewatering the pond and excavating or pumping the accumulated sediment into the active landfill. Only one of the ponds would be decommissioned at any one time and stormwater would be re-routed (with pumping if necessary) into an alternative pond in the event of rain.

6.1.7 Associated Works

a) Source of Cover Material

At present, cover material is carted to the Green Island landfill mainly from Blackhead Quarry. This cartage operation could be reduced if cover material was excavated from the ridge to the south of the site. This borrow pit would be eventually filled with refuse and the area reshaped to conform to the proposed final contour plan. Because about 20% of the refuse volume is required for covering to a sanitary landfill standard, the borrow pit would provide useful landfill capacity. Adequate lining of the base of the area and a leachate collection system would be necessary.

b) Trunk Sewer

The trunk sewer leading to the Green Island Wastewater Treatment Plant follows the south-eastern boundary of the landfill. If the landfill is carried at a high level to the ridge, the forces exerted on the buried sewer main would be excessive and cause the existing pipe to collapse. Therefore, the trunk sewer needs to be upgraded in the future.

c) Watermain

A water supply main is laid adjacent to the trunk sewer and would be re-routed around the landfill.

d) Watercourse Diversion

The watercourse draining the gully east of the Brighton Road near Clariton Avenue, would need to be diverted, firstly in a contour drain around the base of the hill and ultimately piped when access to the borrow area and height of landfilling so required.

6.1.8 Roading

Access to the site itself is by way of a 400 metre long road from Brighton Road to the nominal site boundary. This access, constructed in 1990, provides a convenient route to the landfill and good control on entry to the site. On-site roading from this point will depend on the development strategy for the overall site but the formation of any site roading from this point must provide an all-weather, tidy and convenient access to the final disposal point, be it recycle area, transfer station, weigh bridge, or landfill face.

6.1.9 Buffer Zones

The site will be fenced around its perimeter with substantial planting inside the fence and especially between residential areas and the landfill.

The nature of the proposed landfill development is such that it will be substantially elevated above the plane of the surrounding land and will be difficult to screen from view during its active life.

The mass and height of the landfill will dominate any screening planted within the landfill site. Buffer plantings will act to camouflage rather than screen. For this reason the landscape development concept proposes two methods of buffering the site from the neighbouring residential areas.

The first of these will be the use of mounded earth bunds combined with planting within the site to screen as much as possible of the operational parts of the landfill.

The second will be to establish plantings on the site perimeter and within the community to reduce views of the site and enhance the quality of the surrounding landscape.

6.2 LANDFILL MANAGEMENT PROPOSALS

6.2.1 Introduction

In Section 2.0 Part II of this document recommended practices are provided to ensure that the operation of the extended landfill is performed to accepted sanitary landfill standards.

It covers the type of refuse to be accepted into the site and the means of controlling this. It also deals with the type of equipment used, the personnel requirements and their training, the hours of operation and general features such as the prohibition of scavenging and salvaging. These factors are generally non-site specific for a sanitary landfill operation. There are however several sanitary landfill practices which apply to the Extended Green Island Landfill.

6.2.2 Compaction, Cover and Capping

There are three major elements in the operation of a sanitary landfill:

(i) Proper placement of refuse
(ii) Effective compaction of waste
(ii) Placement of adequate cover.

Waste placement consists of the refuse vehicles unloading at the face of the active filling area. Once the refuse is unloaded, the compactor pushes the waste into the active filling area spreading the waste into 500 mm to 1 m lifts. Then the compactor proceeds to made 3 to 4 passes over the waste compacting it in place to a target density of around 800 kg/m^3 or greater.

Deposited refuse will be covered at the end of each operational day with not less than 150 mm of compacted soil.

Intermediate cover will be applied to all landfill surfaces and slopes which will not receive additional solid waste for 30 days or more. When landfilling operations begin again in areas with intermediate cover, the cover will be stripped from the surface and stockpiled with penetration into the lower layers of the landfill.

As refuse is brought to final grade, the final cover will be applied and vegetated. The final cap will comprise 500 mm compacted low permeability soils, 100 mm topsoil and vegetation.

The final cap will minimize erosion, surface water infiltration, leachate and gas generation.

6.2.3 Surface Water, Leachate and Gas Management

6.2.3.1 Surface Water

Surface water from the peripheral berms and completed areas of the landfill will be collected in channels and discharged away from the face. Due to the nature of a landfill development, reasonably large scale earthworks operations are required, producing large areas of exposed excavation, refuse and landfill cover. Unabated, stormwater runoff will contain high sediment concentration and load which could eventually drain to the Kaikorai Estuary.

The objectives of stormwater control within the Extended Green Island site will be:

- to limit discharge of surface water runoff to the Kaikorai Estuary to those expected from a natural catchment in terms of both flow and water quality criteria

- to limit the risk of leachate 'breakout' into the surface water system

- to safely convey flood flows around the site, without causing streambank erosion.

6.2.3.2 Leachate Management

Leachate produced within the landfill by the action of rainfall percolating into the refuse will travel down through the full depth of refuse before travelling horizontally along the soil interface. When the leachate flow reaches the perimeter of the landfill it will be effectively captured by the collection trench system around the site.

Effective and continual management of the system is imperative to minimise any effects outside the site. This will include:

- Inspecting the system for proper operation;
- Flushing the leachate collection pipes;
- Maintaining the leachate pumping system;
- Maintaining permanent access roads to the system and pumps.

6.2.3.3 Landfill Gas Management

A continual programme of monitoring is required to assess the effectiveness of gas migration control measures and to check for gas in any building on the landfill or in ground near the site boundary.

Bore holes are required for gas monitoring at not more than 20 metre centres, close to the boundary of adjacent properties on Clariton Avenue. Control measures should be taken if methane exceeds 1.0 percent or carbon dioxide exceeds 1.5 percent.

The frequency of monitoring required will depend on the results obtained but should continue until the concentration of methane remains less than 1.0 percent and the level of carbon dioxide remains less than 1.5 percent.

6.2.4 Nuisance Control

6.2.4.1 Introduction

Nuisances exist at all landfills even properly operated sanitary landfills. They generally fall into four categories as described in the following sections.

6.2.4.2 Litter

All refuse transporters entering the site must either have an enclosed container or the loads will be properly covered. One of the most important aspects of ongoing landfill maintenance is litter control. Blowing debris can be minimised by:

- Constructing permanent berms around the site as proposed for the extended landfill;

- Maintaining a small working face;

- Covering portions of the cells as they are filled;

- Cleaning up litter on a daily basis on the site and on access routes;

- Positioning temporary fencing around the working face to intercept blowing debris.

6.2.4.3 Dust and Mud

All of the roads providing access to the site are sealed except for the on-site access. This should be sealed by the Council as soon as practicable.

Dust generation at the landfill can occur from operations such as cover material stripping and replacement, refuse compaction and vehicular traffic on minor access roads within the site. Dust control will limit excessive wear of equipment and eliminate nuisance to residents and site personnel.

Mud during wet weather will be controlled by having paved landfill access roads with asphalt bumps or ridges and well-metalled secondary roads. A wheel wash system will be installed near the gatehouse to service vehicles before leaving the site.

6.2.4.4 Vermin, Birds and Flies

The compaction of refuse deposited at the site by the on-site compactor together with the addition of daily cover makes it more difficult for rodents to become established.

The reduction in working face area, quick and effective compaction plus covering will remove the attractiveness of the site to birds.

Based on experience at other sanitary landfills, flies are not a problem at a well controlled refuse landfill provided that adequate cover is used on the site.

6.2.4.5 Odour and Air Pollution Control

A properly operated sanitary landfill minimises the release of odours and air contaminants. The following steps will be incorporated to control the release of odours and air contaminants.

- Apply daily cover;

- Cover odorous waste immediately after deposition; if odours occur apply odour control chemicals;

- Maintain gas vents and leachate manholes in proper operating condition;

- Remove daily and intermediate cover in designated areas to maximise downward migration of leachate;

6.2.5 Environmental Monitoring

6.2.5.1 Baseline Studies

Monitoring of environmental factors will be carried out throughout the life of the landfill and continue after the landfill has been capped and closed.

6.2.5.2 Groundwater Level Monitoring

The pumping from the perimeter leachate collection trench will produce an inward gradient in the groundwater system around the perimeter of the site. Thus, the groundwater monitoring programme will be primarily focused on groundwater level measurements to confirm the existence of an inward gradient at all locations around the perimeter of the site.

6.2.5.3 Groundwater Quality Monitoring

Due to the particular conditions at the Green Island site, stream water sampling will be relied upon as the primary means of monitoring for contaminant releases from the landfill. The stream water sampling programme, as described in the **Existing Green Island Landfill EIA** provides for monthly sampling at several locations around the perimeter of the site. Monthly samples will be analysed for common indicator parameters. Comparisons of stream water quality from sampling sites upstream and downstream from the landfill could provide an indication of the contaminants reaching the stream.

6.2.5.4 Surface Water Monitoring

A monitoring programme on the inflow and discharge from the sedimentation ponds would be undertaken. Conductivity measurements shall be made weekly and monthly checks of ammonia, iron, BOD and suspended solids are recommended to determine if leachate contamination has occurred.

6.2.5.5 Gas Monitoring Measures

Monitoring is required to check gas migration and assess the effectiveness of any migration control measures and to check for gas in any building existing or proposed on the landfill.

Sub floor and basement areas of buildings on and adjacent to the landfill should be monitored and control measures taken if methane exceeds one percent of carbon dioxide exceeds 1.5 percent.

6.3 SUMMARY OF ENVIRONMENTAL IMPACTS

6.3.1 Introduction

The full range of environmental impacts which will result from the proposed extension of the Green Island Landfill is assessed in Section 3.0 of Part II of this report.

6.3.2 Geotechnical

The proposed extension of the Green Island Landfill involves an increase in the height of fill of up to 15 m. The effects of this increase in fill height on land stability has been assessed.

6.3.2.1 Stability During Construction

The landfill site is underlain by up to 9.0 m of very soft to soft silty clays, sandy silts and silty sands. Increased pore water pressures are likely to occur in these soils as a result of the increased overburden pressure during fill placement. These pressures will reduce the effective strength of the soils. The soil strength will recover in time as these pressures gradually dissipate. In order to maintain stability during construction, care must be taken to avoid excessive increases in pore pressures.

6.3.2.2 Stability After Filling

Analyses have been carried out for the proposed finished ground profile. An acceptable factor of safety under static long term conditions is generally taken to be 1.5 for a risk of failure of 1:200 per annum. The analyses show that this criteria can be achieved for the long term proposed landfill profile.

6.3.2.3 Seismic Risk Assessment

The likely effects of seismicity in the Dunedin area on the stability of the landfill has been investigated along with the risk of a seismic event of sufficient magnitude to cause movement of the fill mass.

Analyses have been carried out which indicate that ground accelerations of approximately 0.1 g (return period of 130 years) would be required to cause movement of the fill mass. At this level of acceleration the types of failure which could be expected would be slumping of the steeper toe slope with lateral movements of 500 mm+ at the toe and settlements of 100 to 300 mm due to consolidation of the weak underlying sands and silts following earthquake shaking.

6.3.3 Hydrogeology

6.3.3.1 Effect on Groundwater Flow

The primary effect of the Extended Green Island Landfill development on groundwater flow will be interception of groundwater in the leachate collection trench around the perimeter of the site. Pumping will lower groundwater levels by about 0.5 m in the trench causing groundwater to flow toward the collection trench from areas outside the landfill and from beneath the landfill area.

Because the groundwater flow system will not be affected by the thickness of the refuse layer, the design of the perimeter leachate collection trench is the same for the Existing Green Island Landfill or the proposed extension. The collection trench will intercept the leachate flowing from beneath the landfill, regardless of the thickness of the refuse layer.

6.3.3.2 Groundwater Quality

Increasing the volume of refuse in the landfill will result in leachate being produced for a longer period of time. Depending on the rate of refuse placement relative to the rate of biological stabilisation of the refuse, it may also result in a slightly higher strength leachate being produced. There will probably be some degradation of groundwater quality beneath the landfill site. Because the leachate and groundwater from beneath the site will be captured in the perimeter leachate collection trench, the strength of the leachate will not affect groundwater quality beyond the perimeter of the site.

6.3.3.3 Leachate Levels within the Landfill

The weight of the additional 15 m of overlying refuse may cause some additional compaction of the refuse in the lower layers of the landfill. Computer modelling studies have indicated that compaction of the lower layers of the refuse will not result in any appreciable build up of leachate levels in the landfill over those expected with the Existing Green Island Landfill.

The cover material presently in place over the Existing Green Island Landfill might provide a layer on which leachate would pond if additional refuse is mounded above. In order to avoid potential problems with leachate ponding, portions of the existing cover material in areas near the perimeter of the landfill should be removed prior to placing additional refuse on top. This would provide pathways for any ponded leachate to percolate downwards and into the leachate collection trench, rather than seep through the side slope. The perimeter bunds around the working levels of the landfill will also act as a barrier to prevent horizontal seepage of leachate out of the fill.

6.3.4 Surface Hydrology

6.3.4.1 Areas Affected by the Proposed Landfill

The proposed extension to the Green Island landfill would alter the drainage pattern within the site. From an impact viewpoint the main change in the hydrological response of the site catchment would be due to the change in form and ground cover, as the additional landfilling proceeds.

As landfilling progresses the affected area would comprise a variety of cover types. Bare soil in the vicinity of the working face should be confined to a maximum area of 2 ha enclosed by a temporary bund from within which incident rainfall will drain as leachate. A borrow area is likely to be established to the south of the landfill, outside the limits of fill, to obtain cover material for the extended landfilling operation. It is proposed that a maximum borrow area of 1 ha would be exposed at any one time with all other areas either maintained in their natural state or revegetated once excavation of cover material is complete.

6.3.4.2 Summary of Hydrological Impacts

Reclamation within the Kaikorai Estuary for farmland, golf course and landfills has replaced about 160 ha of wetland habitat with a raised terrestrial environment. The upper estuary is important as a flood storage area, especially when natural coastal sand movement closes the mouth of the estuary, preventing any outflow to the sea. Since 1958, landfilling operations and bund construction at Green Island have been responsible for reducing the upper estuary area by about 36 ha. Consequently the flood storage capacity of the upper estuary has been significantly reduced.

Storm runoff from the existing Green Island landfill site has an effect on the estuary due to the sediment loads and leachate it contains. The extension of the Green Island Landfill would increase this impact if no mitigating works were proposed to reduce sediment concentration in the discharge to a predetermined level.

6.3.4.3 Proposed Mitigating Works

To mitigate the environmental impact on surface hydrology it is necessary to provide for the control of surface stormwater within the site.

The following works are proposed in conjunction with extended development of the Green Island Landfill:

- Maintain the separation zone from the estuary proposed for the remediation of the existing Green Island Landfill. No landfilling operations would encroach further into the Kaikorai Estuary.

- Maintain the outer landfill face and groundwater leachate collection system as proposed for the upgrading of the existing Green Island Landfill.

- Continue to operate and maintain the two sedimentation ponds proposed for the upgrading of the existing landfilling operation at Green Island. An additional temporary pond may be required in the borrow area to the south of the landfill if runoff cannot be diverted to the southern pond.

- Use contour drains formed in the cover material to restrict the erosion potential of runoff.

6.3.5 Impacts on Water Quality

The leachate collection trench around the perimeter of the Green Island Landfill will lower the groundwater level by some 0.5 m at the trench and the inward gradient formed will prevent escape of leachate from the site.

Leachate will therefore not discharge to the Kaikorai Stream or Estuary and instead will be collected and pumped to the Green Island Wastewater Treatment Plant and Ocean Outfall.

The escape of leachate from the Green Island and Maxwells landfills (1992) was estimated to account for about 20% of the mass load of pollutants entering the Estuary except in the case of ammonia where the landfill contribution was 80%. Non point source pollution from urban and rural areas accounted for the remaining mass load. Because of the diffuse origins of the urban and rura! pollution, reduction of these sources cannot be foreseen in the near future. Consequently, the major improvement in water quality and decrease in the eutrophication potential will result from improvements at the landfills. The leachate collection system will effect these improvements.

6.3.6 Bird Strike Potential

The Green Island Landfill has attracted large numbers of black backed gulls in the past. The site has been a favoured feeding ground and the gull population is higher in this area that it would have been without the landfill although there have been no reports of aircraft bird strikes associated with the landfill.

It has been proven in Auckland and elsewhere overseas, that a new sanitary landfill operation, including bird scare measures, can be free from bird nuisances.

The Ministry of Transport advisor on ornithological aspects, (T Caithness) considers that reduction in total gull population in the area is the primary objective and that operation of the site as a sanitary landfill will achieve this objective.

6.3.7 Landscape Impact

The existing Green Island and Maxwells landfills have caused major modification of the original wetland landscape. On the remaining unfilled land in the estuary the channel realignment appears to have caused the replacement of the original rush wetland with lank, introduced grasses.

The extension of the present landfill upwards would create a mound between ten and fifteen metres higher than the existing finished level.

Unless there is substantial landscape development of the site and the surrounding land, the proposed extension will create major impact on the adjacent residential areas especially in the Clariton Avenue - Melrose area.

At the subregional level the impact would not be significantly greater than that which arises from the present landfilling activity. It will however, act to prolong the period in which impact occurs.

The establishment of landscaped buffer areas and tree planting programme, as proposed, would, in conjunction with a more concentrated and controlled operation, ensure a much lower level of impact than that arising from the existing landfill. The planting programme would be designed to do more than screen the site from the surrounding community. It would enhance landscape values and would recompense it for the loss of amenity arising from the adjacent landfill. It would also enhance the City's southern entrance. Planting adjacent to the motorway would need to be designed to create an entrance landscape rather than merely screen the landfill from view. Purely "functional" screening plantings could create visual impacts as substantial as that arising from the activity they are intended to screen. The planting programme must act in a positive way towards the surrounding community for impact to be minimised.

6.3.8 Roading

Green Island had traditionally been a major City access route and the centre of industrial activity. While the landfill traffic is a significant proportion of traffic through the Green Island township is has not had a great impact on the area for these reasons. Indeed it has helped to retain the commercial area in Green Island. Provided roading is kept up to a good standard and roads are regularly cleaned and tidied, no major impacts on the area are anticipated as far as the traffic is concerned if the landfill operates for a longer period in the future.

The only significant improvement to the roading system identified is the need to upgrade the intersection of Brighton Road with the Access Road. Provision needs to be made for turning vehicles to queue safely and for transfer vehicles to be able to leave and enter Brighton Road conveniently and safely.

6.3.9 Noise

The noise level at any given position will vary depending on the exact location of the operations within the landfill and the degree of exposure to the receiver position. Calculations have been based on there being line of sight between the noise source and receiver position and the closest dwelling in the area. The resulting average maximum noise level (L_{10}) would be 58dBA at the closest point in Clariton Avenue.

It is proposed to construct an earth bund around the perimeter of the landfill at each lift to contain the landfill, allow some visual screening and landscaping and provide acoustic screening for some areas.

The noise criteria for ongoing work as set out in the District Plan for the area is an L_{10} of 55dBA Monday to Saturday from 7.00 am-10.00 pm and 45dBA at all other times. On this basis it can be seen that for the most exposed houses in Clariton Avenue the noise level would be exceeded by 3dBA on Monday to Saturday. At all other sites the 55dBA requirement would be achieved. On Sundays the lower level of 45dBA must be complied with. This is well below the noise level that would be experienced at times from the landfill operation.

6.3.10 Social

There are a range of social impacts associated with both of the proposed Extended Green Island and Smooth Hill landfill sites. Some of these relate to the overall refuse management study and are thus common to both landfill proposals. Others relate to the specifics of each landfill proposal.

At present there are concerns in the community that the full range of options has not been canvassed. The final version of the Refuse Management Study should demonstrate the merits of the preferred option and thereby allay concerns that either one community is carrying an undue burden or that costs and detrimental impacts are being imposed on future generations by inappropriate choices today.

It is extremely difficult to determine whether Green Island or Smooth Hill is the preferable site in terms of social impacts, because the impacts at the two sites are very different. In many respects, the actual social impacts of a well managed landfill at Green Island would be greater than at Smooth Hill, while the perceived impacts associated with Smooth Hill may be seen as more severe and as affecting a wider population. It is essentially a political decision as to which group is to be affected. In making this decision, it must be recognised that in social terms, actual and perceived impacts are equally powerful in people's decision making, particularly in the short term.

A variety of mitigation measures are proposed to reduce the social impacts. These are summarised in Section 6.4.

- **Impact of Borrow Pit.** In order to minimise the visual impact of the possible borrow pit to the south of the site particular attention to screening and revegetation will be required.

- **Litter.** The present site is very exposed to wind but the increased elevation would not noticeably cause more litter to be wind blown. Once the perimeter embankment is in place, the working face would be better sheltered compared with the present operation but litter control fences will be a crucial part of the sanitary landfill operation.

- **Odour.** Odour can be released from a landfill if there is inadequate soil cover and major escapes of landfill gas. The proposed sanitary landfill operation will have good soil covering and soil is a very effective odour treatment method.

6.3.11 Maori/Cultural

The Runanga considers that the deterioration which has occurred in the Kaikorai Estuary will be difficult to repair but that the estuary should be protected from any further damage. Because the site is an existing landfill and has future capacity, in the opinion of the runanga it is worthy of consideration for future landfilling. The Runanga wish to see an archaeological survey carried out on the site and to make further comments when it is complete.

6.4 MEETING COMMUNITY CONCERNS

The range of concerns which have been raised by objectors to the water right applications and by participants in the public consultation programme have been fully covered in this report. The proposed design and management of the Extended Landfill have been tailored to take account of these concerns. In addition, a range of mitigation measures is proposed to reduce environmental impacts to the minimum possible.

The principal matters of concern and the manner in which these issues have been addressed are summarised below:

Issue	Comment
• potential for discharges to receiving waters.	• leachate collection system proposed for the existing landfill will minimise discharge to natural waters. The extended landfill will create no more leachate and will utilise the same system to protect receiving waters.
• insufficient information to assess proposed abstraction and discharge.	• a range of site investigations have been carried out and the results recorded in this document.

• advise effects on the ecology and recreational values of the Estuary.	• protection measures proposed would significantly improve water quality and would allow for the progressive planting and development of the site as an area for passive recreation.
• interlocality equity (whether one community should bear the adverse consequences of a facility that serves the whole of Dunedin).	• an issue which is dealt with in the Refuse Management Strategy.
• intergenerational equity (whether the costs and adverse effects of today's wastes should be borne by future generations).	• an issue which is deal with in the Refuse Management Strategy.
• the need to protect the integrity of ecosystems.	• the proposed leachate collection system would result in improvement in water quality in the Estuary.
• the Estuary has particular use values, i.e. it is valued for particular functions	• its present degraded condition means that it has low use values. The proposed leachate collection system would contribute to improved water quality but other sources of contamination such as urban run-off in general would prevent much improvement in use values.
• visual impact	• proposal to create a series of bunds at different stages of the landfill, and to plant both within the site and outside it, would largely screen the landfill and reduce visual impact.
• litter	• proper site management techniques such as a reduced tip face, consistent covering and provision of litter control fences would effectively eliminate this problem.
• odour	• major escapes of landfill gas caused by inadequate soil cover can be eliminated by proposed soil cover practices.

• visual impact of gaining cover fill.	• stripping process will not be visible from Green Island or Clariton Avenue, only from some elevated properties to the north. Particular attention to screening and revegetation would minimise the impact.
• Surprise element : impact on residents' future plans.	• proposal has been known and available for two years.
• impact on property values.	• properly managed there is unlikely to be a significant impact. The end use for the site has for a long period been proposed as industrial.
• impact on retailers.	• the closure of the Green Island Landfill would result in a significant adverse economic impact on Green Island retailers.
• home enjoyment.	• proposed management as a modern sanitary landfill would minimise detrimental effects on home enjoyment.
• Maori cultural impacts.	• Runanga acknowledge that the degradation of the Estuary would be difficult to repair. The proposal would result in some improvements. An archaeological survey of the site is recommended.

6.5 CONCLUSIONS

The significant conclusions of this EIA report are:-

- The extension of the Green Island Landfill as a mound within the same areal confines as the existing landfill is technically feasible.
- The mound extension will provide some 3 million cubic metres space sufficient for 25 years landfilling beyond the completion level of the present landfill, based on the shape and landscaping provision adopted.
- The extended landfill will not produce any greater volume of leachate than the existing landfill provided it is operated as a proper sanitary landfill.

- The leachate collection and disposal system to be installed for the existing landfill will be adequate for the extended landfill.

- Systems can be readily put in place to minimise surface water and sediment runoff and to control any hazards from the landfill gas generated.

- The major impacts of the extend landfill will be visual and social.

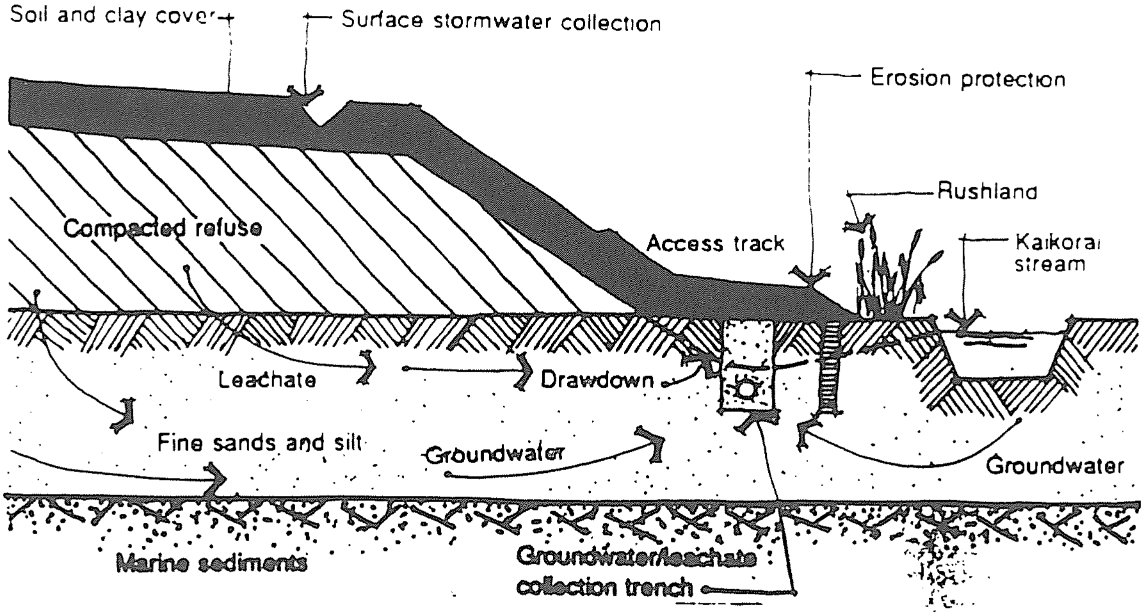
- With proper landscaping in buffer areas and positive screening planting the visual impact of the mounded landfill can be minimised, although of course the period of impact will be prolonged.

- The main social impact relates to the community concern about the continuation of landfilling in their area. Acceptance that the landfill will be operated as a sanitary landfill rather than as the landfill of past years will help to allay that concern. Belief within the community that Council has canvassed all options and has chosen the best and fairest and most cost-effective will also help to overcome people's concerns.

- Development costs for the extended landfill will be relatively minor since the upgrading of the existing landfill will provide environmental control measures that will remain applicable for the extended landfill. The upgrade of operation to a sanitary landfill standard will add some $300,000 annually. The required gate charge to provide a cash flow to cover operating and financial costs is $24 per tonne.

BECA
STEVEN

ENVIRONMENTAL IMPACT ASSESSMENT of the EXISTING GREEN ISLAND LANDFILL



Prepared for
DUNEDIN CITY COUNCIL
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Consulting Environmental Engineers

9.0 PREFERRED UPGRADING SCHEME AND IMPACT MITIGATION

9.1 SUMMARY OF UPGRADING WORK

9.1.1 Introduction

The various options for mitigating environmental impacts were described and evaluated in section 8.0. Obviously, in upgrading a sub-standard situation by retrofitting control measures, the approaches taken need to be site specific and different to the engineering designs which would be applied to a "green field" landfill site.

There has been considerable activity overseas in "clean-ups" of uncontrolled landfills and proven techniques are available. Elsewhere in NZ a number of landfills, located in gullies or quarrys, have been retrofitted with leachate and gas control measures. However, while many landfills are located near estuaries, there appear to be few examples of retrofitted leachate collection systems.

9.1.2 Leachate Collection

The most appropriate method of collecting groundwater will be a perforated collector drain in a gravel filled trench around the landfill perimeter. Pump stations at about 200 m spacing will draw down the groundwater table so that an inward hydraulic gradient is formed. Leachate groundwater from under the landfill will be intercepted by the trench which will also draw water from the stream side. The pump station discharges will be piped to the Green Island Wastewater Treatment Plant.

The pumped flow will be about 12 litres/sec which is a small flow relative to the Green Island Wastewater Outfall's present average flow of 150 litres/sec and peak capacity of 800 litres/sec (refer to Section 8.4.2). The 12 litres/sec flow is the combined flow from the proposed Green Island and Maxwells landfills perimeter collection trenches. Both landfills contributed to the capital cost of the Green Island Wastewater Outfall and were allocated trade waste volumes in excess of this value.

A cut-off wall on the stream side of the gravel collection trench could reduce the pumped flow. However due to the high costs of the wall, this would only be installed if permeabilities were found to be much greater in practice than now assumed. The cut-off wall would likely be a soil-bentonite slurry mixture placed in a 4 m deep trench. This construction can be performed without dewatering the saturated ground and without adversely affecting the estuary.

The bentonite clay swells and provides a low permeability barrier to groundwater movement, in this case forcing groundwater from the stream under the wall via a longer flow path with greater head loss and hence a reduced flow rate.

The gravel trench, and the slurry wall if required, would be constructed independently. There would be little cost penalty if the slurry wall was constructed at a later stage if it was shown to be required.

9.1.3 Visual Improvements

Landscaped mounds will be formed on the landfill surface to screen the landfilling, stockpiling and other activities on the site.

Prior to the perimeter leachate collection trench being installed it would be preferable to pull back the edge of the completed landfill in places where it encroaches on the stream, to form a 10 to 20 m rushland margin and to relieve a restriction of the stream's flood plain. This would involve excavating old refuse and forming a new perimeter embankment which should be landscaped with small shrubs and grass immediately after reformation.

Even though it would shorten the life of the Green Island landfill, the perimeter embankment could be formed between 20m and 50m from the Kaikorai Stream in the southern unfilled area, to:

- create an estuarine margin for vegetation and walkway development
- produce a gradual transition from the filled area to the stream and estuary which will result in a less intrusive visual impact.

Improved reception facilities at the Green Island Landfill are required including a weighbridge. The reception area should be landscaped as a first priority to create a favourable first impression on arrival at the site. The recycling drop off area could be prior to the toll office if there is no charge, so that vehicles with only recyclables do not have to queue at the toll office although this would require some separate form of control for the recycling area itself. Shelter and screen planting or fencing around the recycling area will make the facilities more "user friendly". The access road and recycling centre should be paved to present a tidier appearance.

9.1.4 Cover and Runoff Control

It is normal practice with a modern sanitary landfill to provide a clay cap of 0.5 to 1.0 m depth to seal the surface against rainwater penetration thereby minimising leachate production. However, such a cap is not recommended due to:

- high cost because of the high area to depth ratio

- likely concentration of landfill gas and venting in localised areas through high points and cracks or
- forcing gas to migrate horizontally off site.

The present widespread diffused release of gas can be tolerated provided precautions are taken with buildings and collection drains on the sites. In addition, monitoring bores have been installed along the boundary with properties off Brighton Road to check on gas migration below the surface. This will be an ongoing and important surveillance programme.

Localised mounding of imported cover material is envisaged to provide adequate depth for tree roots to survive without the inhibiting effects of landfill gas presence. Such mounding will also encourage stormwater run off to sediment ponds. Surface run off stored in these ponds would also be recycled to irrigate the planting on the landfill during dry periods.

9.1.5 Sanitary Landfill Operation

Although it is discussed last in this outline of upgrading works, the most important future strategy will be to put the landfilling operations on a sanitary landfill basis. This will entail covering the spread and compacted refuse each afternoon to minimise the attraction of birds and rodents to the tip face. Increased quantities of cover material will be required but odour and litter release will be reduced with the improved cover. Recent changes have been implemented along these lines.

The increase in cover material can be controlled by restricting the tip face open at any time. Even if this creates queues of vehicles at busy times, the benefits will outweigh the delay. These delays are also experienced at transfer stations in other cities as transfer stations have a limited "tip face" due to cost constraints and it is therefore reasonable to restrict the "tip face" at the landfill to achieve a better landfill operation.

It is considered that provision of a transfer station at Green Island should be deferred until the restricted tip face concept has been implemented and demonstrated. There are examples elsewhere in NZ where landfill operations have been improved to an acceptable standard with public access to a restricted tip face. Moveable barriers are required along with a good standard of defined access roading. Most importantly, properly constructed coarse mesh fencing is needed to trap wind blown debris.

While the foregoing upgrading measures will involve increased costs, these should be accepted as part of the appropriate standard provided for such a facility.

9.2 SUMMARY OF IMPACT MITIGATION

9.2.1 Surfacewater

Collection and satisfactory disposal of leachate has been a focus of attention prior to and during this study but the impacts of leachate on the estuary must be seen in relation to the greater magnitude of non-point source pollutants being produced in the whole of the Kaikorai Stream Catchment. Mass productions of heavy metals and other contaminants from the landfills are compared with other catchment sources in Table 7.2. These indicate that with the exception of ammonia, pollutant loads from the landfills are minor.

Other initiatives are being taken to control non-point source pollution such as phasing out of lead in petrol and better control of rural fertiliser applications. In keeping with other point source discharges, discharge permits will be required for leachate discharges and appropriate effluent quality standards will be imposed during this process.

From the limited analyses undertaken so far, the leachate/groundwater mixture when collected, will be of low strength relative to the industrial/domestic wastewater which is discharged through the Green Island outfall. There is allocated hydraulic capacity in the outfall for effluent from the landfill sites. Discharge of leachate/groundwater to the outfall will result in minor to negligible increases in pollutant mass loads.

A sampling and analysis programme for the leachate, groundwater and Kaikorai Stream water, commenced in December 1991 so that appropriate information will be available to support the water permit applications. A wide range of possible contaminants have been tested to quantify the possible concerns.

The results reported by Ogilvie in March 1992 show that heavy metal concentrations are elevated in the Kaikorai Estuary. Some organic compounds were present in leachate collected from within the landfill and Ogilvie concluded that:

- "their presence was not unexpected given their widespread use

- the concentrations of all organic chemicals found were less than the US EPA Water Quality acute criteria for fresh and marine water. With treatment and dilution they will all be less than the chronic criteria as well".

The single greatest improvement likely to be achieved by the leachate collection system will be reduction in the ammonia load on the Estuary. The ammonia nitrogen will have had a fertiliser effect and aggravated the eutrophication potential of the Estuary.

Ammonia load on the ocean when discharged through the Green Island outfall will have negligible impacts. Leachate will be treated along with the present domestic and industrial wastewaters when secondary treatment processes are installed in the future.

9.2.2 Ecology

The benefits to ecological systems will flow from improvements to water quality particularly the reduction in ammonia load on the Estuary. By reducing excessive algae growth and consequent decomposition products, a greater diversity of biota could become established. However, the complex interactions and urban nature of the catchment make predictions uncertain, particularly with respect to the influence of non-point source discharges.

9.2.3 Groundwater

Because the contamination of groundwater has most likely been confined to the immediate vicinity of the landfill and no groundwater wells are used in the area, the improved groundwater quality after collection of the leachate, will not be a noticeable benefit in itself, but indirectly will cause less pollution from groundwater seepage into the Kaikorai Stream.

9.2.4 Visual

Because the landfill sits in a basin and there are elevated vantage points all round, total screening of the site from view is not possible. However, the visual appearance can be greatly improved by an active planting programme supported by irrigation and fertiliser applications to promote rapid growth of native trees of the spreading variety rather than tall upright exotics. Extension of the grassed areas closer to the tip face would soften the impact of bare earth and also control wind blown dust.

Gulls and litter are visual indicators of the landfill and both need to be controlled by improved operation, increased compaction and soil cover, scare measures for gulls and movable mesh fences to capture wind blown litter.

Sealing of the access road to the toll booth and the recycling centre will greatly enhance the visual attractiveness of the site particularly when combined with landscape planting.

9.2.5 Noise

Equipment at the site must have effective exhaust silencers and be operated to minimise noise. At present the noise generated on the site is not intrusive above the background noise from other activities in the area and from the motorway.

9.2.6 Traffic

Generally, the access for traffic to the site is by way of arterial roads and impacts are minor. Some improvements can be made to the junction of the site access road with Brighton Road.

9.2.7 Air Emissions

Landfill gas is generated on the site by the decomposition of the refuse but the quantities are not sufficient to warrant collection and flaring to reduce the greenhouse gas emission effect. Odours can be related to landfill gas but generally arise only from inadequately covered refuse. The improved soil cover proposed will allow soil bacteria to treat the odours released by the landfill.

Dust nuisance will be controlled by more extensive grass and planted areas. Surface runoff will be collected in sediment ponds and the decanted water can be recycled for irrigation of the surface to limit dust release and promote growth.

9.2.8 Social

All the foregoing emissions (litter, dust, gulls, odour) are nuisances to the surrounding community. The improved operation and control measures proposed will result in substantial reductions of these nuisances.

13.0 CONCLUSIONS

A summary of the proposed upgrading works is contained in Section 9.

The significant conclusions of this EIA are:

Present Operation

- the existing Green Island landfill has not been operated in the past as a sanitary landfill and nuisances such as litter, windblown paper and plastics, dust, gulls and odour have been prevalent.

- leachate, produced by infiltration of rainwater and contact with decomposing refuse, has discharged from the site into surface and groundwater flows.

- the ammonia content of the leachate is likely to have had a significant nutrient impact in stimulating excessive algal growth in the Kaikorai Estuary.

Proposed Upgrading

- a sub-surface, perimeter collection trench is proposed which will prevent escape of polluted groundwater from the site to the Kaikorai Stream and Estuary. This contaminated groundwater will be collected and pumped to the Green Island treatment plant. However even with the prevention of leachate discharge to the Kaikorai Estuary, the estuary water quality will be far from pristine due to the significant pollutant loads generated by the balance of the urban and rural catchment. Generally it is estimated that the two landfills are contributing less than 20% of the pollution load in the Estuary with the exception of ammonia discharge which accounts for 80% of the ammonia inputs to Estuary.

- the landfill will be operated as a sanitary landfill and this will greatly reduce the nuisances associated with litter, windblown paper and plastics, dust, birds and odours. Better and stricter controls, moveable litter fences, smaller working faces and improved covering of the refuse will minimise nuisance effects. Some improvements have already been implemented in recent months with noticeable results.

- surface water and silt runoff will be collected and channelled to sedimentation ponds for settling.

- substantial improvements to the appearance of the site can be achieved by implementing a landscape management plan. Extensions of grassed areas and tree planting will provide visual screens and soften the impacts of large expanses of bare earth. At the same time dust emissions will be reduced.

5.0 COSTS

5.1 INTRODUCTION

The economics of landfill development and operation have been historically assessed by focusing on the actual costs to dispose of the waste. This effectively underestimates the real cost of landfill because not all "costs" are usually included in the analysis, that is costs relating to the opportunity cost of the land, rehabilitation and future environment management costs.

The development of an extended capacity Green Island site to a sanitary landfill standard, and the provision of acceptable standards of environmental protection has been described in Part II Section 1.0 of this report. This section of the report presents an economic evaluation of the "total" costs associated with the development and management of the facility, and makes an assessment of the unit cost of waste disposal at the facility as a basis for comparison with other landfill development options. Costs associated with the upgrading of the existing site which are relevant to the extended landfill operation, such as the leachate collection and disposal system, have been included. The basis for this is that those costs will be spread over a repayment period longer than the life of the existing landfill.

The economic evaluation considers the following costs:

(a) Capital cost for initial landfill development.
(b) Ongoing landfill development costs.
(c) Transfer station capital costs. (If required)
(d) Ongoing operating costs.
(e) Landfill after care costs.
(f) Financing costs.
(g) Net present value assessment and required "Gate Charge".
(h) Upgrading costs for the existing Green Island Landfill

An extended capacity Green Island sanitary landfill site has a potential landfill capacity of 3,000,000 m^3 providing an operating life of approximately 25 years, based on the current levels of waste generation. The estimates provided in this report assume that the site would be developed and managed as a landfill facility over a 25 year period at a waste deposition rate of 100,000 m^3/yr, (120,000 m^3/yr including cover) following closure of the Maxwell and other landfill sites.

Land committed to waste disposal is not available for other uses, for example open space, industrial developments, housing, wildlife habitat, or farming until the landfill is completed. Therefore, for the purpose of this economic assessment, the cost of the land or the future beneficial uses of the site have not been included in the analysis and are assumed to be "sunk costs" from the perspective of the Council.

The use of landfill sites after closure and rehabilitation typically include development of passive recreation areas, sports grounds,or a return to rural/grazing use. However, land used for landfill may not have a market value for some time beyond its useful life as a landfill site, and local governments have historically used the land for parks and gardens. For the purpose of this economic assessment, no financial return from sale of the land after landfill closure has been assumed.

5.2 CAPITAL COST OF INITIAL LANDFILL DEVELOPMENT

The estimated capital costs presented below are based on preliminary assessment of likely quantities and bulk rates for specified items of work. Same variation could occur, up or down, following design. In the tables the references are to the particular clauses in Part II which describe the work to be done in greater detail. Because the capital costs are those associated with the upgrading of the existing site reference should also be made to the **Existing Green Island Landfill EIA.**

An engineering and contingency allowance of 30% is allowed in addition to all capital works estimates. A summary of the estimated capital costs for the extended capacity Green Island site development is presented in Table 5.1.

TABLE 5.1 : EXTENDED GREEN ISLAND : CAPITAL COSTS		
ITEM	DESCRIPTION	$(000)
1.0	**Gas Monitoring Bores (1.5)**	8
2.0	**Upgraded Operational Management**	
2.1	Upgraded permanent roading (1.8)	40
2.2	Improved equipment and upgraded site facilities (2.0)	280
	Sub Total	320
3.0	**Leachate Control System (1.3)**	
3.1	Remove refuse in flood plain	200
3.2	Perimeter formation	140
3.3	Excavation perimeter trench	90
3.4	Collection pipe	32
3.5	Gravel filling of trench	240
3.6	Pumping stations and mains	200
	Sub Total	902
4.0	**Leachate Treatment if required (Provisional)**	70
5.0	**Landscape Management**	250
6.0	**Stormwater Control System**	
6.1	Covering and contouring	230
6.2	Drainage and sediment ponds	120
	Sub Total	350
	TOTAL COST	**1900**
	Provisional extra for bentonite slurry cut-off wall around landfill perimeter	1000

5.3 ON-GOING LANDFILL DEVELOPMENT COST

For the purpose of this economic analysis, it is assumed that additional capital expenditure will be required at 5 yearly intervals, as the volume of total waste increases, and new sections of the landfill require roading, landscaping, gas collection, and surface water management. Because of the nature of the landfill operation in a continuing upward extension, facilities such as roading, stormwater drainage and landscaping require continual extending and/or renewal. An estimate of the 5 yearly on-going landfill development capital cost is presented in Table 5.2 below.

TABLE 5.2 : EXTENDED GREEN ISLAND : ON-GOING DEVELOPMENT COST ESTIMATES (IN 1992 DOLLARS)

ITEM	DESCRIPTION	$(000)
1.0	Upgraded permanent roading (1.8)	40
2.0	Landscape management	250
3.0	Stormwater control	230
	On-Going Development Cost (5 yearly intervals)	520

5.4 TRANSFER STATION COSTS (OPTIONAL)

It is recommended that the present public access to be landfill operating face will be continued for an extended capacity Green Island landfill. Provided that the landfill is properly managed, a minimum area of landfill working face can be achieved and will ensure a minimum of odours and litter.

As described in Part III, if waste minimisation and recycling did not succeed as anticipated, a transfer station in the form of a simple, open container type transfer facility for public access only could be appropriate. For the purposes of this economic analysis, it is assumed that approximately 35% of the total waste (the other 65% being delivered by collection vehicles to the working face) would be diverted through such a transfer station. The estimated capital and operation costs for such a facility is presented below with costs based on similar facilities in the Auckland region.

Capital Cost $1.2 million
Operating Costs $4 per tonne, (Based on the 35% waste volume or 24,000 tonnes per annum, the annual cost is $96,000).

5.5 LANDFILL OPERATING COSTS

An estimate of the likely operating costs of an extended Green Island Landfill facility is based on the current unit operating cost, to which the increased unit costs required to raise the operation of the facility to a sanitary landfill standard would have to be added.

An estimate of current unit operating costs for the existing Green Island facility is as follows;

Annual Operating Cost (1991)	= $645,000
Compacted refuse volume placed	= 64,000 m^3
Annual Tonnage @ 700 kg/m^3	= 45,000 tonnes
Unit Operating cost	= $14.50/tonne (approx)

This cost allows for the labour and machine hours, importation of landfill cover and administration costs. However, the current level of operational management at Green Island landfill does not conform to sanitary landfill standards.

Care should be exercised when comparing the present unit operating cost of the Green Island facility with alternative landfill developments and waste management technologies. The above costs do not include some items of sunk capital cost, for example, the cost of the land, or any past capital costs to develop the existing facility.

Therefore, the present unit operating cost is likely to be considerably lower than the cost of developing and operating a replacement sanitary landfill disposal facility to acceptable environmental and engineering standards.

The estimated operation costs required to upgrade the level of operation to sanitary landfill standard is presented in Table 5.3. These costs also include an allowance for on-going environmental management, consisting of landscape management, leachate treatment and stormwater control maintenance, as well as for improved refuse placement operations and landfill covering.

TABLE 5.3 : OPERATING COSTS FOR UPGRADE TO SANITARY LANDFILL STANDARD		
ITEM	**DESCRIPTION**	**$(000) yr**
1.0	**Gas Monitoring**	
1.1	Periodic testing	2
	Sub Total	2
2.0	**Upgraded Operational Management**	
2.1	Increased cover material	80
2.2	Increased equipment hours	50
2.3	Labour, maintenance	20
2.4	Litter fences	23
	Sub Total	173
3.0	**Leachate Control System**	
3.1	Pumping costs	15
3.2	Maintenance of systems	12
	Sub Total	27
4.0	**Leachate Treatment (provisional)**	
4.1	Power charge	13
4.2	Labour and maintenance	6
4.3	Chemicals	5
	Sub Total	24
5.0	**Landscape Management**	70
6.0	**Stormwater Control System**	
6.1	Maintenance	4
	Sub Total	4
	TOTAL ANNUAL INCREASE	**300**

The estimated total annual operation cost at a waste deposition rate of 68,800 tonnes per annum (tpa) is as follows: $(000)/yr

Cost for, 68,800 tpa @ existing $14.50/tonne =	998
Cost of upgrade to Sanitary Landfill Standard	300
TOTAL ANNUAL OPERATING COST	$1298

As landfill operating cost of $19/tonne is therefore used in this economic analysis based on the above figures.

5.6 LANDFILL AFTER CARE COSTS

The economics of development and operation of the Extended Green Island site as a landfill are based on providing a facility developed to sanitary landfill standard, with an acceptable level of environmental protection. However, management of a landfill facility must extend beyond its useful life as a waste disposal facility, since the generation of landfill gases and leachate can extend for 20 years or more after closure.

Post-closure environmental management costs are difficult to quantify. In this analysis, we have assumed that the high standard of engineering allowed for in the cost estimates has obviated the need to make an allowance for future environmental "clean up" costs. While the standard of engineering will be high, post-closure management will still be required.

In evaluating the economics of the Extended Green Island landfill development it is assumed that maintenance of the leachate and stormwater control systems, and monitoring of landfill gas will be required for a period of 20 years after the closure of Green Island as a landfill site.

An estimate of the after care annual costs is presented in Table 5.4 below.

TABLE 5.4 : GREEN ISLAND LANDFILL AFTER CARE

ITEM	DESCRIPTION	$(1000) YR
1.	Gas system monitoring	2
2.	Leachate control system	27
3.	Leachate treatment	24
4.	Stormwater control system	4
	After Care Costs	**57**

5.7 COST SUMMARY

1. *Capital Costs*
   Extended Green Island Developments and Upgrade — $1.900M

2. *On-Going Development*
   (5 yearly intervals) — $0.520M

3. *Operating Cost/Tonne**

Landfill Operation		$19.0
Transfer Station (Provisional)		$4.0
	TOTAL	$23.0

5.8 FINANCING COSTS

The development costs for the extended Green Island development could be financed in a number of ways. The finance method has yet to be assessed by the Dunedin City Council. For the purposes of this economic analysis, it is assumed that the overall cost of funds to the DCC would be 10% real (ie. 10% above the rate of inflation), whether the funds are borrowed or not. This rate is commonly used by government and local authorities for feasibility assessments such as this.

The unit cost of refuse deposited at the extended Green Island landfill facility is calculated below using a net present value, discounted cash flow analysis. Discounted cash flow analysis is a project evaluation technique that weights earlier expenditure and revenues greater than future years' expenditures and revenues. The latter are less valuable because they are not available for immediate consumption or reinvestment. The weighting factor is called the discount rate, or the cost of funds. The analysis used in this evaluation assumes that the overall cost of funds to the DCC is 10% real.

The net present value (NPV) is the figure calculated to provide a cash flow which would cover operating costs, and interest at a rate of 10% over the rate of inflation on the net outstanding funds throughout the life of the facility (whether the funds are borrowed or not), and repay all funds used (whether borrowed or not) within the life of the facility. When assessed on the basis of a per tonne charge throughout the life of the landfill a "required gate charge" can be calculated. This would be the average charge to be made to cover all financing and operating costs.

The required gate charges for the two extremes of capital expenditure options are:

(a) Including a full Transfer Station and the bentonite cut-off wall	$28.30 $/tonne
(b) Not including Transfer Station or cut-off wall	$24.00 $/tonne

10.0 COSTS OF LANDFILL AND TRANSPORTATION

10.1 INTRODUCTION

The economics of landfill development and operation have been historically assessed by focusing on the actual costs to dispose of the waste. This effectively underestimates the real cost of landfill because not all "costs" are usually included in the analysis, including the opportunity cost of the land, rehabilitation and future environment management costs.

The development of the Smooth Hill landfill site to a sanitary landfill standard, and the provision of acceptable standards of environmental protection has been described in Section 5.0 preceding. To develop a site to meet the recommended standards for sanitary landfill is expensive. This section of the report presents an economic evaluation of the "total" costs associated with the development and management of the facility, and makes an assessment of the unit cost of waste disposal at the facility as a basis for comparison with other landfill development options.

The economic evaluation considers the following costs:

(a) Land purchase cost.
(b) Capital cost for initial landfill development.
(c) Ongoing landfill development costs.
(d) Transfer station capital costs.
(e) Transport costs.
(f) Ongoing operating costs.
(g) Landfill after care costs.
(h) Financing costs.
(i) Net present value assessment and required "Gate Charge".
(j) Upgrading costs for the existing Green Island Landfill.

The Smooth Hill site has a potential landfill capacity of 6.4 million cubic metres, providing an operating life in excess of 50 years, based on the current levels of waste generation. The estimates provided in this report assume that the site would be developed and managed as a landfill facility over a 50 year period at a waste deposition rate of 100,000m^3 per annum (or 120,000m^3 per annum including cover material), following closure of the existing Green Island and Maxwell landfill sites.

Land committed to waste disposal is not available for other uses, for example open space, industrial developments, housing, wildlife habitat, or farming. The net benefits which the community could have had from one of these alternatives constitute the "opportunity cost" of committing the land to waste disposal.

The Dunedin City Council has had preliminary discussion regarding the purchase of the Smooth Hill site and Fulton Hogan Ltd have indicated a willingness to sell and a valuation has been undertaken.

However for the purpose of this economic assessment, the land purchase value is based on recent sales of similar areas of land in the area south of Dunedin.

Assumed land purchase cost = $80,000
(80 Ha @ $1000/Ha)

The use of landfill sites after closure and rehabilitation typically include development of passive recreation areas, sports grounds, or a return to rural/grazing use. However, land used for landfill may not have a market value for some time beyond its useful life as a landfill site, and local government have historically used the land for parks and gardens. For the purpose of this economic assessment, no financial return from sale of the land after landfill closure has been assumed.

10.2 CAPITAL COST OF INITIAL LANDFILL DEVELOPMENT

The estimated capital costs presented below are based on preliminary assessment of likely quantities and bulk rates for specified items of work. Significant variation (± 30%) could occur following detailed pre-design investigations and final design.

The cost of installation of leachate control and treatment systems, landscape management, and surface water control systems for the Existing Green Island Landfill is also included as part of the development cost, since this work will be required if the Green Island landfill site is closed. This capital cost has been estimated at $1.572 million in the Green Island EIA documents.

An engineering and contingency allowance of 30% has been built into each individual capital works estimate. A summary of the estimated capital costs for the Smooth Hill site development is presented in Table 10.2.

TABLE 10.1 : SMOOTH HILL LANDFILL INITIAL DEVELOPMENT COSTS

ITEM	DESCRIPTION	COST ($000)
1.0	**Smooth Hill Capital Costs**	
1.1	Upgrade internal access road	700
1.2	Construct silt pond and stormwater drains	260
1.3	Excavate loess material and place liners	300
1.4	Topsoil stripping and storage	20
1.5	Leachate collection system	150
1.6	Amenities building, water supply system	79
1.7	Electrical supply, fencing, landscaping	47
1.8	Smooth Hill Capital Cost Sub-Total	32
2.0	**Green Island Upgrade Capital Cost**	1668
2.1	Leachate control system and bunding	
2.2	Leachate treatment (provisional)	
2.3	Landscape management	902
2.4	Stormwater control system	70
		250
	Green Island Upgrade Cost Sub-Total	350
	Smooth Hill Landfill Development Capital Cost	1572
		3240

10.3 ON-GOING LANDFILL DEVELOPMENT COST

For the purpose of this economic analysis, it is assumed that the landfill will be developed progressively, as increased capacity is required. The initial development in Stage I is shown in Table 10.2 above and covers access roading silt pond, landfill buttress and amenities plus the initial five years landfills preparation work. Thereafter, every five years, a further area is opened up for the landfill, excavated, lined and the stormwater and leachate collection system extended. The civil engineering costs for developing new sections of the landfill are estimated as for the initial capital works.

Since the landfill has a life of 50 years progressive development has been considered for that full period. To compare with the Extended Green Island Landfill costs have been brought back to a Nett Present Value (NPV) later in this document.

An engineering and contingency allowance of 30 % has been built in to the estimates. A summary of the estimated on-going landfill development cost is presented in Table 10.3 below. This allows extension of the landfill every 5 years for Stages 1 and 2 (40 years) with no further development costs for Stage 3 after the initial development of that stage. Since Stage 3 is built on top of Stages 1 and 2 it requires no further liner or leachate system.

TABLE 10.2 : SMOOTH HILL LANDFILL ON-GOING DEVELOPMENT COSTS - 5 YEARLY INTERVALS ($1992)

ITEM	DESCRIPTION	COST ($000)
1.	Topsoil stripping and stockpile, roads	10
2.	Excavation and liner to floor	150
3.	Leachate collection and stormwater systems	180
		340

10.4 TRANSFER STATION COSTS

The 30km distance of the Smooth Hill site from Dunedin would preclude direct transportation of waste to the site, both by Dunedin private residents, and street collection vehicles. A transfer station is required to load bulk haulage vehicles to transport refuse to the Smooth Hill site. No waste would be transported directly to the landfill site, apart from minor quantities of special waste unsuitable for handling of the transfer station.

This analysis assumes that a transfer station is constructed at Green Island with the closure of the Green Island landfill site. It is also assumed that the present Maxwells transfer station will remain at its present capacity of 12,200 T/yr. Therefore the facility for Smooth Hill would have a throughput of 56,600 T/yr (68,800 less 12,200).

The transfer station would be a compacting type, the capital cost of which is based on similar facilities constructed in New Zealand and would be:

Capital Cost (56,600 tpa throughput @ $70/t) = $3,960,000

The cost of three long-haul transfer vehicles is included in this capital cost.

The total waste tonnage transported to the Smooth Hill landfill site would be 68,800 tonnes per year. However, the Maxwell's transfer station located near the harbour would continue to operate at its present level of 12,200 tonnes per annum. The Green Island transfer station would therefore have a waste throughput of the remaining 56,600 tonnes per annum.

An estimate of the unit operating cost for a compacting transfer station to be located in the Green Island area is based on the operating costs of similar facilities in New Zealand. For the purposes of this economic assessment, a transfer station operating cost of $10/tonne is adopted.

Transport costs for collection of waste by contractors would be approximately the same for transport either to landfill or to transfer stations. The only transportation cost of relevance associated with the Smooth Hill development is the additional cost associated with transporting waste from Green Island to the Smooth Hill site (whether via Maxwells or Green Island transfer stations).

Bulk haulage to the Smooth Hill site is assumed in this analysis to be by road in enclosed containers. The cost of bulk haulage by road is derived from the Auckland Regional Authority costs for bulk haulage, which is based on a decreasing scale as the distance increases. For the 24km distance from Green Island to Smooth Hill, the cartage rate is approximately $0.6/tonne/km, or $14.40/tonne for the 24km cartage distance.

All waste collection costs and transportation to Green Island are excluded from the analysis, since these remain the same for the options considered.

10.5 ON-GOING OPERATING COSTS

10.5.1 SMOOTH HILL LANDFILL

(a) Operational Management

The current operational management cost of the Green Island landfill is approximately $14.50/tonne, which allows for labour and machine hours, importation of landfill cover, and administration costs. However, the current level of operational management at Green Island landfill does not conform to sanitary landfill standards. An assessment of costs for increased cover, labour and equipment hours, and litter control would indicate an increase in operational management costs to $19/tonne.

A lesser figure of $16/tonne is assumed for the Smooth Hill site on the basis that suitable cover material will be available for excavation from the site as landfill development proceeds.

(b) Environmental Management Costs

The following annual costs have been assumed for progressive rehabilitation of the site, and for management of leachate recirculation and surface water control systems.

TABLE 10.3 : ENVIRONMENTAL MANAGEMENT COSTS ($1992)		
ITEM	DESCRIPTION	COST ($000)/YR
1.	Landscape Management	70
2.	Stormwater control system maintenance	4
3.	Leachate reticulation maintenance	20
	Environmental Management Costs per annum	94

10.5.2 GREEN ISLAND LANDFILL AFTER CARE COSTS

Landfills developed and operated to sanitary landfill standard have a lower potential for adverse impacts on the environment. However, management of the Green Island landfill will be required beyond its useful life as a waste disposal facility, since the generation of landfill gases and leachate can extend for up to 20 years after closure of landfills.

In evaluating the economics of development of the Smooth Hill site, it is assumed that maintenance of the leachate and stormwater control systems, and monitoring of landfill gas will continue to be required at the Green Island site for a period of 20 years after its closure. This costs is estimated at $57,000 per year.

10.6 SMOOTH HILL LANDFILL AFTER CARE COSTS

The economics of development and operation of the Smooth Hill site as a landfill are based on providing a facility developed to sanitary landfill standard, with an acceptable level of environmental protection. However, management of a landfill facility must extend beyond its useful life as a waste disposal facility, since the generation of landfill gases and leachate can extend for up to 20 years after closure.

Post-closure environmental management costs are difficult to quantify. In this analysis, we have assumed that the high standard of engineering allowed for in the cost estimates has obviated the need to make an allowance for future environmental "clean up" costs. While the standard of engineering will be high, post-closure management will still be required.

In evaluating the economics of the Smooth Hill landfill development it is assumed that maintenance of the leachate and stormwater control systems, and monitoring of landfill gas will be required for a period of 20 years after the closure of Smooth Hill as a landfill site.

An estimate of the after care annual costs is presented in Table 10.5 below.

TABLE 10.4 : SMOOTH HILL LANDFILL AFTER CARE ($000)		
ITEM	DESCRIPTION	COST/YR
1.	Gas item monitoring	2
2.	Leachate control system	27
3.	Leachate treatment	24
4.	Stormwater control system	4
	After Care Costs	**57**

10.7 COST SUMMARY

TABLE 10.5 : COST SUMMARY			
1	**Capital Costs**		
	a. Smooth Hill Initial Development (incl land cost)		$1.668M
	b. Green Island Upgrade		$1.572M
	c. Transfer Station		$3.960M
		Initial Capital Cost	**$7.200M**
2	**On-Going Development (5 yearly intervals)**		**$0.340M**
3	**Operating Costs/tonne**		
	a. Smooth Hill Landfill		$16.0
	b. Green Island Aftercare		0.8
	c. Transfer Station		10.0
	d. Refuse Transportation		14.4
	e. Maintenance and Environmental Monitoring		1.4
	Based on 56,600 T/yr through Transfer Station and 68,800 T/yr into Landfill	**Total**	**$43.1**

10.8 FINANCING COSTS

The development costs for the Smooth Hill development could be financed in a number of ways. The finance method has yet to be assessed by the Dunedin City Council. For the purposes of this economic analysis, it is assumed that the overall cost of funds to the DCC would be 10% real (ie. 10% above the rate of inflation), whether the funds are borrowed or not. This rate is commonly used by government and local authorities for feasibility assessments such as this.

The unit cost of refuse deposited at the Smooth Hill landfill facility is calculated below using a net present value, discounted cash flow analysis. Discounted cash flow analysis is a project evaluation technique that weights earlier expenditure and revenues greater than future years expenditures and revenues. The latter are less valuable because they are not available for immediate consumption or reinvestment. The weighting factor is called the discount rate, or the cost of funds. The analysis used in this evaluation assumes that the overall cost of funds to the DCC is 10% real.

The net present value cost per tonne is the figure calculated to provide a cash flow which would cover operating costs, and interest at a rate of 10% over the rate of inflation on the net outstanding funds throughout the life of the facility (whether the funds are borrowed or not), and repay all funds used (whether borrowed or not) within the life of the facility. When assessed on the basis of a per tonne charge throughout the life of the landfill a "required gate charge" can be calculated. This would be the average charge to be made to cover all financing and operating costs.

Based on the capital and operating costs plus ongoing development and maintenance costs over the 50 year life of the Smooth Hill landfill and its aftercare costs, the required gate charge has been assessed as follows:

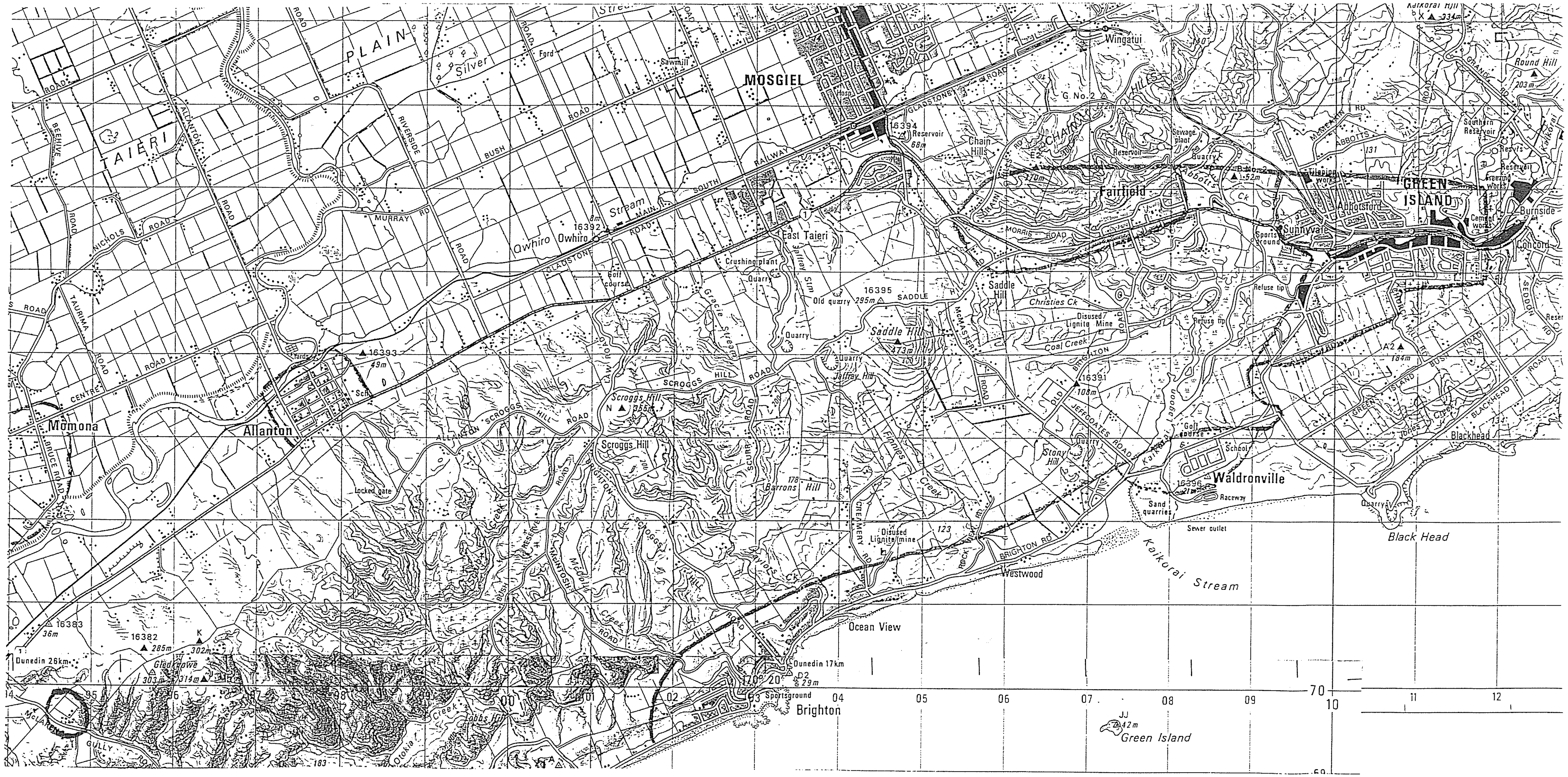
SMOOTH HILL REQUIRED GATE CHARGE IS $48.85/tonne

APPENDIX I SUMMARY TABLE OF PUBLIC SUBMISSIONS

Dunedin City Council Solid Waste Management Strategy									
Summary of Submissions									
		Number of responses on this item	% of total [143] supporting this item	% of Green Island (43) supporting this item	% of Smooth Hill (53) supporting this item	% of other areas (32) supporting this item	% of groups & societies (11) supporting this item	% of community assns (2) supporting this item	% of regulatory bodies (2) supporting this item
A	Landfill Site								
A1	Approve Extended Green Island Site	52	36%	33%	40%	41%	27%	50%	0%
A2	Disapprove Extended Green Site	21	15%	37%	0%	3%	27%	50%	0%
A3	Approve Smooth Hill Site	19	13%	30%	0%	9%	27%	0%	0%
A4	Disapprove Smooth Hill Site	43	30%	2%	70%	9%	18%	0%	0%
A5	Disapprove Both Sites	4	3%	0%	6%	3%	0%	0%	0%
A6	Concern SH Geological Stability	10	7%	0%	15%	0%	18%	0%	0%
A7	Concern Effect on SH Ground Water	2	1%	0%	2%	0%	9%	0%	0%
B	Landfill Operation								
B1	Appove Landscaping. Environmental Upgrade	23	16%	16%	11%	19%	27%	0%	50%
B2	Suggest Include Maxwells in Landscaping	1	1%	0%	0%	3%	0%	0%	0%
B3	Approve Sanitary Landfill Operation	4	3%	2%	0%	6%	9%	0%	0%
B4	Approve Leachate Control and Treatment	14	10%	7%	6%	13%	36%	0%	0%
B5	Approve Transfer Stations/Skips	23	16%	23%	6%	25%	18%	0%	0%
B6	Concern Noise of landscaping operation	2	1%	2%	0%	0%	9%	0%	0%
B7	Concern General Noise	4	3%	5%	0%	3%	9%	0%	0%
B8	Concern Visual Effect	16	11%	35%	0%	3%	0%	0%	0%
B9	Concern Odour	15	10%	30%	0%	3%	9%	0%	0%
B10	Concern Wind-Blown Rubbish	10	7%	16%	6%	0%	0%	0%	0%
B11	Concern Gulls	3	2%	5%	2%	0%	0%	0%	0%
B12	Concern Trucks in Brighton area	4	3%	0%	8%	0%	0%	0%	0%
B13	Concern Suitability of Mclaren Gully Road	3	2%	0%	6%	0%	0%	0%	0%
B14	Concern Source of Fill	4	3%	5%	0%	0%	18%	0%	0%
B15	Disaprove Public Access GIL	4	3%	2%	2%	3%	9%	0%	0%
B16	Disapprove Industrial Zoning GIL	5	3%	9%	0%	0%	9%	0%	0%
B17	Suggest Recreation/Reserve GIL	7	5%	9%	0%	6%	9%	0%	0%
B18	Disapprove Seagull Culling	1	1%	2%	0%	0%	0%	0%	0%
B19	Disapprove GIL Operation	2	1%	2%	0%	0%	9%	0%	0%
B20	Concern SH Forest Fire Risk	2	1%	0%	4%	0%	0%	0%	0%
B21	Concern Rubbish from Trucks. Cars	10	7%	12%	8%	3%	0%	0%	0%
B22	Suggest Compress Waste Before Landfilling	1	1%	2%	0%	0%	0%	0%	0%
B23	Approve Gas Collection for Use	3	2%	0%	0%	0%	18%	0%	50%
B24	Suggest Rail Link to SH	4	3%	0%	0%	6%	18%	0%	0%
B25	Prisoners to Sort Rubbish	1	1%	0%	0%	3%	0%	0%	0%
B26	Suggest Large Collection Bins	1	1%	0%	0%	3%	0%	0%	0%
C	Costs								
C1	Approve extra spending for Smooth Hill	6	4%	12%	0%	0%	9%	0%	0%
C2	Disapprove extra spending for Smooth Hill	19	13%	9%	21%	6%	18%	0%	0%
C3	Doubt extra cost for Smooth Hill	1	1%	0%	0%	0%	9%	0%	0%
C4	Approve Greater User Charges	4	3%	0%	2%	6%	9%	0%	0%
D	Environmental Concern								
D1	Concern Pollution in the Kaikorai Estuary	14	10%	16%	2%	6%	36%	0%	0%
D2	Concern Pollution in the Otokia Stream	41	29%	0%	62%	13%	36%	0%	0%
D3	Concern Effect of Smooth Hill on Farmland	6	4%	0%	8%	3%	9%	0%	0%
D4	Concern Effect of Smooth Hill on Brighton Beach and Community	22	15%	0%	34%	6%	18%	0%	0%
E	Alternative Waste Management								
E1	Approve Waste Reduction	22	15%	5%	11%	25%	45%	0%	50%
E2	General Approval Recycling	54	38%	21%	34%	66%	45%	50%	0%
E3	Suggest More Recycling Stations	11	8%	9%	6%	9%	9%	0%	0%
E4	Approve Kerbside Recycling	10	7%	5%	2%	19%	9%	0%	0%
E5	Approve Other Technologies	20	14%	14%	8%	16%	27%	50%	50%
F	Special/Hazardous Wastes								
F1	Concern Toxic Substances	13	9%	2%	6%	13%	36%	0%	50%
G	Social/Cultural Issues								
G1	Approve Community Liasson Commitee	0	0%	0%	0%	0%	0%	0%	0%
G2	Suggest Lack of Council Credibility	3	2%	2%	2%	3%	0%	0%	0%
G3	Distrust of Selection Procedures	6	4%	7%	2%	3%	9%	0%	0%
G4	Concern Property Values	4	3%	5%	4%	0%	0%	0%	0%
G5	Concern Property Values Based on Expectation that GIL Will Close	1	1%	2%	0%	0%	0%	0%	0%
G6	Approve Public Education	9	6%	7%	4%	6%	18%	0%	0%
G7	Suggest Council Purchase Surrounding Property	3	2%	5%	2%	0%	0%	0%	0%
G8	GIL Option Delays Construction of Road GI to Fairfield	1	1%	2%	0%	0%	0%	0%	0%

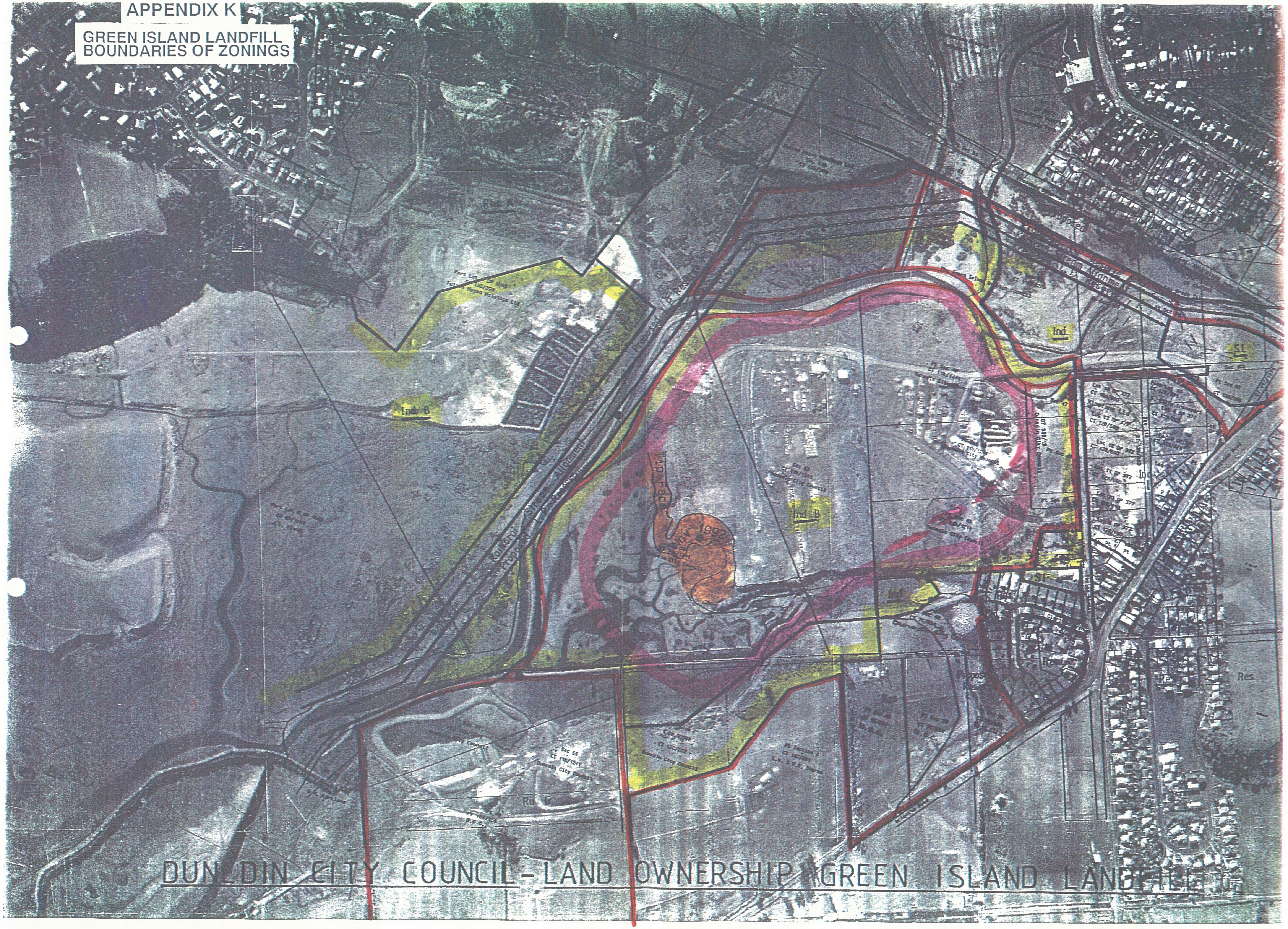
APPENDIX J

DUNEDIN CITY COUNCIL
SOLID WASTE MANAGEMENT STRATEGY
BRIGHTON & GREEN ISLAND DIRECT MAILING AREAS



APPENDIX K

GREEN ISLAND LANDFILL
BOUNDARIES OF ZONINGS



DUNEDIN CITY COUNCIL
SOLID WASTE MANAGEMENT STRATEGY

SUBMISSION FORM:

NAME: ______________________________

ADDRESS: ______________________________

____

CONTACT TELEPHONE: ____________________ DATE: ____________________

Return Submissions to:

Solid Waste Management Strategy
Dunedin City Council
PO Box 5045
DUNEDIN

Attention: Mr Trevor Buchanan

Submissions Close: **26th February 1993.**

SOLID WASTE STUDY HOTLINE – TELEPHONE 474.3600

Check List.

The following points can be used as a check list when you write your submission. Please write your submission on the back of this form, and add extra pages if necessary.

- Public Education e.g. Recycling
- Waste Reduction, Reuse, Recycling
- Landfill location
- Sanitary Landfill Operation, Daily cover, minimal odour, noise, birds, vermin, dust, windblow litter, public access
- The current Green Island Operation
- Proposed Site – Extended Green Island
  Proposed Site – Smooth Hill
- Leachate Control & Treatment
- Environmental Protection
- Special & Hazardous Wastes
- Transfer Stations/Skips
- Costs
- Social/Cultural Issues
- Community Liaison Committee

Full reports are available from Council Libraries and Service Centres.

Summaries of reports (four in all) are available by telephoning the Hotline.

"KEY ISSUES"

The following "Key Issues" are from the City Council perspective.

A. SOLID WASTE (REFUSE) MANAGEMENT STRATEGY

- Reduce waste, reuse and recycle. This will increase landfill life.
- Promot waste minimisation. This would include how to make compost and where and what to recycle.
- Promote recycling at source by separating recyclable materials the home, business and industry.
- Where practicable operate landfills as Sanitary Landfills i.e cover the tipping face daily which will control odour, birds and vermin. Control leachate and stormwater. Effectively landscape the site to screen from neighbours.
- Tighten controls on Special and Hazardous Wastes.
- Landfilling is the most practicable way of disposal of solid waste for Dunedin at present.
- Review transfer station and skip locations. If Smooth Hill is the chosen landfill site a major transfer station would be needed. The present Green Island landfill site could be used.
- Monitor regularly the effects of the landfill operation on surrounding areas. This relates to both neighbours and the environment.
- Keep up to date with new technology relating to waste disposal.

B. EXISTING GREEN ISLAND LANDFILL

- At present the Green Island landfill is not being operated as a sanitary landfill. However today's Green Island landfill operations are much closer to that of a sanitary landfill. The appearance and operation of the landfill has improved with less annoyance to neighbours over the past twelve months.
- Proper landscaping will considerably improve the appearance of the landfill to both neighbours and the general public.
- Currently both the Green Island and Maxwells landfill areas are zoned for industrial sites and use.
- Leachate from the Green Island landfill is affecting the Kaikorai Estuary mainly in terms of nutrients sometimes causing excessive growth of plant life. This can result in odour when the plants are

exposed to air and die off. Run off from farmland also causes this to a considerable degree.

The leachate needs to be controlled, collected and treated as necessary.

- A leachate control system is proposed as part of the environmental upgrade for the existing Green Island landfill. Landscaping, screening, windblown litter control, road sealing and operation as a sanitary landfill are all part of the environmental upgrade. Some of this work has already commenced particularly with regard to a small tipping face, regular cover, windblown litter control and recycling.

  The above improvements will be made whether we stay at Green Island or not.

C. EXTENDED GREEN ISLAND SANITARY LANDFILL

- The proposed mound will be a maximum height of 15 metres above the existing landfill. Sides of the mound will be very gently sloping.
- The extended landfill will have a life of some 25 years.
- The leachate collection system proposed for the existing Green Island landfill will be satisfactory for the extended landfill.
- The extended landfill mound will have a major visual impact but will be softened by landscaping and screen tree planting.

D. SMOOTH HILL

- The site is technically suitable for a sanitary landfill.
- The Consultants state that there is no risk of contamination by leachate at the Brighton Estuary or beach.
- Access to the landfill would be by State Highway One. There will be no public access.
- Transfer stations would be required.
- Transportation and transfer station costs for solid waste disposal at Smooth Hill will have a major impact on the cost of disposal at this site.

APPENDIX M

OTOKIA STREAM

WATER QUALITY REVIEW

DUNEDIN CITY COUNCIL

OCTOBER 1992

Report Prepared By
BARRY ROBERTSON & ASSOCIATES
ENVIRONMENTAL CONSULTANTS
DUNEDIN

9.0 CONCLUSIONS

Water chemistry in the Otokia catchment are dominated by the presence of volcanic parent rock material and the proximity of the catchment to the coast. As a result, the waters have low levels of calcium but elevated concentrations of sea-derived ions (ie sodium, chloride and magnesium). Moving downstream the waters become more concentrated as they pass through agriculturally developed areas on sedimentary rocks. Near the coast they are most concentrated. The waters are of the typical bicarbonate type and are moderately alkaline (60 mg/l)).

Because of their remoteness and lack of any major point source discharges or urban development, our understanding of these waters is limited. However, using the chemical data collected in this survey a number of water quality problems have been found to exist. They include:

(i) dissolved oxygen depletion in the main creek and estuary (at night).

(ii) excessive benthic algal growths in the estuary.

(iii) presence of faecal indicator bacteria in the creek and estuary.

(iv) symptoms of severe eutrophication in estuary.

The presence of these water quality problems place restrictions on the human use potential of the creek and estuary. As a result these waterbodies;

(i) are unsafe for bathing at times.

(ii) are of limited value as a recreational fishery.

(iii) must be treated before use as drinking water.

(iv) any shellfish beds in the estuary are likely to be bacterially contaminated.

The cause of the water quality problems can primarily be attributed to historical changes in catchment landuse. Development of the Otokia catchment for intensive agriculture was the primary aim of European settlers in the area. This objective resulted in a shift from a forest and tussock-covered watershed, with widespread wetlands, to one dominated by short pasture and extensive drainage channels. The associated clearing, drainage and flood control programmes altered the flow and water quality characteristics of associated waterbodies. Now with the shift back towards forestry in the catchment an improvement to water quality is expected. However, the flushing characteristics would need to be significantly improved to alter the quality of the estuary.

GREEN ISLAND LEACHATE MANAGEMENT PROPOSALS

INDEPENDENT AUDIT FOR THE OTAGO REGIONAL COUNCIL

Prepared for :
Dunedin City Council
April 1993

Woodward-Clyde

Woodward-Clyde (NZ) Ltd
22 Heather Street,
PO Box 37 547, Parnell,
Auckland, NEW ZEALAND

12.0 OVERALL FINDINGS

1. The Dunedin City Council landfill is only one of a number of activities contributing to a degradation of the ecology of the Kaikorai estuary.

2. The present understanding of local conditions does not enable a complete picture to be obtained of how much the landfill contributes to the overall degradation, nor of how much results from surface water compared to groundwater transport of contaminants.

3. The engineering solution proposed is therefore a pragmatic one that should result in satisfactory mitigation of any adverse effects on the estuary arising from the landfill.

4. Some form of monitoring is required to check the effectiveness of the proposed solution and this should ideally form part of a more comprehensive programme for the estuary as a whole.

5. The Applicant should be required to provide an assessment of what changes might occur to leachate composition in the future, and how these would affect the conditions of the existing discharge right from the Green Island sewage treatment plant. This should be in a tabulated form showing the effects of both measured and possible future leachate composition. While long term leachate strength will decrease with time, some short term increases could occur. Any discharge consent granted should provide for a monitoring period to check actual site values and a period of time afterwards for suitable pretreatment facilities to be constructed if required.

6. Following a series of stages involving the provision of further information by the DCC, the audit team is satisfied that the approach being taken by the DCC can be supported as an appropriate means of mitigating any adverse effects occurring at the Green Island Landfill.