Wood & Grieve
ENGINEERS

APPENDIX 1
BOWMAN BISHAW GORHAM REPORT

EFFLUENT DISPOSAL OPTIONS STUDY

TOURIST AND RESIDENTIAL DEVELOPMENT
SUSSEX LOCATION 413
SMITHS BEACH

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EXECUTIVE SUMMARY

The Canal Rocks Unit Trust intends to implement a tourist and residential development at Sussex Location 413, Smiths Beach. No sewer facility is currently available to the area.

The study recognises the environmental values of the region, together with strategic planning necessary for orderly and sustainable development.

This report focuses on the identification and assessment of effluent treatment and disposal options for the proposed Smiths Beach development from both technical and environmental perspectives. The report is based on the requirements of a consultants brief issued for the study, defined in consultation with the Water Corporation's Bunbury Office, and concludes the following.

- Connection of the development site to the Water Corporation's wastewater proposed treatment plant at Anniebrook is considered feasible and achievable, through the use of new and existing infrastructure. This option may also permit the connection of existing development at Smiths Beach, both the existing and proposed extension of the Yallingup townsite, and Caves House.

- The approach to strategic planning for sewerage treatment and disposal has now shifted from the historical convention of primary or secondary treatment followed by ocean or river outfalls, or infiltration/evaporation, towards approaches which can contain the treated effluent on land and can achieve the beneficial re-use of the final effluent. In Western Australia the recent trend in treated effluent disposal is to re-use treated effluent in plantation forestry, for irrigation of recreational playing fields, or in horticulture.

- The establishment of a dedicated effluent treatment and disposal facility for the existing and proposed development at Smiths Beach is considered feasible and achievable, subject to more detailed site assessment and design. Modelling has estimated that a woodlot plantation, winter storage pond and appropriate buffer would require a land area of approximately 45ha. Irrigated viticulture would require a land area of approximately 100ha.

- Mapped data describing the following factors has been assembled to identify potential treatment and disposal sites within an 8km radius of Smiths Beach:

  - large areas previously cleared of native vegetation;
  - land capability and soil types based on the Department of Agriculture regional land capability study;
  - land use planning policy;
  - existing land use including roads and road reserves; and
  - general drainage and topography.

- A suite of 21 potential sites were evaluated to identify areas where a woodlot or vineyard of suitable size ares present or could be established for the purpose of disposing treated effluent.

- Land north of Wildwood Road has been precluded for establishment of the disposal facility due to designation of rural-residential living in the Leeuwin-Naturaliste Ridge Statement of Planning Policy (SPP).

- A number of sites with land area and capability suitable for the establishment of a woodlot plantation or area of vines have been identified. A land parcel totalling 360 ha located close to Smiths Beach immediately south of Canal Rocks Road appears the most suitable of those investigated, and may be compatible with the objectives of the SPP.

- Potential sites located on Wildwood and Abbeys Farm Roads may present environmental, social and economic difficulty regarding the installation of a pipeline within the road reserve. Difficulty is likely to increase with distance from the Smiths Beach site.

- Assuming appropriate design and achievement of an acceptable buffer, the installation of a treatment plant and infiltration basins at the Vidler Road quarry appears feasible, subject to more detailed hydrogeological investigation.

- On-site effluent disposal through septic tank and leach drain systems, ocean disposal, and disposal to surface streams have been discounted as feasible options due to environmental, social and engineering constraints.

- An economic analysis indicates that two options, the establishment of a high quality treatment plant with stream discharge, and connection to the Dunsborough wastewater treatment plant, have similar cost implications and are the most economic of the options considered.

- Based on the combined economic and environmental factors considered in this study, connection to the Dunsborough sewerage system is the favoured option.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

TABLE OF CONTENTS (CONT'D)

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS (CONT'D)

LIST OF TABLES (Cont'd)

APPENDICES

1.0 INTRODUCTION

1.1 Background

The Canal Rocks Unit Trust proposes to implement a residential and tourist development for up to 2,000 persons on Sussex Location 413 (28ha), Smiths Beach (Figure 1). Planning for the project is well advanced, however prior to this investigation options for the collection, treatment and disposal of effluent generated from the project had not been addressed to a level of detail which provides specific evidence as to feasibility.

The Smiths Beach area is not currently serviced by a reticulated sewerage system. Existing tourist development which cater for up to 590 persons, namely Chandlers Caravan Park and Smiths Beach chalets, rely on on-site effluent disposal systems. Similarly, the nearby Yallingup settlement and Caves House facility currently dispose effluent by using on-site effluent disposal systems.

Consequently connection of the proposed development at Smiths Beach to an existing local disposal facility is not possible.

This report focuses on the identification and assessment of effluent treatment and disposal options for the proposed Smiths Beach development from both technical and environmental perspectives. Also, economic considerations associated with the disposal options have been addressed by project engineers Wood and Grieve.

The investigation and report respond to the requirements of a consultants brief for the study, which has been defined in consultation with the Water Corporation's Bunbury Office.

The report describes the development proposal, evaluates alternative effluent management strategies in the context of local planning, social and environmental objectives, and following economic appraisal of options presents conclusions.

1.2 Objectives of Investigations

The objectives of the investigations detailed in this report are to:

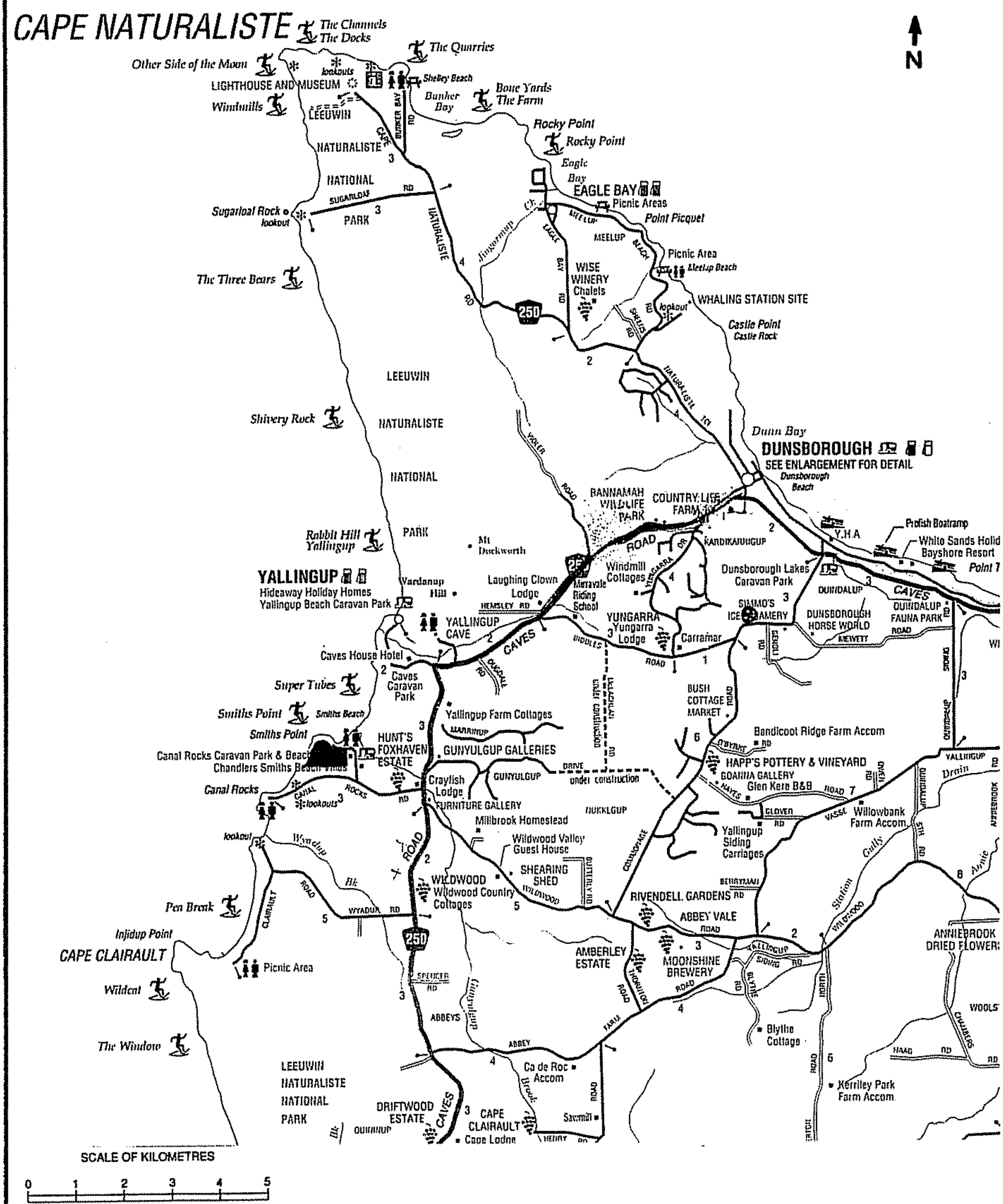


FIGURE 1

REGIONAL SITE LOCATION

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

- describe the site and its local environmental setting in terms of potential effluent disposal strategies;

- identify the effluent management requirements of the proposal and also consider the consequences and feasibility of incorporating settlement at Yallingup in the management strategy;

- identify alternative management strategies for the treatment and disposal of effluent;

- investigate the feasibility of implementing the alternative treatment and disposal options, including an analysis of potential sites; and

- demonstrate the feasibility of one or more of the options identified for the treatment and disposal of effluent generated from the project.

Each issue is further discussed in the following sections.

2.0 THE DEVELOPMENT PROPOSAL

2.1 The Site and Its Environmental Context

The environmental characteristics of Sussex Location 413, Smiths Beach, have previously been described by Tingay and Associates (1997), and summary information presented here or drawn from that reference.

Topographic Setting

The site is located on the coastal lower slopes of upland topography extending northwards from the adjacent Leeuwin Naturaliste National Park. The development area is located on land sloping from 58mAHD in the south to 6mAHD in the north.

Land Capability and Soils

In a regional land capability study, Tille and Lantzke (1990) identified two soil types over the site. The Wilyabrup Exposed Slopes (We3) consist of low slopes (gradients generally 5-10%) exposed to strong winds off ocean. Soils for this unit are described as either yellow brown gravelly duplex or red brown gravelly gradational soils. Wilyabrup Granitic Headlands (WRE) occur on areas on the west coast dominated by granitic outcrops. Soils are described as shallow gravels, bleached sand or rocky soils directly overlying granite.

Soil investigations by Tingay and Associates (1997) do not specifically confirm the occurrence of these two soil types, however a gradational soil profile is described and presumably corresponds to the We3 unit. Another soil type described as a moderately sorted quartz sand derived from weathering of Tamala limestone, occurs in the south-eastern parts of the site.

The permeability of the gradational soil type is assumed to be high at the surface and to decrease with depth due to an increase of clay content. The permeability of the quartz sand is assumed moderate with no or little clay content.

Vegetation

The site contains seven vegetation associations. Aerial photography and ground-truthing indicate that the vegetation remains in good biological condition. None of the native species previously identified from the site are gazetted as rare or endangered (Tingay and Associates, 1997).

Shallow Groundwater

Tingay and Associates (1997) detected no significant sources of groundwater during a soil investigation drilling program. Thin saturated lenses of quartz sand did occur at depths greater than 7m, however these lenses were considered insignificant as a groundwater resource.

Local Surface Drainage Pattern

The site does not include any surface drainage.

Gunyulgup Brook is the major surface drainage discharging to the Indian Ocean at Smiths Beach, which drains land to the south east and east of Smiths Beach. Wyadup Brook is a smaller semi-permanent stream which drains the upland plateau south of Smiths Beach. In common with many surface drainages in the region, these streams have been dammed at various points along their lengths to provide water for agricultural and horticultural uses.

2.2 The Development Plan

The development proposal for the site is described in detail in the planning document formulated for the project by planners Chappell and Lambert (1997). Broadly, the concept includes:

- a mixture of single residential and grouped housing;
- tourist orientated accommodation;
- a shopping area;
- a hotel development;
- public open space; and
- a conservation area.

Development staging and resultant effluent generation volumes calculated from population estimates are greater described in the following section.

2.3 Development Staging and Effluent Generation

This section presents effluent generation volume estimates for both proposed and existing development at Smiths Beach based on projected high, low and 100% occupancy rates. Estimated effluent generation volumes are also provided for the existing Yallingup settlement, together with potential future expansion. Estimates developed here are used in subsequent sections of the report which evaluate land area requirements for various treatment and disposal options.

2.3.1 Smiths Beach

The development is proposed for implementation in 4 stages over a 10 year period. Table 1, provided by Wood and Grieve Engineers, estimates sewer flows for high and low occupancy rates at each stage of the development (see table notes for assumptions), together with calculations for the connection of infill sewer for the existing caravan park and Chandler chalets.

Table 1 demonstrates that during the high occupancy period the total effluent generated by the completed development (all 4 stages) will be 1,997 EP, with a further potential contribution of 535 EP from existing Smiths Beach development, totalling 2,532 equivalent persons (EP).

During low occupancy rates, estimated effluent generation falls to 1,375 EP for the development, with a total of 1,642 EP including existing development.

The total potential effluent volumes for high and low occupancy are therefore 456m^3 and 296m^3 per day respectively, based on 180L/day generation per EP.

At full development and 100% occupancy, the projected effluent generation for the proposed development is 2,132 EP with an additional 594 EP from existing development, giving a total of 2,725 EP (491m^3/day).

Table 1

Estimated Sewer Flows for High and Low Occupancy Rates at Smiths Beach

(Source: Wood and Grieve Engineers)

Stages	Type	No. Units	People/ Unit	High Occupanc	High EPS	Low Occupancy	Low EPS	Total High EPS	Total Low EPS
1	Single Residential	45	3.5	100%	158	95%	150		
	Tourist Site	60	3	90%	162	45%	81		
	R40 development	23	3	90%	62.1	45%	31		
	Shopping Area			90%	3.645	45%	4	385	266
2.	Single Residential	109	3.5	100%	382	95%	363		
	Tourist Site	180	3	90%	486	45%	243		
	Shopping Area			90%	9	45%	5	877	610
3.	Single Residential	83	3.5	100%	291	95%	276		
	Shopping Area			90%	24.3	45%	12	315	289
4.	R40 Development	22	3	90%	59.4	45%	30		
	Hotel	200	2	90%	360	45%	180	419	210
Development Total								**1997**	**1375**
Backlog	Caravan Park	168	3	90%	453.6	45%	227		
	Chandler	30	3	90%	81	45%	41	535	267
Overall Total								**2532**	**1642**

2.3.2 Yallingup

The Yallingup townsite currently utilises on-site effluent disposal systems. If a treatment and disposal facility is established in the locality due to development at Smiths Beach, it is worthwhile considering whether settlement at Yallingup could also be connected. The Water Corporation has therefore directed that this possibility should be considered within the current study.

The Leeuwin-Naturaliste Ridge Planning Review Urban Settlement Study (1996) provides existing and projected population data for the Yallingup townsite. There are currently 160 lots within the townsite, with the potential for a further 198 to be created through future subdivision (denoted in the plan as Res. 1 and 2).

Wood and Grieve Engineers has calculated the potential effluent contribution from these sources, with an additionally allowance for Caves House, totalling 1,353 EP. Wood and Grieve has also indicated that if connection of Yallingup was to occur, the existing backlog would not be connected for approximately 10 years, with new development connected in at least 5 years time, and more likely 8-10 years. The latter scenario would correspond to Stage 4 development of the Smiths Beach timetable.

Based on the development staging volumes previously presented for Smiths Beach, Table 2 present a schedule of potential effluent generation for the proposed development at Smiths Beach (100% occupancy), including both backlog sewer and provision for new development at Yallingup.

Table 2

Summary of Potential Effluent Generation Volumes (assuming 100% occupancy of proposed development)

Smiths Beach			Yallingup		Both Sites
Stage	EP[1]	Cumulative Daily Volume (m^3)[1]	EP[1]	Daily Volume (m^3)[1,2]	Cumulative Daily Volume (m^3)[1]
1	416	75 (171)	-	-	75
2	1,348	243 (339)	-	-	243
3	1,666	300 (396)	-	-	300
4	2,132	384 (480)	1,353	234	618 (714)

Notes

1 Advice from Wood & Grieve.
2. Connection in 10 years, advice from Wood & Grieve.
Figures in parenthesis indicate volumes including existing caravan park and chalets at Smiths Beach.

2.3.3 Adopted Effluent Generation Scenario

For the purpose of this study, the primary consideration is to identify appropriate treatment and disposal options for effluent generated by the proposed development of Location 413 Smiths Beach, with secondary consideration to existing development at Smiths Beach. Opportunistic connection of existing and proposed development at Yallingup is considered in a longer term context ie 10 year period.

Consequently, the evaluation of treatment and disposal options presented in the following sections focuses primarily on the total effluent generated during the high occupancy period (rather than 100%) at the completed development (all 4 stages) of 1,997 EP, with a further potential contribution of 535 EP from existing Smiths Beach development, totalling 2,532 EP per annum and 456m^3/day.

3.0 ALTERNATIVE EFFLUENT MANAGEMENT STRATEGIES

3.1 Connection to Dunsborough Wastewater Treatment Plant

The following section considers the feasibility of connecting the proposed Smiths Beach development to the Water Corporation's Dunsborough wastewater treatment plant, using a new sewer main and pumping stations.

3.1.1 Capacity of the Treatment Plant

The Water Corporation's Dunsborough wastewater treatment plant is located on Commonage Road in Dunsborough, approximately 9 km north east of the Smiths Beach site. In recent years the capacity of the plant has been exceeded during peak holiday periods, however the Water Corporation plans to construct a new upgraded treatment plant at Anniebrook, about 20km east of the site, by the end of 1999. It is proposed to dispose treated effluent by irrigation to a tree plantation. The capacity of the new plant and irrigation area is unknown at present.

The Water Corporation has advised Wood and Grieve that the Anniebrook treatment plant will have sufficient effluent treatment capacity to allow for the connection of the Smiths Beach development, together with an allowance for growth within the general region. This investigation therefore considers the connection of the proposed Smiths Beach development to the Dunsborough reticulated sewerage system, with ultimate treatment at the designated wastewater treatment facility.

3.1.2 Feasibility of Connection to Existing Sewer Rising Main

Connection of the proposed development at Smiths Beach to the Water Corporations proposed Anniebrook treatment facility would require a new pump station and sewer main connection to the existing sewer infrastructure at Dunsborough. A rising sewer main is located near the intersection of Caves Road and Naturaliste Terrace near the Dunsborough townsite, approximately 12km (by road) north east of the site.

Route options for the new sewer main were identified from colour aerial photography at scale 1:12,500, supplemented by local road maps, topographic, land use and cadastral information. Site survey included inspection of potential routes between the Caves Road Naturaliste Terrace intersection and the Smiths Beach site.

Suitability criteria applied to route option identification included:

(i) shortest possible distance;
(ii) highest possible utilisation of existing service corridors;
(iii) avoidance of private property crossings;
(iv) avoidance of vegetated areas;
(v) avoidance of National Park.

Moving south from Dunsborough to Yallingup, construction within the Caves Road reserve is the most apparent route for the sewer main, as all of the suitability criteria are effectively met.

From Yallingup south, two options are initially apparent:

(a) continuation along Caves Road, west along to Canal Rocks Road and north along Smiths Beach Road;

(b) west along Yallingup Beach Road for approximately 500m, then south along a firebreak in the National Park, then west through cleared land in private ownership including crossing Gunyalgup Brook and into the site.

Figure 2 indicates the location of these route options.

From a general engineering perspective, desktop investigation indicates either route is feasible, although the Caves Road/Canal Rocks Road/Smith Beach Road option is marginally longer.

Application of the suitability criteria suggest that option (b) is less suitable because of private property crossings including Gunyulgup Brook, minor clearing requirements and National Park crossing.

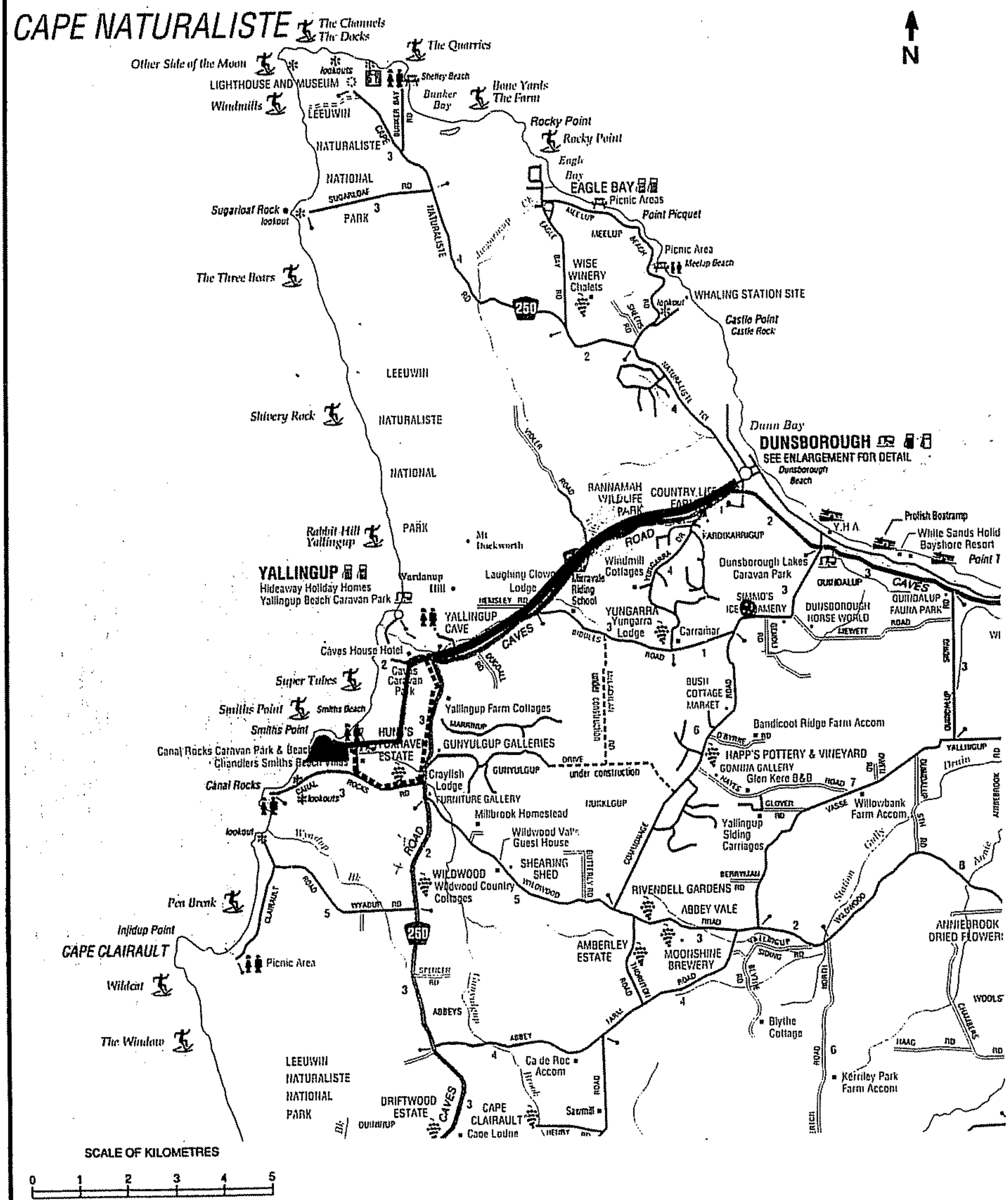


FIGURE 2

SEWER MAIN ROUTE OPTIONS

Consequently, for the purposes of this investigation the best option is considered to be the installation of the sewer pipeline within the existing road reserves between the Smiths Beach site and Dunsborough. The pipeline route would travel south from the site along Smiths Beach Road, east along Canal Rocks Road, then north along Caves Road to the rising main near the Dunsborough townsite (see Figure 1 for road locations).

Visual inspection of the road reserve route between the site and Dunsborough (as described above) indicates that the cleared section of the road reserve is reasonably wide, and moderate in alignment. An appropriately designed and managed sewer installation to the shoulder of the road pavement would not present a significant impact to vegetation in the road reserve. Limited if any clearing of roadside trees would be required and root damage to large trees would be minimal.

Furthermore, the water supply for the project will require the installation of a pipeline between the Water Corporation's Vidler Road reservoir tank and the site. Shared trenching would be implemented in this regard, thereby minimising construction costs and potential installation impact within the road reserve.

The route is simple, relatively direct and crosses moderately undulating terrain. Soil profiles are sandy, gravelly or clayey and apart from possible laterite caprock areas, there are no obvious signs of extensive rock in the reserve.

3.1.3 Preliminary Conclusions

Connection of the proposed Smiths Beach development to the Water Corporation's new wastewater treatment plant is considered to be feasible.

This solution provides a low impact environmentally acceptable option with the potential for connection of other development sites in the locality, namely Yallingup and Caves House.

The likely route for the sewer installation to Dunsborough between Vidler Road and Smiths Beach is the same as for proposed water supply as piped water must be installed from Vidler Road to the site regardless of the effluent disposal strategy finally adopted. Shared trenching could be implemented to minimise any additional impact to vegetation located within the road reserve for this portion of the route.

Visual inspection of the road reserve between the site and Dunsborough indicates that installation of a sewer main at the road pavement shoulder under controlled and managed conditions is unlikely to create any significant environmental impacts.

3.2 Dedicated Disposal Facility for Smiths Beach

3.2.1 Background

An alternative option to connection to the Water Corporation's treatment facility is to establish a stand alone facility to treat and dispose effluent from Smiths Beach. The proposal must be technically viable, and must demonstrate compliance with a range of planning and environmental criteria, including the following:

- In terms of location of the treatment plant and disposal facility, compliance with the objectives of the draft Statement of Planning Policy for the Leeuwin-Naturaliste Ridge region (WAPC, 1997). This factor includes the establishment of any infrastructure required, including treatment plant, pipeline or irrigation area (woodlot).

- Establishment of a treatment plant on a site of (say) 4,000 - 6,000m^2 within a buffer of adequate size to prevent risk of odour nuisance to existing residences and areas proposed for future residential development. An initial buffer zone of 500m is assumed, however it is anticipated that this distance could be significantly reduced by incorporation of appropriate odour control technology, if required.

- Disposal of treated effluent in a manner which maintains surface water and groundwater resources within water quality criteria which reflect their beneficial uses as described in Draft Western Australian Water Quality Guidelines for Fresh and Marine Waters (EPA, 1993), and additionally protects public health.

- Establishment of the treatment plant site and disposal area at a site which can meet more general environmental objectives requiring protection of vegetation, flora habitat and fauna of special conservation interest or value.

3.2.2 Treatment and Disposal Options

The approach to strategic planning for sewerage treatment and disposal outside of major urban areas has now shifted from the historical convention of primary or secondary treatment followed by ocean or river outfalls, or infiltration/evaporation, towards approaches which can contain the treated effluent on land and can achieve the beneficial re-use of the final effluent.

This trend recognises potential water quality problems which can arise from discharge of treated effluent to surface and groundwaters, and the economic and environmental benefits which can derive from using treated wastewater in areas where good quality water resources are relatively scarce.

In addition to the conventional performance targets of high BOD and suspended solids removal, there is now also a focus on high efficiency nutrient removal. This is because eutrophication of Australian inland and coastal waters is recognised as a widely distributed, economically and environmentally serious problem.

The enrichment of shallow groundwater by nitrogen is a further undesirable outcome of land disposal of treated effluent, which can be mitigated by good nutrient removal in the treatment and disposal process.

In Western Australia the recent trend in treated effluent disposal is to re-use treated effluent in plantation forestry, for irrigation of recreational playing fields, or in horticulture. New facilities have also been constructed with final effluent polishing using constructed wetlands prior to infiltration to groundwater. Some examples of alternative disposal methods include:

- The Albany Wastewater Treatment Plant uses primary and secondary treated effluent to irrigate a blue gum plantation which is managed for commercial wood production by CALM. The capacity of the final scheme will be 60,000 EP.
- At Mundaring, an extended aeration/activated sludge plant with phosphorus removal by chemical dosing passes effluent to an open water constructed wetland for further nutrient polishing prior to disposal to an infiltration trench, or re-use for irrigation of local Public Open Space. The capacity of this plant is around 1,000 EP.

- At Walpole, the Water Corporation proposes an extended aeration/activated sludge plant, further nutrient removal in constructed wetlands of reed bed treatment system design, initial disposal by soil infiltration, and subsequent disposal to irrigated woodlots. The capacity of the plant will ultimately be 2,500 EP.

- At Dunsborough the current oxidation ponds/soil infiltration/evapotranspiration system will soon be superseded by a new treatment plant and disposal to a woodlot by irrigation.

- At Mount Barker, we are advised that the Houghton's vineyard uses treated effluent from the townsite to irrigate vines.

Recognising the location of the Smiths Beach site in a region and locality where viticulture and forestry in a rural setting are historically important land uses, it is logical to focus the initial investigation towards identifying any opportunities for treated effluent to be re-used for irrigation of one of these crops.

Identification of an acceptable disposal area for treated effluent is the most crucial element of planning for the Smiths Beach project under this option. Whilst economic factors are clearly important in terms of treatment technology selection, there are now many commercial suppliers of treatment plants which produce good quality effluent, and a variety of processes with characteristic operational and performance features from which a preferred choice can be selected.

The final effluent quality requirement is largely determined by the proposed method of disposal:

- if rapid dispersion of contaminants within a very small mixing zone could be demonstrated ocean disposal might require secondary standard effluent treatment;

- if onshore surface water disposal was the only option, tertiary treatment with a very high degree of nutrient removal and disinfection would be required;

- for land disposal, by re-use for irrigation, a relatively low degree of treatment might be acceptable although prevention of nutrient export risk and public health protection must also be demonstrated, and effluent quality suited to the equipment used for irrigation must also be achieved;

- for land disposal by soil infiltration/groundwater recharge, a relatively low degree of treatment might suffice if the beneficial uses of groundwater are not reduced and clogging of infiltration ponds can be managed;

- above and beyond these considerations, environmental risk (actual or perceived) management can be achieved by using very high performance treatment plants using the latest sophistication in process design.

This study has proceeded on the initial assumption that land disposal of treated effluent including re-use for irrigation will be the preferred method of disposal. This initial assumption is based on several factors:

- local experience with irrigation to woodlots at Albany;

- selection of this approach by the Water Corporation for the new Anniebrook facility;

- common support for irrigation re-use demonstrated in previous consultation programs instigated by the Water Corporation;

- an apparent abundance of suitable land in the vicinity of the Smiths Beach site, including viticulture and eucalyptus woodlots.

The implications and requirements for treatment plant type are dealt with subsequently.

3.2.3 Approach to the Investigation

The implementation of this component of the investigation has proceeded in the following logical steps:

(i) An appropriate water balance/irrigation model has been used to determine the amount of land required for a eucalyptus woodlot or vineyard, which can fully utilise peak wastewater production for irrigation under local climatic conditions.

(ii) Mapped data describing the following factors has been assembled:

- land areas previously cleared of native vegetation;
- land capability/soil type;
- land use planning policy;
- existing land use including roads and road reserves; and
- general drainage and topography.

Land resources were evaluated to identify potential sites where a woodlot or vineyard of suitable size is present or could be established for the purpose of disposing treated effluent.

(iii) Environmental data has been overlain on a colour aerial photograph of the Smiths Beach hinterland in a radius of up to approximately 8km surrounding the development site. The study area is generally bounded by Biddle Road to the north east, Commonage Road to the east, Abbey's Farm Road to the south and south east, and the coast to the west.

(iv) A suite of potentially suitable land parcels was identified from the mapped information, with further examination by ground-truthing. The site surveys confirmed the following factors:

- existing land use, adjacent land use and residential settlement pattern;
- apparent commercial viability of existing land use;
- topography and drainage;
- apparent soil types and shallow soil profiles;
- landscape setting of the sites and access routes (recognising the importance of landscape values to the local tourist industries); and
- potential for the location of a sewage treatment plant.

Based on the findings of this work, several potentially suitable properties were identified and subsequently examined in more detail in regard to their suitability for a sewage treatment plant and treated effluent irrigation scheme.

A detailed discussion of the investigations is presented below.

3.2.4 Potential Effluent Irrigation Disposal Sites

3.2.4.1 Modelling of Disposal Area Requirement

The New South Wales Environmental Protection Authority (NSWEPA, 1995) has developed a model specifically to assist the development industry in achieving an ecologically sustainable method of storing and disposing of treated sewage effluent from centralised treatment plants. The model was developed with the aim of:

- encouraging the beneficial use of effluents and providing guidance as to how this might be accomplished in an ecologically sustainable manner; and

- providing guidance for the planning, design, operation and monitoring of effluent irrigation systems in order to minimise risks to the environment and public health.

This investigation has utilised the NSWEPA irrigation model to determine the appropriate size of the disposal area (vegetative plantation) and winter storage pond based on the characteristics of the project and receiving environment.

Input to the modelling was based on the following assumptions:

- occupancy of existing and proposed development at Smiths Beach of 2,500 EP (ie the high occupancy scenario, see Section 2.3.3);

- precipitation data spanning 92 years (1904-1996) from Busselton (Cape Naturaliste) weather station;

- evaporation data spanning 20 years (1976-1996) from Busselton (Jarrahwood) weather station. To allow assessment of data prior to 1976 to be included in the model, the monthly averages of this period were used to represent the monthly averages from 1904-1976;

- percolation of 20mm/month during the winter months (May to September) to represent naturally occurring soil infiltration/groundwater recharge;

- a crop factor of 0.8 applied to the pan evaporation data to represent the amount of water which is lost to the atmosphere through plant uptake and usage; and

- temporary effluent storage during wet weather unfavourable for irrigation because of surface runoff risk from the irrigation area

Modelling results are presented in full as Appendix A.

The model concludes that approximately 32ha of woodlot plantation would be required for irrigated disposal of treated effluent generated by 2,500 EP, the generation rate at Stage 4 (full) development, high occupancy rate for all months of the year, and the connection of existing development at Smiths Beach (see Section 2.3 for staging and effluent generation). The irrigation area required for disposal could also be established in stages commensurate with staged effluent generation from the development.

The model also indicates that an additional area for a winter storage of 120,000m^3 of treated effluent would also be required. A dam with an area of 5ha based on an average depth of 3m would be required for this purpose. The dam volume allows for 7 months per year of non-irrigation (90 percentile rainfall), together with the capacity to accommodate rainfall from the 1 in 100 year storm event (0.5m freeboard allowance).

A second important consideration is the area of plantation required to utilise nutrients delivered to the woodlot via the effluent solution. With a final assumed effluent quality of 0.5 and 10 mg/L for phosphorus and nitrogen respectively (which for example is achievable using an IDEA plant), and a plantation uptake of 15kg/ha/year for phosphorus and 90kg/ha/year for nitrogen (NSW EPA, 1995), 6 ha of plantation would be required to ensure that uptake of all effluent phosphorus, and 20ha for nitrogen. Given that 32ha of plantation is required for water uptake, it is assumed that no additional plantation area is required for the specific purpose of ensuring total nutrient uptake by conversion to eucalypt biomass.

We have assumed a further land requirement for the plantation area to:

- provide a non-irrigated perimeter buffer to the plantation as a safe-guard against run-off and acceptable nutrient uptake; and

- at the same time provide an aesthetic buffer consisting of tree vegetation planted to landscape specifications to shield the irrigated portion of the plantation, which would likely be planted in a rectilinear pattern.

For the purpose of this investigation, we have adopted a buffer of 25% of the area required for the irrigated plantation, which equates to approximately 8ha. Consequently, the total area required for the storage and disposal facility is estimated to be 45ha.

Given that the region is important for grape production and that many areas which may lack a suitable water supply may otherwise be suitable for viticulture, modelling was also conducted to establish the area of vines required to dispose of the same volume of irrigated effluent.

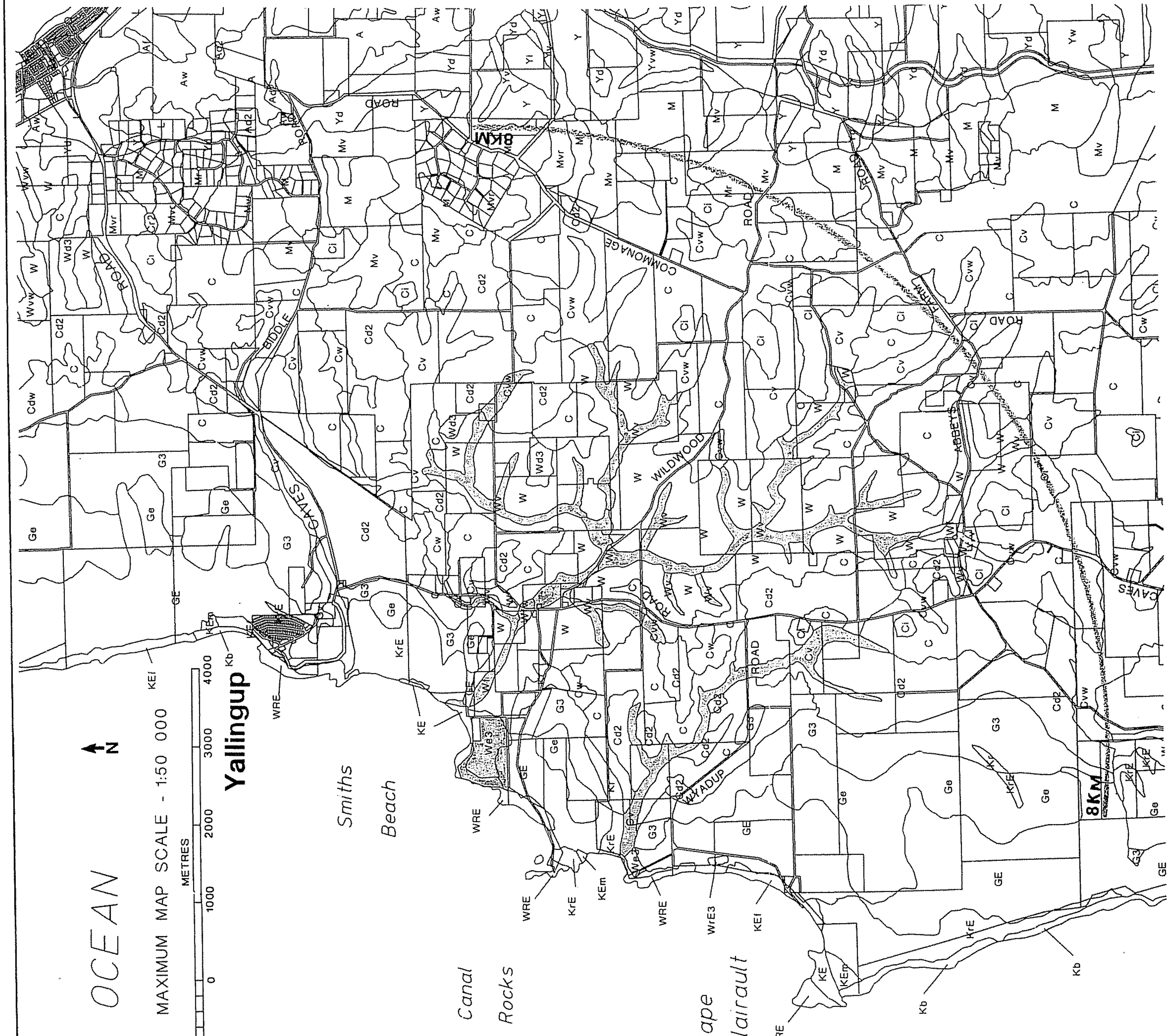
The crop factor for both table grape and wine grape vines is approximately 50% or more lower than for tree plantation species such as Tasmanian bluegums or pines. In addition, the water use period is smaller resulting in the requirement for a larger storage dam. Consequently the requisite area for disposal to vines with buffer is estimated to equate to approximately 100ha.

3.2.4.2 Land Units and Land Capability

The Department of Agriculture (Tille and Lantzke, 1990) has conducted a regional-scale investigation, including land within 8km of Smiths Beach, with regard to land capability for various uses. Land capability assessment identifies land units, which are characterised by key landform, soil and hydrological characteristics relevant to land use capabilities. Land units of the area as defined by the study are shown in Figure 3.

Whilst regional classification is not intended to replace site-specific land capability assessment, it provides a useful tool for regional planning and is considered adequate for the current level of investigation. It is noted however, that in the event a site or sites are selected for the establishment of a treated effluent disposal plantation, additional detailed site investigation will be required to confirm the regional assessment.

Three land systems have been defined within the area of investigation, being Cowaramup Upland (C), Wilyabrup Valleys (W), and Gracetown Ridge (G).



Cowaramup Uplands Land Systems

C - Cowaramup Flats ; Flats (0-2% gradient) with gravelly duplex (Forest Grove) and pale grey mottled (Mungite) soils. Also included in areas mapped as C are areas of ; **C2- Cowaramup Gentle Slopes** ; Gentle slope (2-5% gradient) with gravelly duplex (Forest Grove) soils. The flats (C) are the dominant unit, the gentle slopes (C2) occur on the margins of this unit. usually adjacent to the Wilyabrup slopes.

Cd2 - Cowaramup Deep Sandy Rises ; Flats and gently sloping rises (gradients 0-5%), with deep bleached sands. Some areas of low and moderate slopes (gradients 5-15%).

Cdw - Cowaramup Deep Sandy Wet Flats ; Poorly drained flats and depressions with deep organic stained sands.

Ci - Cowaramup Ironstone Flats ; Flats and gentle slopes (0-5% gradient) with some laterite outcrop and shallow gravelly sands over laterite.

Cr2 - Cowaramup Rocky Gentle Slopes ; Flats and gentle slopes (0-5% gradient) with shallow rocky soils and some granitic outcrop.

CR - Cowaramup Rock Outcrop ; Areas dominated by granitic outcrop.

Cv - Cowaramup Vales ; Small, narrow V-shaped drainage depressions with gravelly duplex (Forest Grove) soils.

Cvw - Cowaramup Wet Vales ; Small, broad U-shaped drainage depressions with swampy floors. Gravelly duplex (Forest Grove) soils on sideslopes and poorly drained alluvial soils on valley floor. This unit can be subdivided into the (side) slopes and the (valley) floor.

Cw - Cowaramup Wet Flats ; Poorly drained flats and slight depressions with pale grey mottled (Mungite) soils.

Gracetown Ridge Land Systems

G2 - Gracetown Gentle Slopes ; Gentle slopes (gradients 2-5%) with deep reddish and yellow brown siliceous sands over limestone (Spearwood Sands). Not exposed to prevailing winds.

G3 - Gracetown Low Slopes ; Low slopes (gradients 5-10%) with deep yellow brown siliceous sands over limestone (i.e. Spearwood Sands). Not exposed to prevailing winds.

Ge - Gracetown Exposed Flats ; Ridge crest, exposed to prevailing winds, with deep and shallow yellow brown siliceous sands over limestone (i.e. Spearwood sands).

GE - Gracetown Exposed Slopes ; Moderate slopes (gradients 10-15%) on the west coast exposed to prevailing wind directly off the ocean, with deep and shallow yellow brown siliceous sands over limestone (i.e. Spearwood Sands).

GEm - Gracetown Blowouts ; Small blowouts with deep yellow siliceous sands.

Gk - Gracetown Karst Areas ; Small areas with sinkholes, dolines, limestone scarps and cave entrances.

Gv - Gracetown Valleys ; Deepish narrow valleys incised into the Gracetown Ridge.

Wilyabrup Valleys Land Systems

W - Wilyabrup Slopes ; Slopes with gradients generally 5-15%, but ranging from 2-30%, and gravelly soils (i.e. Forest Grove and Keenan Soils). This unit can be divided into; **W3 - Wilyabrup Low Slopes** ; Gradients 5-10% and **W4 - Wilyabrup Steep Slopes** ; Gradients 10-15%. In most cases W3 is the dominant unit present.

Wd3 - Wilyabrup Deep Sandy Slopes ; Low slopes (gradients generally 5-10%) with deep bleached sands.

We3 - Wilyabrup Exposed Slopes ; Low slopes (gradients generally 5-10%) exposed to strong winds off ocean.

WEw - Wilyabrup Exposed Swamps ; Swamp on granitic headland at Cape Leeuwin.

Wf - Wilyabrup Fertile Flats ; Well drained valley flats and floodplains with deep alluvial soils, often red brown loams (i.e. Marybrook soils).

Wfw - Wilyabrup Wet Fertile Flats ; Poorly drained valley flats and floodplains with deep alluvial soils.

WI3 - Wilyabrup Ironstone Slopes ; Low slopes (gradients generally 5-10%) with shallow gravelly sands over laterite.

Wr3 - Wilyabrup Rocky Slopes ; Low slopes (gradients generally 5-10%) with shallow rocky soils and some granitic outcrop.

WR - Wilyabrup Rock Slopes ; Slopes dominated by granitic outcrop.

WrE3 - Wilyabrup Exposed Rocky Slopes ; Low slopes (gradients mainly 5-10%) with shallow rocky soils and some granitic outcrop, exposed to strong winds off the ocean.

WRE - Wilyabrup Granitic Headlands ; Areas on the west coast dominated by granitic outcrop.

Wv - Wilyabrup Valleys ; Narrow V-shaped drainage depressions.

Wvw - Wilyabrup Wet Valleys ; Broad U-shaped drainage depressions with swampy floors.

Ww3 - Wilyabrup Wet Slopes ; Low slopes (gradients 5-10%) with high winter water tables.

FIGURE 3

LAND SYSTEMS AND UNITS AND PREDOMINANT DRAINAGE (blue) IN THE VICINITY OF THE SITE

(After Tille and Lantzke, 1990)

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

The regional land capability study defined land units suitable for a number of land uses including forestry, which is considered to correspond to a woodlot plantation (although unirrigated), and also for viticulture. Major land unit types within the study area with "fair" or greater capability for forestry and/or viticulture are shown in Table 3, with limitations abbreviated as lower case letters.

Table 3

Major Land Units Within the Study Area with "Fair" or Greater Capability for Forestry and/or Viticulture

Land Unit	*Land Capability	
	Forestry	Viticulture
Cowaramup Land System		
C	III w	II tw
Cv	IIr	II hrwz
Cvw	IIr	II hrwz
Gracetown Ridge		
G2	II df	III p
G3	II df	III hp
Wilyabrup Valleys		
W	IIr	II hpw
Wf	I	I

* After Tille and Lantzke, 1990

Definition of Limitations
d - soil moisture availability
f - soil fertility
h - water erosion hazard
p - water supply (from bores, dams etc.)
r - rooting conditions (soil depth and rockiness)
t - wind exposure
w - waterlogging
z - trafficability

In the context of the present investigation where the woodlot or vineyard would be irrigated with treated effluent, land use limitations of soil moisture availability (d), soil fertility (f), and water supply from bores, dams etc. (p) are not applicable. It should also be noted that the land capability considers the land in it's natural state, with no allowance for potential improvement through remedial management, which can result in greater land use capability eg. irrigation by treated effluent containing nutrients on infertile soils with low soil moisture or water supply infertile soils.

A full description of the environmental characteristics derived for each land unit, and subsequently used to provide a land capability classification for land use, is provided in Tille and Lantzke (1990).

Land units from both the Cowaramup and Gracetown Ridge land systems are potentially suitable for forestry and /or viticulture. The Wilyabrup Valleys in this area correspond to the mid and upper slopes of the valley systems which contain major drainage lines, Gunyulgup and Wyadup Brooks and their tributaries (highlighted on Figure 3). The drainage lines are generally not suitable for either forestry or viticulture, the exceptions being the W and Wf land units, which are gentle slopes and well-drained fertile flats respectively.

3.2.4.3 Areas Cleared of Native Vegetation

The process of identifying potential sites for the establishment of effluent disposal has adopted the criteria that no large areas of native vegetation should be cleared, and that farmland previously cleared of native vegetation should be preferentially selected. Suitable lots containing areas cleared of native vegetation have been determined through the use of current aerial photography.

National Parks have not been considered as potential sites.

3.2.4.4 Potential Disposal Sites

Using desktop analysis of mapped information, a total of 21 potential disposal sites were identified within an approximate 8 km radius of the proposed Smiths Beach development site (Figure 4). All have previously been cleared for farming use and include land units identified as suitable for forestry, and in some case viticulture. However in addition to the physical characteristics of the land, it is also essential to consider strategic planning issues.

In this respect, the draft Leeuwin-Naturaliste Ridge Statement of Planning Policy (SPP) (Western Australian Planning Commission, 1997) provides the strategic planning framework for the policy area for the next 30 years. It is intended to promote sustainable development, conservation and land and resource management, and provides assistance to managing land use change and a guide to development. The land use strategy plan from the SPP is shown as Figure 5.

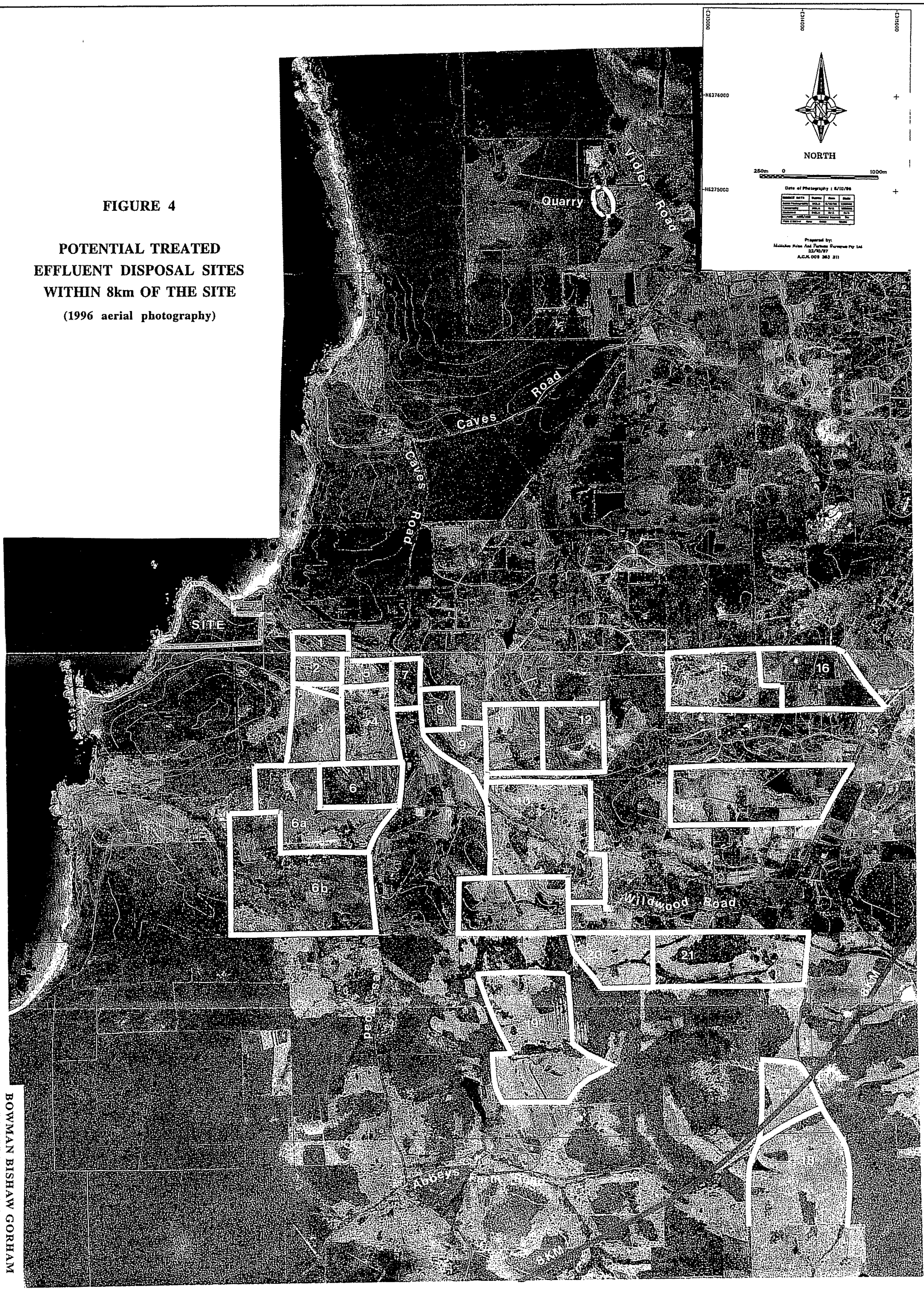


FIGURE 4

POTENTIAL TREATED EFFLUENT DISPOSAL SITES WITHIN 8km OF THE SITE

(1996 aerial photography)

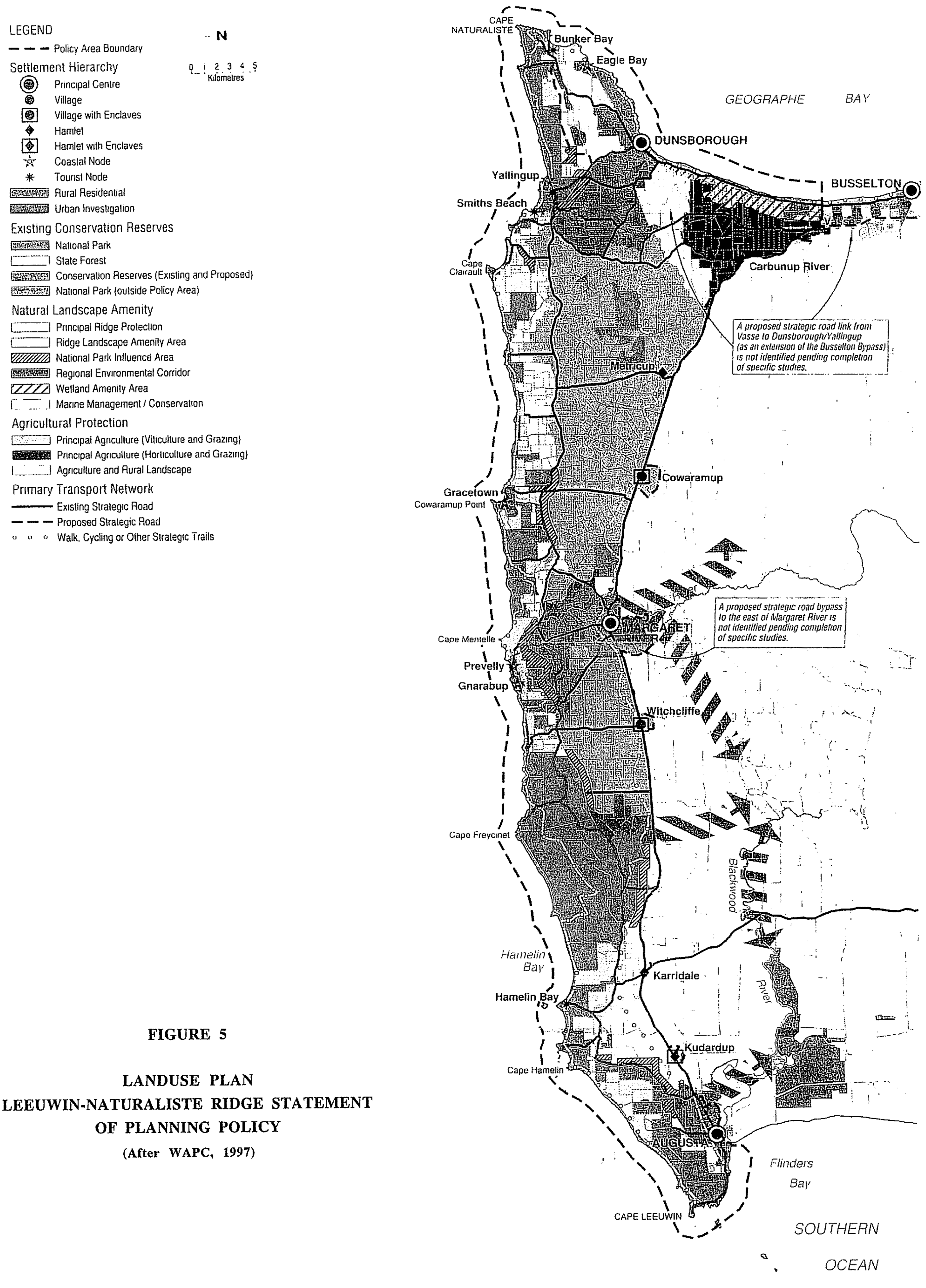


FIGURE 5

LANDUSE PLAN
LEEUWIN-NATURALISTE RIDGE STATEMENT
OF PLANNING POLICY
(After WAPC, 1997)

The SPP identifies land north of Wildwood Road as a rural-residential precinct. Rural-residential development within the policy area will be restricted to the identified areas only, and consequently nominated land becomes valuable from both limited resource and economic perspectives.

This investigation has identified nine potential sites situated north of Wildwood Road (Sites 7-12 and 14-16 inclusive). However, land north of Wildwood Road has not been considered further for the establishment of a treated effluent disposal plantation due to the potential for future rural-residential zoning identified in the SPP.

A number of sites in relatively close proximity to the Smiths Beach site were investigated. Sites 1, 2 and 5 north of Canal Rocks Road have a total area of approximately 40ha, and occur within the SPP Ridge Landscape Amenity Area. This category includes a presumption against further subdivision and clearing, and encourages landowners to strategically replant vegetation. The establishment of a wood lot would presumably fulfil this objective.

The Water Corporation generally requires a 500m buffer to sewage treatment facilities. To consider a reduction in buffer distance, the treatment facility and storage dam would need to demonstrate strict odour and noise control, which could be achieved through appropriate high quality effluent treatment, disinfection and odour scrubbing technology.

Adjoining sites 3, 4, 6, 6a and 6b have a combined area of approximately 360ha, and are the western edge of an elevated plateau. Land capability information indicates that the majority of this area has Class II capability for forestry and viticulture, although drainage management may be required to avoid the potential for waterlogging. The Cd2 land unit which occurs in some areas of these sites has a Class IV capability for forestry and viticulture, limited by soil moisture availability. Irrigation would negate this limitation.

Based on the above information, and recognising that site-specific investigation would be required to confirm the sites land capability and other characteristics, Sites 3, 4, 6, 6a and 6b (or a combination of selected lots) appear to offer sufficient land area with appropriate land capability potential for the establishment of a woodlot plantation close to the Smiths Beach development site.

These sites are located principally within the SPP Principal Agriculture (Viticulture and Grazing) designation, the objective of which is to continue the protection and viability of agricultural land within the policy area. The SPP considers that the quality and quantity of water resource availability remains a crucial point which will affect the viability of agricultural practice. Whether woodlot establishment may be considered compatible with the protection of agricultural use (as irrigated horticulture) would need confirmation from a planning perspective.

Land within the vicinity of, and immediately adjacent to, Caves Road is also considered to have scenic value from a tourism perspective. However, the land rises relatively steeply from Caves Road before reaching the plateau on which the sites are located, effectively screening the sites from the Caves Road.

The area immediately south and south east of the junction of Wildwood and Caves Roads has been discounted due to steep grades and the occurrence of drainage lines.

The area of Site 10 south of Wildwood Road and adjoining Site 13 have land units with capability suitable for forestry (trafficability is a problem for viticulture) and a combined area of about 125ha.

Site 19 has a total cleared area of approximately 100ha, and appropriate land capability for forestry and viticulture, but is substantially planted with vines at present and has irrigation dams based on natural runoff in place.

Sites 20 and 21 have a total area of approximately 150ha and appropriate land capability, although some areas would be unsuitable for planting due to soil conditions (rockiness) and the occurrence of drainage lines which bisect the site.

Site 17 located in the south eastern extremity of the study area, approximately 8m from Smiths Beach, has an area of approximately 40ha, and has suitable land capability for forestry and vines. Similarly, Site 18 on the southern side of Abbeys Farm Road has suitable capability, but is already significantly planted to irrigated vines.

Whilst the land capability of the sites identified in this area may be conducive to the establishment of a treated effluent disposal facility, as their distance from Smiths Beach increases and approaches the distance between Smiths Beach and Dunsborough so their apparent merit diminishes compared to simple sewer connection to Dunsborough. Also the installation of a pipeline within the road reserve of both Wildwood and Abbeys Farm Roads could present greater difficulties from environmental, social and engineering perspectives compared to the Caves Road Reserve. These roads are relatively narrow, winding, have well vegetated reserves and are significant tourist and access routes in the region. These factors potentially restrict the use of sites adjacent to Wildwood and Abbeys Farm Roads, 10, 13, 17-21.

In terms of the installation of sewer mains and associated infrastructure, increasing distance from Smiths Beach results in a significant increase in establishment and pumping costs, an issue discussed in Section 4. Consequently, sites at the extremity of the study area, approximately 8km from Smiths Beach, are less desirable from this perspective.

3.2.4.5 Sludge Disposal

If any option other than connection to the Water Corporation's treatment plant is adopted, sludge produced by the effluent treatment process will require management and disposal in accordance with the recently formulated National Biosolids Management Guidelines (Unkovich, undated).

A sludge generation estimate from Wood and Grieve Engineers indicates that at full development 200-400m^3/yr of sludge will realistically be produced.

3.2.4.6 Preliminary Conclusions

Sites north of Wildwood Road, 7-12 and 14-16 inclusive, are considered unsuitable due to potential for future rural-residential zoning identified in SPP.

Sites 1 to 6b inclusive located south east of Smith's Beach appear to have low economic value for farming, suitable area and land capability for the establishment of a woodlot or vines, which may be compatible with the objectives of the SPP, a factor which would require confirmation at the more detailed design stage of the project.

Sites further from Smiths Beach also have potential for the establishment of a treated plant and disposal facility. However as the distance of these sites increases and approaches the distance between Smiths Beach and Dunsborough, their merit decreases as the Smith Beach solution increasingly approaches a duplication of the proposed Anniebrook facility.

3.3 Other Disposal Methods Considered

Whilst it has been logical to focus on effluent re-use for irrigation as a preferred disposal option, other methods of disposal have also been considered in order to ensure that all possible alternatives have been investigated.

3.3.1 On-site Effluent Disposal

The potential for on site effluent disposal in accordance with the development plan proposed for Location 413 Smiths Beach is presented below.

3.3.1.1 Site Capability for On-site Disposal

It is recognised that the site has an inherent capacity to sustain on-site effluent disposal using soil infiltration of treated effluent by septic tanks and conventional leach drains or small-scale aerobic treatment units. The site's capacity to sustain on-site disposal may be calculated based on the area of land available and long-term hydraulic application rates which can be sustained by the prevailing soil types.

Soil types over the site have been described in Section 2.1. Long term acceptance rates (LTAR) hydraulic application rates for effluent disposal by soil infiltration are extrapolated from soil permeability tests to represent the permeability of a soil type once a clogging layer has developed, which typically occurs 1 to 6 months following commencement of effluent disposal.

In the absence of site specific soil permeability tests, an estimate can be made based on soil texture classification. Assuming that the dominant soil type on site is expressed as the gradational gravelly profile then a representative surface soil permeability of 0.6m/day can be adopted. The LTAR for this soil permeability is $26L/m^2/day$.

3.3.1.2 Staging Considerations

Table 4 shows the length of infiltration trench (leach drain) required for disposal of the sewage volumes generated by each stage of the proposed development. Trench dimensions are assumed to be 0.6m x 0.6m or a wetted trench area of 1.2m (width plus twice the depth of wetted walls).

Table 4
Length of Disposal Trenches Required for Staged Development

Stage	EP[1]	Daily Volume (m^3)[1]	Trench Length (m)
1	416	75	2,403
2	1,348	243	7,788
3	1,666	300	9,615
4	2,132	384	12,307

Notes
1 On advice from project engineers Wood & Grieve.
2 Based on methodology from AS1547.

Theoretically, the adoption of this disposal technology to the site could be possible for the volume of effluent generated at Stage 1, requiring a total trench length of approximately 2.4km arranged across the western parts of the site (away from Stage I) in parallel descending lines along the contours.

However, on-site disposal for subsequent stages becomes rapidly impracticable due to the lack of suitable area needed for installation of the disposal trenches. Furthermore, the installation of this infrastructure for Stage I would be on a temporary basis only, pending the development of further stages and subsequent connection to a reticulated sewerage disposal facility.

From a social perspective, there would likely be community opposition to the installation of a large number on-site effluent disposal systems adjacent to an important tourist node such as Smiths Beach. Use of very high performance on-site systems to resolve water, contaminant removal and public health management issues associated with on-site disposal could be achieved however the temporary service lifetime required compared to last is considered unlikely to be justifiable.

This option is not considered further in this investigation for long term solutions, although it is reasonable to conclude that temporary disposal could be achieve onsite for a portion of Stage 1 pending the connection to Dunsborough or a stand along facility if required by construction/sales schedules.

3.3.2 Disposal by Infiltration Basins

The existence of land areas with known hydrogeology including deep permeable soil profiles of Spearwood Sands which are known to have good phosphorus retention capacity, at least several metres separation between ground surface and maximum water tables, an absence of nearby potable water abstraction bores or wetlands based on groundwater, would represent an opportunity for disposal by aquifer recharge using infiltration basins.

Treated wastewater disposal by infiltration is practiced at Kwinana wastewater treatment plant, where these conditions prevail.

Assuming a hydraulic conductivity of 10m/day for the Spearwood sand soil profile, Wood and Grieve advise that a $500m^2$ infiltration basin 2m deep would be sufficient to dispose of a daily effluent volume of up to $1000m^3$ generated by the existing and proposed Smiths Beach development, and the nearby townsite of Yallingup together with possible expansion areas.

Due to reduced infiltration capacity caused by the development of a clogging layer, and to allow for routine maintenance, a second basin would likely be needed for use on a rotational basis.

The process of desktop and site survey has identified an area where deep yellow Spearwood sand profiles occur and infiltration basins could potentially be established subject to further hydrogeological investigations. The site is a sand quarry nearing exhaustion located north of Smiths Beach on Vidler Road (Figure 3), within the G3 land unit. The site exhibits deep yellow sands and is likely to be underlain by limestone formations. The distance to the coast is approximately 2.7 km, with separation by a ridge line and the native vegetation of the Leeuwin-Naturaliste National Park.

Based on a visual reconnaissance, the installation of a pipeline in the Vidler Road reserve would not appear to be constrained by significant environmental issues.

The Leeuwin-Naturaliste Ridge Statement of Planning Policy (SPP) (Western Australian Planning Commission, 1997) identifies land immediately west of the sand quarry as suitable for rural-residential living, and this area is under development at present. A refuse disposal operation is located adjacent to the site, on the northern side of Vidler Road.

As previously discussed, the Water Corporation generally requires a 500m buffer to sewage treatment facilities. At present a 200m separation distance exists between the quarry and the eastern boundary of the rural-residential precinct, which is densely vegetated with native species. To consider a reduction in buffer distance, the treatment facility and infiltration basins would need to demonstrate strict odour and noise control, which could be achieved through appropriate high quality effluent treatment, disinfection and odour scrubbing technology, with possible positioning of the plant underground.

Based on the above information, and assuming appropriate design and achievement of an acceptable buffer, the installation of a treatment plant and infiltration basins at the Vidler Road quarry appears feasible, subject to more detailed hydrogeological investigation.

3.3.3 Ocean Disposal

The oceanic waters adjacent to the Smiths Beach area appear to offer suitable conditions for ocean disposal in terms of the dilution and dispersion of effluent which could be achieved.

However, for this investigation it has been considered appropriate to discount this option based on the following factors:

- uncertain engineering viability and cost of establishing an appropriate offshore outfall;
- the popularity of the offshore areas for commercial and recreational fishing;
- the importance of good water quality at this high-profile tourist location to maintain swimming and surfing beaches; and
- the likelihood of strong local and regional community opposition regardless of whether technical/economic feasibility could be demonstrated.

Consequently this option is not considered further from an environmental perspective in this investigation.

3.3.4 Disposal to Surface Streams

Within a 6km radius of Smiths Beach permanent and seasonal surface drainages are limited in occurrence and annual flow. Many of the streams have been dammed by landowners to provide water for stock and crop irrigation.

Gunyulgup Brook is the major drainage discharging to the ocean at Smiths Beach and drains land to the south east and east of Smiths Beach.

Wyadup Brook is a smaller semi-permanent stream which drains the plateau located south of Smiths Beach.

Flow in these streams varies significantly with seasons. During summer, groundwater baseflow is the apparent dominant water source and flow is naturally low. During winter, increased baseflow is supplemented by surface runoff and flow is comparatively much higher.

Importantly, the maintenance of good water quality in the streams is paramount for several reasons:

- both flow through privately owned land for the bulk of their length and are used for recreation, irrigation, mariculture, stock watering and possibly for potable supplies in some circumstances; and

- both discharge to the ocean at the popular tourist sites of Wyadup Bay and Smiths Beach.

Recognising that low summer stream flows volumes place a limit on the ability to dilute treated effluent, and that existing beneficial uses oblige the maintenance of very high water quality, treated effluent disposal to local natural water courses has been discounted as an option at this stage.

Consequently this option is not considered further from an environmental perspective in this investigation.

4.0 ECONOMIC ANALYSIS OF OPTIONS

Two main solutions for the treatment and disposal of effluent from the Smiths Beach development exist, namely:

OPTION A	Stand alone treatment plant with effluent disposal.
OPTION B	Pump effluent and connect into existing Dunsborough reticulation system. Treatment at existing Water Corporation plant.

Discussion of these options and sub-sets of these options follow:

4.1 Option A – Dedicated Disposal Facility for Smiths Beach

Generally under this option the development area is served with a fully reticulated gravity sewerage system. The system gravitates to a sewerage pumping station at or near the lowest point in the development site.

This pumping station would pump through a pressure main and discharge at a dedicated treatment plant. The treatment plant would be required to be off-site due to minimum buffer distance parameters.

Once treated, the effluent would be disposed of in one of a number of possible solutions, as detailed below.

4.1.1 <u>Disposal Option A1 – Ocean Outfall</u>

Treated effluent is pumped back to Smiths Beach and disposed of through an Ocean Outfall. For the purposes of economic analysis, it is assumed that a very high level of treatment and nutrient removal would be required if this proposal were adopted. Note that it is unlikely this system would be acceptable, due to previously stated reasons. However, for completeness, we have costed this alternative. Costs are difficult to ascertain for the ocean outfall part of the works, but we have assumed some excavation through rock is required due to the known nature of site. This is especially true in the area of the point which would be the logical site of such an outfall.

4.1.2 Disposal Option A2 – Disposal to Streamflow

Again this solution is unlikely to find favour on environmental grounds as previously discussed, however it has been costed out for completeness.

Location of the treatment plant would be on a site such that a suitable stream is close by. Again to have any hope of acceptance, the treatment plant would be required to produce treated effluent with very low levels of nutrients, BOD and suspended solids.

An advantage is the low land requirement, as the site would only need to accommodate the treatment plant and discharge area.

Possible suitable sites (from an engineering perspective) are likely within the Gunyulgup Brook and Wyadup Brook. These areas are within 6km of Smiths Beach. Hence, our feasibility study on costs is based on a site being suitable within this area.

4.1.3 Disposal Option A3 – Infiltration Basins

A possible solution in which treatment effluent is discharged is the use of infiltration areas. Specific ground conditions are required for this solution to be viable. A likely suitable discharge area has been identified previously in this report. A site exists on Vidler Road which is a sand quarry area nearing exhaustion. The site exhibits deep yellow sand and underlain by limestone formation.

It is proposed that raw effluent is pumped to the treatment plant with this plant located adjacent to the intended infiltration ponds. The cost of this solution therefore, includes a rising main suitable of delivering effluent to this site ie 150mm diameter.

Due to the change in levels, ie going from ~ 0m RL (at the first pump station site) up to ~ 110 RL at the corner of Vidler Road and Caves Road, it is likely that a second pumping station is required to boost the flow along the way. The Total Dynamic Head would be greater than 120m which would result in unacceptable pump flow with the use of only one pumping station.

An area set aside for infiltration basins of 25ha has been assumed together with a 1.5ha site for the treatment plant. A high level of treatment is assumed for this disposal option.

4.1.4 Disposal Option A4 – Woodlot Irrigation

Again the treatment plant would be located off-site adjacent to the intended effluent disposal area. A number of potentially suitable sites have been discussed previously. In order to cost this solution an idealised treatment site and hence rising main length has been chosen as 6000m. This being mid-way between the closest suitable site and the furthest likely acceptable site.

Due to the length of the rising main and likely ground levels, only one pumping station is likely to be required.

An area for ultimate conditions, of approximately 45ha would be required. This includes space for the woodlot, winter storage dam, buffers and treatment plant site. For evaluation purposes we have estimated land component costs to be $25,000/ha. We have not costed in the cost of planting out the woodlot, as we have assumed the costs for this would ultimately be off-set by returns and likely to be carried out by agreement with a timber producer.

4.2 Option B – Connection to Dunsborough Sewerage Reticulation System

The second major option for effluent disposal is the provision of a pumping station and directly connecting the Smiths' Beach system to the Dunsborough Sewerage Reticulation system. The benefits of this system are that the effluent is pumped back to Dunsborough and ultimately treated at the Dunsborough Wastewater treatment plant. There are obvious economies of scale in treating effluent at Dunsborough and in not having secondary satellite treatment facilities. Economies would also be obtained in maintenance and operating costs.

Elements of this scheme are detailed below. Note that due to the local topography, the highest point to pump over is at the corner of Vidler and Caves Road. This has a level of approximately 110.0m RL. As such, with this large pumping head a secondary pumping station is likely to be required at approximately the 50 m RL level to ensure adequate flow rates are maintained.

Elements of this system includes:

- Gravity Reticulation to Smith's Beach Development.
- Primary Pumping Station at the low point of development area.

- 150 Ø Rising Main along Smiths Beach Road, Canal Rocks Road and Caves Road.
- Secondary Pumping Station along the route at about RL 50.0m.
- Connection of the rising main to the Dunsborough Sewer Reticulation System.
- Discharge system to deal with Odour Control. The rising main would be in the order of 12,500m in length.

The major issue of pumping effluent back to Dunsborough is the length of time the effluent spends in pumping pits and the pressure main. An excessive length of time can cause the effluent to undergo anaerobic breakdown known as septification. This can produce unpleasant odours at discharge points and requires management to ensure odours are not an issue.

Table 5 details flow production, flow rates and anticipated length of time of effluent in pump pits and rising mains.

Table 5

Flow Rates and Time of effluent in pipe for the connection to Dunsborough Option

STAGE NO	TOTAL PEOPLE (CUMULATIVE)	OCCUPANCY (%)	EFFLUENT PER DAY (m^3)	STORAGE VOL IN PIPE (m^3)	TIME IN PIPE (DAYS)
1	411	95%	70.3	220	3.1
		50%	37.0	220	5.9
2	1343	95%	229.7	220	1.0
		50%	120.9	220	1.8
3	1661	95%	284.0	220	0.8
		50%	149.5	220	1.5
4	2127	95%	363.7	220	0.6
		50%	191.4	220	1.1
+ Backlog Area	2721	95%	465.3	220	0.5
		50%	244.9	220	0.9

Some possible solutions to this issue are:

(1) Direct injection of oxygen or ozone at the discharge point.

(2) Discharge into a manhole with organic material.

(3) Discharge directly at the treatment plant site.

The last option is feasible if the rising main discharged at the current treatment plant located on Commonage Road, near Biddles Road. However, this plant is earmarked for relocation to a site in Anniebrook within the next few years. The pumping distance to Anniebrook makes this solution not viable.

Costs have been calculated using present day dollars and current construction rates for similar works in this area.

Detailed costing sheets are attached as appendices to evaluate various alternatives.

4.3 Summary of Capital Costs

Table 6 gives a summary of capital costs of the various options. Detailed costings are provided in the Appendix. Costs are in today's dollars and based on current construction rates for similar works. Land component costs have been estimated by applying an estimate of cost per ha for variously sized parcels of land.

Table 6

Estimate Capital Cost of Various Options

No	Option	Total Capital Cost
A1	Treatment/Ocean Disposal	$ 4.27 mil
A2	Treatment/Stream Disposal	$ 2.21 mil
A3	Treatment/Infiltration Disposal	$ 2.82 mil
A4	Treatment/Wood Lot Disposal	$ 3.61 mil
B	Connection to Dunsborough	$ 2.70 mil

4.4 Operating and Maintenance Costs

For each of the options, we have estimated the operating and maintenance costs. Costs include an estimate of the cost of power consumption to operate pump stations and the treatment plants using current power tariffs. Also, an estimate of the cost of operating stand alone treatment plants has been made. For the Dunsborough connection option, we have assumed a treatment plant pro-rata operating cost. There is obviously economies of scale advantages to be had in operating costs for this option, as the operating costs is really a marginal extra over cost to deal with the increased numbers.

Table 7

Estimated Annual Operating and Maintenance Costs for Various Treatment Options at Full Development

COST TYPES	TREATMENT OPTIONS				
	OCEAN OUTFALL	STREAMFLOW	INFILTRATION	WOODLOT	DUNSBOROUGH
PUMP STATIONS					
Power	$10,000	$ 9,500	$23,500	$16,500	$25,000
Maintenance	$ 5,000	$ 5,000	$ 7,500	$ 6,000	$ 8,000
*TREATMENT PLANT					
Power, Maintenance and operation	$60,000	$60,000	$55,000	$50,000	$10,000
TOTAL OPERATION & MAINTENANCE COSTS/YR	$75,000	$70,000	$86,000	$73,500	$43,000

* Estimated from information regarding IDEA plants. Our Dunsborough solution estimated from a proportion (say 10%) of total costs (say $100,000).

4.5 Total Costs

In order to assess the total costs of each proposal, an economic life has to be assumed. We have chosen our economic life at 15 years to assess each proposal. Due to the low inflation environment, we have not included an allowance for this. At any rate, as this exercise is to judge the relative merits of each option, ignoring inflationary effects is unlikely to have any significant effect on the relativity of the solutions.

On Table 8, we have added together the capital cost of each solution with the estimated, operating and maintenance costs over a 15 year period to give total economic life costs.

This does not intimate that the assets require replacement after 15 years, rather it is an assumed time period in which to judge economic relativities.

Table 8
Total Costs of Various Treatment Options
– Capital Costs and Operating and Maintenance Costs Over 15 Years

COST TYPES	TREATMENT OPTIONS ($ mil)				
	OCEAN OUTFALL	STREAMFLOW	INFILTRATION	WOODLOT	DUNSBOROUGH
CAPITAL COST	$ 4.27	$ 2.21	$ 2.82	$ 3.61	$ 2.70
Operating and Maintenance Cost for 15 yrs	$ 1.12	$ 1.05	$ 1.29	$ 1.10	$ 0.65
TOTAL Economic Life Costs	$ 5.39	$ 3.26	$ 4.11	$ 4.71	$ 3.35
RANK	5	1	3	4	2

4.6 Conclusions

Table 8 indicates that in relative terms the most economical solutions are:

(a) Treatment plant and discharge to streamflow and;
(b) Connection to Dunsborough WWT System.

Total costs for both are approximately the same. From previous work carried out and detailed within this report, it seems likely that the option of discharging to a streamflow area is unlikely to gain environmental approval from the wider community, due to the negative public perception of this type of solution.

Therefore, at a similar total cost the connection to the Dunsborough sewerage system is favoured on economic grounds.

Appendix B presents further detailed information regarding capital costs and various treatment plant solutions and parameters.

5.0 CONCLUSIONS

Based on the information presented in this investigation it may be concluded that a number of options for the treatment and disposal of effluent generated by development at Smiths Beach are available, subject to more detailed site-specific investigations prior to implementation:

- connection to the Water Corporations new wastewater treatment plant at Anniebrook through existing and new sewerage infrastructure. This option may also allow the connection of the existing development at Smiths Beach, the Yallingup townsite and Caves House;

- establishment of a dedicated facility to serve both existing and new development at Smiths Beach via high quality effluent treatment with disposal to woodlot or vines at a number of potential sites located up to 8km from Smiths Beach; and

- establishment of a treatment plant and infiltration/groundwater recharge basins at a sand quarry nearing exhaustion at Vidler Road north of Smiths Beach, subject to detailed hydrogeological investigation.

The economic analysis indicates that the establishment of a high quality treatment plant with stream discharge and connection to the Dunsborough Wastewater Treatment Plant have similar cost and are the most economical of the options considered.

Based on the combined economic and environmental factors considered in this study, connection to the Dunsborough sewerage system is the favoured option.

6.0 REFERENCES

Department of Agriculture (Tille and Lantzke, 1990). Busselton Margaret River Augusta Land Capability Study. Land Resources Series No.5.

EPA (Environmental Protection Authority) (1993). Western Australian Water Quality Guidelines for Fresh and Marine Waters. Draft. EPA Bulletin 711.

NSWEPA (1995). Environmental Guidelines for Industry - The Utilisation of Treated Effluent in Industry. New South Wales Environment Protection Authority. Bankstown.

Tingay and Associates (1997). Environmental Appraisal and Environmental Management Plan - Tourist and Residential Development, Sussex Location 413, Smiths Beach. Draft.

Unkovich, I. (undated). Sludge Treatment and Disposal Considerations for Small Wastewater Treatment Plants. Water Corporation of Western Australia.

Western Australian Planning Commission (1997). Leeuwin-Naturaliste Ridge Statement of Planning Policy Report. Draft for Public Comment.

APPENDIX A

Modelling of Disposal Area Requirement

Rainfall Data													
Year	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Annual**
1904	7.90	2.50	74.70	48.50	91.40	181.60	96.00	108.70	49.00	69.60	23.60	9.40	762.90
1905	4.60	6.10	4.10	34.80	189.00	103.90	162.80	80.00	87.60	38.60	16.00	13.50	741.00
1906	14.70	14.50	23.90	19.80	158.80	169.20	152.40	98.80	110.00	24.90	4.30	1.80	793.10
1907	14.70	15.30	30.70	19.80	128.10	166.00	305.50	115.80	97.40	95.00	27.10	5.10	1020.50
1908	17.00	9.90	29.90	25.00	90.50	160.90	169.50	137.00	38.10	65.80	48.50	5.40	797.50
1909	0.50	3.40	34.40	45.00	135.30	227.40	156.10	156.10	86.50	41.60	10.00	1.10	897.40
1910	21.50	6.90	11.60	34.40	231.60	271.50	241.70	108.40	86.20	32.90	23.50	5.60	1075.80
1911	1.00	1.80	10.40	47.20	71.50	224.50	212.40	62.00	59.70	38.20	5.20	5.10	639.00
1912	7.10	7.50	10.10	4.40	78.00	186.30	300.60	103.70	115.50	39.10	10.90	32.60	895.80
1913	7.80	3.60	74.80	46.30	64.10	215.60	167.40	160.50	57.10	54.40	24.20	63.60	939.40
1914	0.80	29.00	1.90	28.00	82.30	133.20	200.70	58.00	27.10	80.30	75.00	7.20	723.50
1915	2.80	60.50	57.70	26.10	55.50	206.30	164.50	136.40	91.50	56.30	15.50	3.90	877.00
1916	23.80	7.90	6.60	48.50	126.00	93.60	162.50	132.10	10.20	80.20	58.00	2.50	751.90
1917	0.30	43.10	20.70	50.90	220.10	301.00	127.40	139.40	197.10	55.30	0.80	36.60	1192.70
1918	31.40	62.80	10.70	79.80	166.10	107.90	94.70	142.80	102.10	63.50	10.30	4.90	877.00
1919	18.10	2.90	4.10	15.60	78.20	69.70	242.20	74.30	49.40	49.60	20.20	2.90	627.20
1920	5.20	15.30	28.80	9.90	169.60	171.30	156.70	189.20	50.10	23.00	11.50	4.90	835.50
1921	2.30	107.90	23.30	31.30	226.70	224.90	128.00	137.70	60.40	76.30	38.80	17.80	1075.40
1922	2.30	5.10	25.30	35.90	79.40	123.80	331.70	111.00	68.90	43.50	26.70	33.10	886.70
1923	47.70	2.70	43.30	46.70	0.00	122.50	211.80	106.10	113.10	166.80	38.50	1.80	901.00
1924	4.00	8.10	7.40	3.60	127.40	142.70	106.20	111.10	95.90	106.90	25.00	0.60	738.90
1925	12.20	9.70	17.10	21.80	94.80	134.90	147.30	48.10	86.20	59.90	8.50	73.70	714.20
1926	1.00	20.20	22.40	154.10	156.20	123.40	196.50	104.70	88.60	82.20	22.80	8.40	980.50
1927	30.30	4.30	80.80	38.20	113.10	190.30	128.40	80.10	103.00	35.50	5.60	2.90	812.50
1928	27.80	6.40	1.60	25.70	93.30	134.30	164.30	143.40	111.90	85.70	6.40	16.10	816.90
1929	0.60	24.00	6.70	46.40	183.30	214.20	151.70	93.50	40.70	30.70	73.00	9.10	873.90
1930	0.80	2.30	4.90	29.40	71.60	262.80	158.30	55.10	66.80	47.90	25.40	9.30	734.60
1931	5.60	5.30	12.20	43.40	78.20	97.00	160.60	143.00	101.90	40.50	1.30	5.30	694.30
1932	7.60	0.30	41.10	32.30	173.70	244.60	188.00	116.00	42.70	52.40	9.90	1.60	910.20
1933	11.20	2.60	34.90	24.10	100.10	220.10	128.80	141.10	73.00	116.80	5.60	2.80	861.10
1934	13.90	5.40	66.70	40.40	119.40	227.30	181.00	108.00	79.20	43.60	22.50	19.10	926.50
1935	6.20	22.20	2.50	26.80	65.20	159.00	217.00	107.60	100.30	56.20	13.00	8.40	784.40
1936	14.30	1.00	7.90	26.20	97.60	168.70	124.90	128.00	48.10	33.90	13.00	0.80	664.40
1937	1.60	8.50	7.10	69.10	148.80	170.00	93.20	120.80	65.40	33.60	11.50	12.40	742.00

1938	1.30	16.50	28.70	32.20	111.60	85.70	161.50	110.80	69.20	51.20	25.60	14.40	708.70
1939	13.00	24.00	0.60	23.70	127.60	214.40	205.90	173.50	21.30	57.50	36.90	2.50	900.90
1940	10.20	3.90	5.30	25.00	91.80	128.90	153.20	57.50	53.50	51.40	15.20	14.90	610.80
1941	1.20	10.70	24.40	76.00	113.40	220.00	158.00	99.50	77.20	39.40	31.50	4.60	855.90
1942	2.10	6.60	49.20	84.00	165.50	242.70	131.80	105.70	100.40	48.80	6.30	6.50	949.60
1943	15.30	1.90	93.80	98.10	73.00	143.10	119.70	91.10	97.70	15.80	8.50	5.90	763.90
1944	1.40	0.80	8.70	34.30	89.60	163.60	144.40	90.00	46.30	33.80	54.50	52.20	719.60
1945	5.90	4.90	31.50	35.40	131.90	229.70	165.50	162.40	116.80	24.70	21.50	23.50	953.70
1946	3.20	2.60	17.00	53.90	103.10	179.40	194.50	63.80	35.60	14.50	47.20	24.90	739.70
1947	2.60	13.70	10.30	101.20	176.00	214.40	135.60	75.80	71.30	96.70	13.30	24.90	935.80
1948	4.40	0.00	9.00	43.60	44.50	119.30	174.80	106.20	87.90	29.70	33.70	26.30	679.40
1949	4.80	0.00	28.70	128.60	41.20	108.70	164.80	151.30	71.60	73.00	28.70	0.00	801.40
1950	11.50	2.60	0.80	16.60	174.20	178.30	150.00	95.20	92.40	40.80	42.40	16.10	820.90
1951	25.40	38.70	3.60	109.70	80.10	222.40	83.00	185.30	67.00	46.00	29.90	23.80	914.90
1952	5.30	1.30	24.40	5.70	162.70	174.80	267.10	123.60	57.90	49.00	22.10	8.20	902.10
1953	3.60	22.30	2.10	18.30	110.50	267.50	84.20	58.50	39.40	134.50	24.80	4.60	770.30
1954	8.90	2.80	7.80	33.30	112.90	76.00	156.90	68.80	43.70	54.90	42.40	14.30	622.70
1955	8.70	26.90	1.50	70.60	103.00	115.70	143.20	222.10	67.10	83.90	10.10	19.70	872.50
1956	0.00	0.80	57.80	28.70	209.40	178.90	141.30	42.00	66.40	24.70	25.90	12.30	788.20
1957	2.60	1.00	53.80	80.30	127.00	264.10	86.60	131.50	39.40	32.40	3.90	3.80	826.40
1958	30.60	4.90	3.00	19.00	110.30	97.90	248.60	121.30	31.00	36.70	24.40	3.90	731.60
1959	6.40	3.90	6.40	35.90	35.40	184.80	95.60	62.70	35.60	53.60	37.90	24.70	582.90
1960	58.50	9.40	70.20	34.90	128.80	90.80	180.20	103.30	64.40	17.00	3.90	17.10	778.50
1961	3.90	11.70	38.50	187.60	66.00	188.70	131.60	98.00	54.00	24.50	17.60	15.60	837.70
1962	0.30	3.90	4.30	20.30	147.00	104.80	156.00	155.80	73.50	62.70	43.60	41.50	813.70
1963	24.10	7.70	5.30	52.20	220.30	180.50	213.40	186.30	59.90	54.30	11.00	1.90	1016.90
1964	0.80	8.30	8.60	55.80	45.90	311.20	243.20	168.50	59.50	97.60	20.40	40.60	1060.40
1965	8.60	1.80	120.40	69.30	110.50	167.70	146.70	133.80	71.20	143.20	78.90	57.40	1109.50
1966	6.10	6.80	8.50	48.80	79.60	232.90	211.20	114.50	92.00	36.80	13.60	19.80	870.60
1967	1.00	11.60	19.80	62.20	137.70	306.10	189.20	152.40	56.10	42.70	23.40	38.90	1041.10
1968	35.40	2.00	45.40	62.4	79.3	227.9	173.5	133.8	105.6	69.3	9.8	3	947.40
1969	2.6	0	16.1	94	127	155.4	104.2	75.2	14.5	3.8	47.5	8.70	649.00
1970	2.5	50.1	6.3	71.7	82.5	310.5	176.2	109.1	111.7	43.5	23.9	2.60	990.60
1971	15.5	8.4	68.1	30.7	164.5	92.6	128.7	79.5	130.2	86.8	26	5.90	836.90
1972	3.8	0	16.7	48.5	84.1	127.7	167.3	197.6	86.8	57.9	5.6	0.80	796.80
1973	10.9	3.6	1.5	130.1	149.6	253.6	219.3	147.9	132.3	51.9	22.3	3.30	1126.30

1974	28.4	13.4	0.2	72	282.8	167.9	283.5	117.6	38.9	64.9	16.9	3.40	1089.90
1975	0	0	36	21	135.2	177.4	271.4	78.1	97.5	86.8	25.2	3.20	931.80
1976	64.4	2.4	1	53	102.6	67.6	118.2	114.8	88	51	64	11.90	738.90
1977	8.6	3.4	14.8	4.2	133	125.4	123.6	93.4	49.8	86.8	12.2	3.00	658.20
1978	2	22	11.4	18.8	179.8	179.8	133.8	49	136.8	35	28.8	23.00	820.20
1979	4.4	20.4	18	59.2	114.4	156.6	84.4	92	62.8	56.4	60.6	5.00	729.20
1980	0	13.8	6.2	94.6	83.8	229.6	273.8	104.6	65.8	47.2	45	21.20	985.60
1981	0	1.6	18.5	41.4	155.6	157.4	118.8	119.2	74.8	37.4	74.2	17.60	816.50
1982	54	7.2	6.6	0	54	204.4	189.4	49.2	104.4	43.2	17.6	14.80	744.80
1983	11.4	31.2	1.6	22.6	52.8	196.4	165	218	102.4	22.6	22.2	21.80	868.00
1984	1	4.4	20	33.2	161.2	144.8	131.2	112	81.2	43.4	53.8	21.60	807.80
1985	2.6	0	1	84.2	65.4	153.8	103.4	153.8	83.2	37.8	36.8	13.60	735.60
1986	4.2	20	42.6	15.8	210.6	112.8	252.8	145.4	66.2	38	15.8	0.60	924.80
1987	7.6	0	29	52.4	85.6	196.4	119.4	55.4	61.2	29	34	6.90	676.90
1988	11.6	6.6	12	25.2	125.4	256.6	136.2	188.6	114.4	39.4	42.2	0.60	958.80
1989	20.2	64.6	8.4	35	82.8	102.4	185.4	97	87.4	123.6	5.4	15.20	827.40
1990	16.2	25.6	52	112.4	116	61.4	325.4	119.6	80.6	76.4	20.2	3.80	1009.60
1991	6.2	14.4	4.6	42.2	177.8	245.8	154.2	117.2	89	24.4	67	2.40	945.20
1992	0.60	19.20	70.00	21.60	96.30	208.40	133.00	204.70	68.20	15.80	81.20	8.40	927.40
1993	2.20	0.20	26.20	17.40	80.40	100.70	142.40	85.40	90.80	30.20	11.80	1.80	589.50

Evaporation													
Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1904	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1905	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1906	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1907	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1908	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1909	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1910	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1911	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1912	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1913	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1914	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1915	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1916	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1917	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1918	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1919	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1920	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1921	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1922	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1923	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1924	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1925	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1926	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1927	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1928	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1929	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1930	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1931	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1932	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1933	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1934	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1935	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1936	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1937	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30

1938	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1939	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1940	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1941	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1942	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1943	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1944	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1945	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1946	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1947	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1948	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1949	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1950	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1951	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1952	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1953	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1954	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1955	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1956	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1957	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1958	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1959	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1960	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1961	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1962	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1963	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1964	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1965	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1966	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1967	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1968	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1969	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1970	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1971	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1972	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1973	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30

1974	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1975	186.70	156.50	132.60	77.30	50.60	42.70	44.20	54.20	68.80	95.30	127.00	167.40	1203.30
1976	182.40	161.00	140.40	78.20	44.50	35.60	43.60	55.10	70.40	99.20	124.80	169.80	1205.00
1977	194.80	175.80	133.20	87.40	50.00	38.00	42.60	60.00	64.40	96.40	124.40	174.40	1241.40
1978	161.00	162.20	114.00	83.00	57.80	36.60	44.80	47.00	68.00	99.00	151.00	163.60	1188.00
1979	177.60	140.00	119.20	72.20	51.80	39.40	44.60	51.60	74.60	118.40	129.00	193.20	1211.60
1980	222.20	165.40	143.60	71.00	51.20	39.70	50.10	67.00	69.40	99.00	140.30	175.00	1293.90
1981	230.00	172.20	140.70	61.10	49.30	43.20	47.80	64.90	70.60	112.00	117.90	180.60	1290.30
1982	167.30	153.80	114.10	67.00	51.10	50.50	46.20	57.00	60.90	109.40	113.90	159.80	1151.00
1983	214.80	119.90	134.40	76.40	55.70	44.40	40.00	61.20	78.40	95.40	141.60	184.20	1246.40
1984	204.40	175.70	131.10	88.30	46.50	31.80	38.70	42.40	60.80	94.40	106.10	134.50	1154.70
1985	160.00	169.40	131.40	74.00	40.50	44.40	37.40	61.80	77.20	90.20	127.00	141.80	1155.10
1986	204.10	126.50	119.60	70.90	46.40	35.80	37.80	38.10	52.90	94.60	135.80	162.80	1125.30
1987	180.70	180.80	140.00	80.80	43.80	41.40	43.80	52.00	78.40	96.80	141.00	163.90	1243.40
1988	180.50	204.00	155.00	93.80	50.60	47.20	41.60	56.30	78.40	87.80	137.40	185.80	1318.40
1989	172.40	154.60	143.20	79.60	53.00	43.00	44.40	64.50	72.00	85.00	130.60	161.40	1203.70
1990	164.00	133.20	112.80	66.20	46.40	42.50	49.80	49.40	62.50	82.20	118.70	151.00	1078.70
1991	172.20	141.50	125.30	80.20	52.50	40.30	42.70	53.80	71.00	94.20	111.90	158.40	1144.00
1992	186.60	143.40	125.40	73.60	51.90	48.60	47.80	50.20	61.90	92.60	117.60	150.60	1150.20
1993	179.20	154.80	112.90	63.80	43.80	40.20	44.00	57.80	76.00	91.50	124.20	182.60	1170.80

Evapotranspiration and Percolation													
Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1904	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1905	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1906	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1907	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1908	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1909	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1910	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1911	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1912	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1913	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1914	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1915	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1916	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1917	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1918	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1919	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1920	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1921	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1922	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1923	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1924	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1925	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1926	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1927	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1928	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1929	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1930	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1931	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1932	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1933	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1934	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1935	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1936	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1937	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64

1938	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1939	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1940	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1941	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1942	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1943	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1944	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1945	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1946	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1947	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1948	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1949	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1950	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1951	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1952	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1953	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1954	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1955	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1956	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1957	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1958	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1959	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1960	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1961	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1962	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1963	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1964	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1965	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1966	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1967	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1968	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1969	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1970	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1971	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1972	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1973	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64

1974	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1975	149.36	125.20	106.08	61.84	60.48	54.16	55.36	63.36	75.04	76.24	101.60	133.92	1062.64
1976	145.92	128.80	112.32	62.56	55.60	48.48	54.88	64.08	76.32	79.36	99.84	135.84	1064.00
1977	155.84	140.64	106.56	69.92	60.00	50.40	54.08	68.00	71.52	77.12	99.52	139.52	1093.12
1978	128.80	129.76	91.20	66.40	66.24	49.28	55.84	57.60	74.40	79.20	120.80	130.88	1050.40
1979	142.08	112.00	95.36	57.76	61.44	51.52	55.68	61.28	79.68	94.72	103.20	154.56	1069.28
1980	177.76	132.32	114.88	56.80	60.96	51.76	60.08	73.60	75.52	79.20	112.24	140.00	1135.12
1981	184.00	137.76	112.56	48.88	59.44	54.56	58.24	71.92	76.48	89.60	94.32	144.48	1132.24
1982	133.84	123.04	91.28	53.60	60.88	60.40	56.96	65.60	68.72	87.52	91.12	127.84	1020.80
1983	171.84	95.92	107.52	61.12	64.56	55.52	52.00	68.96	82.72	76.32	113.28	147.36	1097.12
1984	163.52	140.56	104.88	70.64	57.20	45.44	50.96	53.92	68.64	75.52	84.88	107.60	1023.76
1985	128.00	135.52	105.12	59.20	52.40	55.52	49.92	69.44	81.76	72.16	101.60	113.44	1024.08
1986	163.28	101.20	95.68	56.72	57.12	48.64	50.24	50.48	62.32	75.68	108.64	130.24	1000.24
1987	144.56	144.64	112.00	64.64	55.04	53.12	55.04	61.60	82.72	77.44	112.80	131.12	1094.72
1988	144.40	163.20	124.00	75.04	60.48	57.76	53.28	65.04	82.72	70.24	109.92	148.64	1154.72
1989	137.92	123.68	114.56	63.68	62.40	54.40	55.52	71.60	77.60	68.00	104.48	129.12	1062.96
1990	131.20	106.56	90.24	52.96	57.12	54.00	59.84	59.52	70.00	65.76	94.96	120.80	962.96
1991	137.76	113.20	100.24	64.16	62.00	52.24	54.16	63.04	76.80	75.36	89.52	126.72	1015.20
1992	149.28	114.72	100.32	58.88	61.52	58.88	58.24	60.16	69.52	74.08	94.08	120.48	1020.16
1993	143.36	123.84	90.32	51.04	55.04	52.16	55.20	66.24	80.80	73.20	99.36	146.08	1036.64

Hydraulic Loading													
Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1904	141.46	122.70	31.38	13.34	0.00	0.00	0.00	0.00	26.04	6.64	78.00	124.52	544.08
1905	144.76	119.10	101.98	27.04	0.00	0.00	0.00	0.00	0.00	37.64	85.60	120.42	636.54
1906	134.66	110.70	82.18	42.04	0.00	0.00	0.00	0.00	0.00	51.34	97.30	132.12	650.34
1907	134.66	109.90	75.38	42.04	0.00	0.00	0.00	0.00	0.00	0.00	74.50	128.82	565.30
1908	132.36	115.30	76.18	36.84	0.00	0.00	0.00	0.00	36.94	10.44	53.10	128.52	589.68
1909	148.86	121.80	71.68	16.84	0.00	0.00	0.00	0.00	0.00	34.64	91.60	132.82	618.24
1910	127.86	118.30	94.48	27.44	0.00	0.00	0.00	0.00	0.00	43.34	78.10	128.32	617.84
1911	148.36	123.40	95.68	14.64	0.00	0.00	0.00	1.36	15.34	38.04	96.40	128.82	662.04
1912	142.26	117.70	95.98	57.44	0.00	0.00	0.00	0.00	0.00	37.14	90.70	101.32	642.54
1913	141.56	121.60	31.28	15.54	0.00	0.00	0.00	0.00	17.94	21.84	77.40	70.32	497.48
1914	148.56	96.20	104.18	33.84	0.00	0.00	0.00	5.36	47.94	0.00	26.60	126.72	589.40
1915	146.56	64.70	48.38	35.74	4.98	0.00	0.00	0.00	0.00	19.94	86.10	130.02	536.42
1916	125.56	117.30	99.48	13.34	0.00	0.00	0.00	0.00	64.84	0.00	43.60	131.42	595.54
1917	149.06	82.10	85.38	10.94	0.00	0.00	0.00	0.00	0.00	20.94	100.80	97.32	546.54
1918	117.96	62.40	95.38	0.00	0.00	0.00	0.00	0.00	0.00	12.74	91.30	129.02	508.80
1919	131.26	122.30	101.98	46.24	0.00	0.00	0.00	0.00	25.64	26.64	81.40	131.02	666.48
1920	144.16	109.90	77.28	51.94	0.00	0.00	0.00	0.00	24.94	53.24	90.10	129.02	680.58
1921	147.06	17.30	82.78	30.54	0.00	0.00	0.00	0.00	14.64	0.00	62.80	116.12	471.24
1922	147.06	120.10	80.78	25.94	0.00	0.00	0.00	0.00	6.14	32.74	74.90	100.82	588.48
1923	101.66	122.50	62.78	15.14	60.48	0.00	0.00	0.00	0.00	0.00	63.10	132.12	557.78
1924	145.36	117.10	98.68	58.24	0.00	0.00	0.00	0.00	0.00	0.00	76.60	133.32	629.30
1925	137.16	115.50	88.98	40.04	0.00	0.00	0.00	15.26	0.00	16.34	93.10	60.22	566.60
1926	148.36	105.00	83.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.80	125.52	541.36
1927	119.06	120.90	25.28	23.64	0.00	0.00	0.00	0.00	0.00	40.74	96.00	131.02	556.64
1928	121.56	118.80	104.48	36.14	0.00	0.00	0.00	0.00	0.00	0.00	95.20	117.82	594.00
1929	148.76	101.20	99.38	15.44	0.00	0.00	0.00	0.00	34.34	45.54	28.60	124.82	598.08
1930	148.56	122.90	101.18	32.44	0.00	0.00	0.00	8.26	8.24	28.34	76.20	124.62	650.74
1931	143.76	119.90	93.88	18.44	0.00	0.00	0.00	0.00	0.00	35.74	100.30	128.62	640.64
1932	141.76	124.90	64.98	29.54	0.00	0.00	0.00	0.00	32.34	23.84	91.70	132.32	641.38
1933	138.16	122.60	71.18	37.74	0.00	0.00	0.00	0.00	2.04	0.00	96.00	131.12	598.84
1934	135.46	119.80	39.38	21.44	0.00	0.00	0.00	0.00	0.00	32.64	79.10	114.82	542.64
1935	143.16	103.00	103.58	35.04	0.00	0.00	0.00	0.00	0.00	20.04	88.60	125.52	618.94
1936	135.06	124.20	98.18	35.64	0.00	0.00	0.00	0.00	26.94	42.34	88.60	133.12	684.08
1937	147.76	116.70	98.98	0.00	0.00	0.00	0.00	0.00	9.64	42.64	90.10	121.52	627.34

1938	148.06	108.70	77.38	29.64	0.00	0.00	0.00	0.00	5.84	25.04	76.00	119.52	590.18
1939	136.36	101.20	105.48	38.14	0.00	0.00	0.00	0.00	53.74	18.74	64.70	131.42	649.78
1940	139.16	121.30	100.78	36.84	0.00	0.00	0.00	5.86	21.54	24.84	86.40	119.02	655.74
1941	148.16	114.50	81.68	0.00	0.00	0.00	0.00	0.00	0.00	36.84	70.10	129.32	580.60
1942	147.26	118.60	56.88	0.00	0.00	0.00	0.00	0.00	0.00	27.44	95.30	127.42	572.90
1943	134.06	123.30	12.28	0.00	0.00	0.00	0.00	0.00	0.00	60.44	93.10	128.02	551.20
1944	147.96	124.40	97.38	27.54	0.00	0.00	0.00	0.00	28.74	42.44	47.10	81.72	597.28
1945	143.46	120.30	74.58	26.44	0.00	0.00	0.00	0.00	0.00	51.54	80.10	110.42	606.84
1946	146.16	122.60	89.08	7.94	0.00	0.00	0.00	0.00	39.44	61.74	54.40	109.02	630.38
1947	146.76	111.50	95.78	0.00	0.00	0.00	0.00	0.00	3.74	0.00	88.30	109.02	555.10
1948	144.96	125.20	97.08	18.24	15.98	0.00	0.00	0.00	0.00	46.54	67.90	107.62	623.52
1949	144.56	125.20	77.38	0.00	19.28	0.00	0.00	0.00	3.44	3.24	72.90	133.92	579.92
1950	137.86	122.60	105.28	45.24	0.00	0.00	0.00	0.00	0.00	35.44	59.20	117.82	623.44
1951	123.96	86.50	102.48	0.00	0.00	0.00	0.00	0.00	8.04	30.24	71.70	110.12	533.04
1952	144.06	123.90	81.68	56.14	0.00	0.00	0.00	0.00	17.14	27.24	79.50	125.72	655.38
1953	145.76	102.90	103.98	43.54	0.00	0.00	0.00	4.86	35.64	0.00	76.80	129.32	642.80
1954	140.46	122.40	98.28	28.54	0.00	0.00	0.00	0.00	31.34	21.34	59.20	119.62	621.18
1955	140.66	98.30	104.58	0.00	0.00	0.00	0.00	0.00	7.94	0.00	91.50	114.22	557.20
1956	149.36	124.40	48.28	33.14	0.00	0.00	0.00	21.36	8.64	51.54	75.70	121.62	634.04
1957	146.76	124.20	52.28	0.00	0.00	0.00	0.00	0.00	35.64	43.84	97.70	130.12	630.54
1958	118.76	120.30	103.08	42.84	0.00	0.00	0.00	0.00	44.04	39.54	77.20	130.02	675.78
1959	142.96	121.30	99.68	25.94	25.08	0.00	0.00	0.66	39.44	22.64	63.70	109.22	650.62
1960	90.86	115.80	35.88	26.94	0.00	0.00	0.00	0.00	10.64	59.24	97.70	116.82	553.88
1961	145.46	113.50	67.58	0.00	0.00	0.00	0.00	0.00	21.04	51.74	84.00	118.32	601.64
1962	149.06	121.30	101.78	41.54	0.00	0.00	0.00	0.00	1.54	13.54	58.00	92.42	579.18
1963	125.26	117.50	100.78	9.64	0.00	0.00	0.00	0.00	15.14	21.94	90.60	132.02	612.88
1964	148.56	116.90	97.48	6.04	14.58	0.00	0.00	0.00	15.54	0.00	81.20	93.32	573.62
1965	140.76	123.40	0.00	0.00	0.00	0.00	0.00	0.00	3.84	0.00	22.70	76.52	367.22
1966	143.26	118.40	97.58	13.04	0.00	0.00	0.00	0.00	0.00	39.44	88.00	114.12	613.84
1967	148.36	113.60	86.28	0.00	0.00	0.00	0.00	0.00	18.94	33.54	78.20	95.02	573.94
1968	113.96	123.20	60.68	0.00	0.00	0.00	0.00	0.00	0.00	6.94	91.80	130.92	527.50
1969	146.76	125.20	89.98	0.00	0.00	0.00	0.00	0.00	60.54	72.44	54.10	125.22	674.24
1970	146.86	75.10	99.78	0.00	0.00	0.00	0.00	0.00	0.00	32.74	77.70	131.32	563.50
1971	133.86	116.80	37.98	31.14	0.00	0.00	0.00	0.00	0.00	0.00	75.60	128.02	523.40
1972	145.56	125.20	89.38	13.34	0.00	0.00	0.00	0.00	0.00	18.34	96.00	133.12	620.94
1973	138.46	121.60	104.58	0.00	0.00	0.00	0.00	0.00	0.00	24.34	79.30	130.62	598.90

1974	120.96	111.80	105.88	0.00	0.00	0.00	0.00	0.00	36.14	11.34	84.70	130.52	601.34
1975	149.36	125.20	70.08	40.84	0.00	0.00	0.00	0.00	0.00	0.00	76.40	130.72	592.60
1976	81.52	126.40	111.32	9.56	0.00	0.00	0.00	0.00	0.00	28.36	35.84	123.94	516.94
1977	147.24	137.24	91.76	65.72	0.00	0.00	0.00	0.00	21.72	0.00	87.32	136.52	687.52
1978	126.80	107.76	79.80	47.60	0.00	0.00	0.00	8.60	0.00	44.20	92.00	107.88	614.64
1979	137.68	91.60	77.36	0.00	0.00	0.00	0.00	0.00	16.88	38.32	42.60	149.56	554.00
1980	177.76	118.52	108.68	0.00	0.00	0.00	0.00	0.00	9.72	32.00	67.24	118.80	632.72
1981	184.00	136.16	94.06	7.48	0.00	0.00	0.00	0.00	1.68	52.20	20.12	126.88	622.58
1982	79.84	115.84	84.68	53.60	6.88	0.00	0.00	16.40	0.00	44.32	73.52	113.04	588.12
1983	160.44	64.72	105.92	38.52	11.76	0.00	0.00	0.00	0.00	53.72	91.08	125.56	651.72
1984	162.52	136.16	84.88	37.44	0.00	0.00	0.00	0.00	0.00	32.12	31.08	86.00	570.20
1985	125.40	135.52	104.12	0.00	0.00	0.00	0.00	0.00	0.00	34.36	64.80	99.84	564.04
1986	159.08	81.20	53.08	40.92	0.00	0.00	0.00	0.00	0.00	37.68	92.84	129.64	594.44
1987	136.96	144.64	83.00	12.24	0.00	0.00	0.00	6.20	21.52	48.44	78.80	124.22	656.02
1988	132.80	156.60	112.00	49.84	0.00	0.00	0.00	0.00	0.00	30.84	67.72	148.04	697.84
1989	117.72	59.08	106.16	28.68	0.00	0.00	0.00	0.00	0.00	0.00	99.08	113.92	524.64
1990	115.00	80.96	38.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74.76	117.00	425.96
1991	131.56	98.80	95.64	21.96	0.00	0.00	0.00	0.00	0.00	50.96	22.52	124.32	545.76
1992	148.68	95.52	30.32	37.28	0.00	0.00	0.00	0.00	1.32	58.28	12.88	112.08	496.36
1993	141.16	123.64	64.12	33.64	0.00	0.00	0.00	0.00	0.00	43.00	87.56	144.28	637.40
											90 Percentile:		**527.21**
Daily Effluent Generation (m^3)			**Yearly Effluent Generation (m^3)**				**EP**		**EP Generation (L)**		**Percolation (mm)**		
	455.76			165896.64			2532.00		180.00		20.00		
					Monthly Effluent Generation (fraction)								
Days/mon	31.00	29.00	30.00	30.00	31.00	29.00	31.00	31.00	30.00	31.00	30.00	31.00	364.00
Fraction	0.09	0.08	0.08	0.08	0.09	0.08	0.09	0.09	0.08	0.09	0.08	0.09	1.00

Storage Requirements													
Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1904	0.00	0.00	12.07	42.18	87.08	129.09	173.99	218.89	236.30	274.56	240.01	160.39	274.56
1905	60.53	0.00	0.00	16.41	61.31	103.32	148.22	193.12	236.57	243.83	201.68	126.16	243.83
1906	36.40	0.00	0.00	1.41	46.31	88.32	133.22	178.12	221.57	215.13	161.28	74.06	221.57
1907	0.00	0.00	0.00	1.41	46.31	88.32	133.22	178.12	221.57	266.47	235.42	151.50	266.47
1908	64.04	0.00	0.00	6.61	51.51	93.52	138.42	183.32	189.83	224.29	214.64	131.02	224.29
1909	27.06	0.00	0.00	26.61	71.51	113.52	158.42	203.32	246.77	257.03	208.88	120.96	257.03
1910	38.00	0.00	0.00	16.01	60.91	102.92	147.82	192.72	236.17	237.73	203.08	119.66	237.73
1911	16.20	0.00	0.00	28.81	73.71	115.72	160.62	204.16	232.27	239.13	186.18	102.26	239.13
1912	4.90	0.00	0.00	0.00	44.90	86.90	131.80	176.70	220.16	227.92	180.67	124.25	227.92
1913	27.59	0.00	12.17	40.08	84.98	126.99	171.89	216.79	242.30	265.36	231.41	205.99	265.36
1914	102.33	48.13	0.00	9.61	54.51	96.52	141.42	180.96	176.47	221.37	238.22	156.40	238.22
1915	54.74	32.04	27.11	34.83	74.75	116.75	161.65	206.55	250.00	274.96	232.31	147.19	274.96
1916	66.53	0.00	0.00	30.11	75.01	117.02	161.92	206.82	185.43	230.33	230.18	143.66	230.33
1917	39.50	0.00	0.00	32.51	77.41	119.42	164.32	209.22	252.67	276.63	219.28	166.86	276.63
1918	93.80	73.40	21.47	64.93	109.83	151.83	196.73	241.63	285.08	317.24	269.39	185.27	317.24
1919	98.91	18.62	0.00	0.00	44.90	86.90	131.80	176.70	194.52	212.78	174.83	88.71	212.78
1920	0.00	0.00	0.00	0.00	44.90	86.90	131.80	176.70	195.22	186.88	140.23	56.11	195.22
1921	0.00	24.70	0.00	12.91	57.81	99.82	144.72	189.62	218.43	263.33	243.98	172.76	263.33
1922	70.60	0.00	0.00	17.51	62.41	104.42	149.32	194.22	231.53	243.69	212.24	156.32	243.69
1923	99.56	19.06	0.00	28.31	12.73	54.74	99.64	144.54	187.99	232.89	213.24	126.02	232.89
1924	25.56	0.00	0.00	0.00	44.90	86.90	131.80	176.70	220.16	265.06	231.91	143.49	265.06
1925	51.23	0.00	0.00	3.41	48.31	90.32	135.22	164.86	208.31	236.87	187.22	171.90	236.87
1926	68.44	5.44	0.00	43.45	88.35	130.36	175.26	220.16	263.61	308.51	273.16	192.54	308.51
1927	118.38	39.48	57.65	77.47	122.37	164.37	209.27	254.17	297.62	301.78	249.23	163.11	301.78
1928	86.45	9.66	0.00	7.31	52.21	94.22	139.12	184.02	227.47	272.37	220.62	147.70	272.37
1929	43.84	0.00	0.00	28.01	72.91	114.92	159.82	204.72	213.83	213.19	228.04	148.12	228.04
1930	44.46	0.00	0.00	11.01	55.91	97.92	142.82	179.46	214.67	231.23	198.48	118.76	231.23
1931	19.90	0.00	0.00	25.01	69.91	111.92	156.82	201.72	245.17	254.33	197.48	113.76	254.33
1932	16.90	0.00	0.00	13.91	58.81	100.82	145.72	190.62	201.73	222.79	174.54	87.12	222.79
1933	0.00	0.00	0.00	5.71	50.61	92.62	137.52	182.42	223.83	268.73	216.18	129.96	268.73
1934	39.40	0.00	4.07	26.08	70.98	112.99	157.89	202.79	246.24	258.50	222.85	152.93	258.50
1935	54.67	0.00	0.00	8.41	53.31	95.32	140.22	185.12	228.57	253.43	208.28	127.66	253.43
1936	37.50	0.00	0.00	7.81	52.71	94.72	139.62	184.52	201.03	203.59	158.44	70.22	203.59
1937	0.00	0.00	0.00	43.45	88.35	130.36	175.26	220.16	253.97	256.23	209.58	132.96	256.23

1938	29.80	0.00	0.00	13.81	58.71	100.72	145.62	190.52	228.13	247.99	215.44	140.82	247.99
1939	49.36	0.00	0.00	5.31	50.21	92.22	137.12	182.02	171.73	197.89	176.64	90.12	197.89
1940	0.00	0.00	0.00	6.61	51.51	93.52	138.42	177.46	199.37	219.43	176.48	102.36	219.43
1941	0.00	0.00	0.00	43.45	88.35	130.36	175.26	220.16	263.61	271.67	245.02	160.60	271.67
1942	58.24	0.00	0.00	43.45	88.35	130.36	175.26	220.16	263.61	281.07	229.22	146.70	281.07
1943	57.54	0.00	31.17	74.62	119.52	161.53	206.43	251.33	294.78	279.24	229.59	146.47	294.78
1944	43.41	0.00	0.00	15.91	60.81	102.82	147.72	192.62	207.33	209.79	206.14	169.32	209.79
1945	70.76	0.00	0.00	17.01	61.91	103.92	148.82	193.72	237.17	230.53	193.88	128.36	237.17
1946	27.10	0.00	0.00	35.51	80.41	122.42	167.32	212.22	216.23	199.39	188.44	124.32	216.23
1947	22.46	0.00	0.00	43.45	88.35	130.36	175.26	220.16	259.87	304.77	259.92	195.80	304.77
1948	95.74	12.54	0.00	25.21	54.13	96.14	141.04	185.94	229.39	227.75	203.30	140.58	229.39
1949	40.92	0.00	0.00	43.45	69.07	111.08	155.98	200.88	240.89	282.55	253.10	164.08	282.55
1950	71.12	0.00	0.00	0.00	44.90	86.90	131.80	176.70	220.16	229.62	213.87	140.95	229.62
1951	61.89	17.39	0.00	43.45	88.35	130.36	175.26	220.16	255.57	270.23	241.98	176.76	270.23
1952	77.60	0.00	0.00	0.00	44.90	86.90	131.80	176.70	203.02	220.68	184.63	103.81	220.68
1953	2.95	0.00	0.00	0.00	44.90	86.90	131.80	171.84	179.66	224.56	191.21	106.79	224.56
1954	11.23	0.00	0.00	14.91	59.81	101.82	146.72	191.62	203.73	227.29	211.54	136.82	227.29
1955	41.06	0.00	0.00	43.45	88.35	130.36	175.26	220.16	255.67	300.57	252.52	183.20	300.57
1956	78.74	0.00	0.00	10.31	55.21	97.22	142.12	165.66	200.47	193.83	161.58	84.86	200.47
1957	0.00	0.00	0.00	43.45	88.35	130.36	175.26	220.16	227.97	229.03	174.78	89.56	229.03
1958	15.70	0.00	0.00	0.61	45.51	87.52	132.42	177.32	176.73	182.09	148.34	63.22	182.09
1959	0.00	0.00	0.00	17.51	37.33	79.34	124.24	168.48	172.49	194.75	174.50	110.18	194.75
1960	64.22	0.00	7.57	24.08	68.98	110.99	155.89	200.79	233.60	219.26	165.01	93.09	233.60
1961	0.00	0.00	0.00	43.45	88.35	130.36	175.26	220.16	242.57	235.73	195.18	121.76	242.57
1962	17.60	0.00	0.00	1.91	46.81	88.82	133.72	178.62	220.53	251.89	237.34	189.82	251.89
1963	109.46	33.96	0.00	33.81	78.71	120.72	165.62	210.52	238.83	261.79	214.64	127.52	261.79
1964	23.86	0.00	0.00	37.41	67.73	109.74	154.64	199.54	227.45	272.35	234.60	186.18	272.35
1965	90.32	8.92	52.37	95.83	140.73	182.73	227.63	272.53	312.14	357.04	377.79	346.17	377.79
1966	247.81	171.42	117.29	147.70	192.60	234.60	279.50	324.40	367.86	373.32	328.77	259.55	373.32
1967	156.09	84.49	41.66	85.11	130.01	172.02	216.92	261.82	286.33	297.69	262.94	212.82	297.69
1968	143.76	62.56	45.34	88.79	133.69	175.69	220.59	265.49	308.94	346.90	298.55	212.53	346.90
1969	110.67	27.48	0.00	43.45	88.35	130.36	175.26	220.16	203.07	175.53	164.88	84.56	220.16
1970	0.00	0.00	0.00	43.45	88.35	130.36	175.26	220.16	263.61	275.77	241.52	155.10	275.77
1971	66.14	0.00	5.47	17.78	62.68	104.69	149.59	194.49	237.94	282.84	250.69	167.57	282.84
1972	66.91	0.00	0.00	30.11	75.01	117.02	161.92	206.82	250.27	276.83	224.28	136.06	276.83
1973	42.50	0.00	0.00	43.45	88.35	130.36	175.26	220.16	263.61	284.17	248.32	162.60	284.17

1974	86.54	16.74	0.00	43.45	88.35	130.36	175.26	220.16	227.47	261.03	219.78	134.16	261.03
1975	29.70	0.00	0.00	2.61	47.51	89.52	134.42	179.32	222.77	267.67	234.72	148.90	267.67
1976	112.28	27.88	0.00	33.89	78.79	120.80	165.70	210.60	254.05	270.59	278.20	199.16	278.20
1977	96.82	1.58	0.00	0.00	44.90	86.90	131.80	176.70	198.44	243.34	199.47	107.85	243.34
1978	25.95	0.00	0.00	0.00	44.90	86.90	131.80	168.10	211.56	212.26	163.71	100.73	212.26
1979	7.95	0.00	0.00	43.45	88.35	130.36	175.26	220.16	246.73	253.31	254.16	149.50	254.16
1980	16.64	0.00	0.00	43.45	88.35	130.36	175.26	220.16	253.89	266.79	243.00	169.10	266.79
1981	30.00	0.00	0.00	35.97	80.87	122.88	167.78	212.68	254.45	247.15	270.48	188.50	270.48
1982	153.56	79.72	38.49	28.35	66.37	108.37	153.27	181.77	225.22	225.80	195.73	127.59	225.80
1983	12.05	0.00	0.00	4.93	38.07	80.08	124.98	169.88	213.33	204.51	156.88	76.22	213.33
1984	0.00	0.00	0.00	6.01	50.91	92.92	137.82	182.72	226.17	238.95	251.32	210.22	251.32
1985	129.72	36.20	0.00	43.45	88.35	130.36	175.26	220.16	263.61	274.15	252.80	197.86	274.15
1986	83.68	44.48	34.85	37.39	82.29	124.29	169.19	214.09	257.54	264.76	215.37	130.63	264.76
1987	38.57	0.00	0.00	31.21	76.11	118.12	163.02	201.72	223.65	220.11	184.76	105.44	223.65
1988	17.54	0.00	0.00	0.00	44.90	86.90	131.80	176.70	220.16	234.22	209.95	106.81	234.22
1989	33.99	16.91	0.00	14.77	59.67	101.68	146.58	191.48	234.93	279.83	224.20	155.18	279.83
1990	85.08	46.12	51.33	94.79	139.69	181.69	226.59	271.49	314.94	359.84	328.53	256.43	359.84
1991	169.77	112.98	60.79	82.28	127.18	169.18	214.08	258.98	302.44	296.38	317.31	237.89	317.31
1992	134.11	80.59	93.72	99.89	144.79	186.80	231.70	276.60	318.73	305.35	335.92	268.74	335.92
1993	172.48	90.84	70.18	79.99	124.89	166.89	211.79	256.69	300.14	302.04	257.93	158.55	302.04
											100 Percentile		**377.79**
	Minimum Area Required for Irrigation (Ha)												
		31.55											
	Storage Dam Volume (m^3)				**Storage Dam Depth(m)**		**Storage Dam Area (m^2)**						
		119205.37			3.00			48749.77					
	Rainfall over Evaporation												
		554.75											

APPENDIX B

Capital Cost Details and
Various Treatment Plant Solutions and Parameters.

Wood and Grieve Engineers

Wood & Grieve
ENGINEERS

COST ESTIMATE OF SEWERAGE OPTION

for : Canal Rocks Unit Trust

Job Name	*Smith's Beach Effluent Disposal*
Job No	*11161B*
Land usage	*Residential / Tourism*
Option A2	***Treatment Plant with Stream Disposal***
Location	*Shire of Busselton*

		$
1. Preliminaries		27500
2. Pumping Station		174500
3. Rising Main		303500
4. Treatment Plant		1000000
5. Stream Disposal		240500
6. Land Requirements		100000
7. Contingency (Contract)		92500
Total Contract Works		1938500
8. Professional Fees		
8.1	Engineering	145500
8.2	Surveying	25000
8.3	Environmental review	80000
8.4	Geotechnical	5000
9. Contingency (Project)		13000
Sub Total		2207000
Cost escalation *(Estimated by developer)*		
TOTAL COST		

This estimate makes no allowance for acquisition costs, cost escalation, holding charges, legal costs or selling costs and assumes that no abnormal or unusual cost overruns occur from any cause.

The estimate of costs is based on average current contract rates applied to quantities and conditions estimated to be required for the works. The costs are subject to alteration owing to Local Authority and other Authorities conditions of approval and phyiscal constraints that cannot be defined at the time of this estimate without detailed design, environmental, and geotechnical investigations.

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COST ESTIMATE OF SEWERAGE OPTION

Wood & Grieve
ENGINEERS

for : Canal Rocks Unit Trust

Job Name	*Smith's Beach Effluent Disposal*
Job No	*11161B*
Land usage	*Residential / Tourism*
Option **A1**	***Treatment Plant with Ocean Disposal***
Location	*Shire of Busselton*

		$
1. Preliminaries		54000
2. Pumping Station		174500
3. Rising Main		303500
4. Treatment Plant		1000000
5. Ocean Outfall		2075500
6. Land Requirements		50000
7. Contingency (Contract)		183000
Total Contract Works		3840500
8. Professional Fees		
8.1	Engineering	288000
8.2	Surveying	20000
8.3	Environmental review	80000
8.4	Geotechnical	25000
9. Contingency (Project)		20500
Sub Total		4274000
Cost escalation *(Estimated by developer)*		
TOTAL COST		

This estimate makes no allowance for acquisition costs, cost escalation, holding charges, legal costs or selling costs and assumes that no abnormal or unusual cost overruns occur from any cause.

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Wood & Grieve
ENGINEERS

COST ESTIMATE OF SEWERAGE OPTION

for : Canal Rocks Unit Trust

Job Name	*Smith's Beach Effluent Disposal*
Job No	*11161B*
Land usage	*Residential / Tourism*
Option A3	***Treatment Plant with Disposal to Infiltration Area***
Location	*Shire of Busselton*

		$
1.	Preliminaries	35500
2.	Pumping Station (Primary)	196500
3.	Rising Main	707500
4.	Treatment Plant	1000000
5.	Pumping Station (Secondary)	182500
6.	Infiltration Area	61500
7.	Land Requirements	208000
8.	Contingency (Contract)	119500
	Total Contract Works	2511000
9.	Professional Fees	
9.1	Engineering	188500
9.2	Surveying	500
9.3	Environmental review	80000
9.4	Geotechnical	25000
10.	Contingency (Project)	14500
	Sub Total	2819500
	Cost escalation *(Estimated by developer)*	
	TOTAL COST	

This estimate makes no allowance for acquisition costs, cost escalation, holding charges, legal costs or selling costs and assumes that no abnormal or unusual cost overruns occur from any cause.

The estimate of costs is based on average current contract rates applied to quantities and conditions estimated to be required for the works. The costs are subject to alteration owing to Local Authority and other Authorities conditions of approval and phyiscal constraints that cannot be defined at the time of this estimate without detailed design, environmental, and geotechnical investigations.

Wood & Grieve
ENGINEERS

COST ESTIMATE OF SEWERAGE OPTION

for : Canal Rocks Unit Trust

Job Name	*Smith's Beach Effluent Disposal*
Job No	*11161B*
Land usage	*Residential / Tourism*
Option A4	***Treatment Plant with Woodlot Disposal***
Location	*Shire of Busselton*

		$
1. Preliminaries		45500
2. Pumping Station		193500
3. Rising Main		462500
4. Treatment Plant		1000000
5. Woodlot Outfall		258500
6. Land Requirements		1125000
7. Contingency (Contract)		154500
Total Contract Works		3239500
8. Western Power Fees		1000
9. Professional Fees		
9.1	Engineering	243000
9.2	Surveying	500
9.3	Environmental review	80000
9.4	Geotechnical	25000
10. Contingency (Project)		17500
Sub Total		3606500
Cost escalation *(Estimated by developer)*		
TOTAL COST		

This estimate makes no allowance for acquisition costs, cost escalation, holding charges, legal costs or selling costs and assumes that no abnormal or unusual cost overruns occur from any cause.

The estimate of costs is based on average current contract rates applied to quantities and conditions estimated to be required for the works. The costs are subject to alteration owing to Local Authority and other Authorities conditions of approval and phyiscal constraints that cannot be defined at the time of this estimate without detailed design, environmental, and geotechnical investigations.

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Wood & Grieve
ENGINEERS

COST ESTIMATE OF SEWERAGE OPTION

for : Canal Rocks Unit Trust

Job Name	*Smith's Beach Effluent Disposal*
Job No	*11161B*
Land usage	*Residential / Tourism*
Option B	***Connection to Dunsborough Sewerage System***
Location	*Shire of Busselton*

		$
1. Preliminaries		34500
2. Pumping Station (Primary)		196500
3. Rising Main		1041000
4. Discharge Details		240000
5. Pumping Station (Secondary)		194500
6. Water Corp Headworks		630000
7. Contingency (Contract)		117000
Total Contract Works		2453500
8. Professional Fees		
8.1	Engineering	184000
8.2	Surveying	20000
8.3	Environmental review	25000
8.4	Geotechnical	10000
9. Contingency (Project)		12000
Sub Total		2704500
Cost escalation *(Estimated by developer)*		
TOTAL COST		

This estimate makes no allowance for acquisition costs, cost escalation, holding charges, legal costs or selling costs and assumes that no abnormal or unusual cost overruns occur from any cause.

The estimate of costs is based on average current contract rates applied to quantities and conditions estimated to be required for the works. The costs are subject to alteration owing to Local Authority and other Authorities conditions of approval and phyiscal constraints that cannot be defined at the time of this estimate without detailed design, environmental, and geotechnical investigations.

Comparision of Stand-alone Treatment Plants

Treatment Plant													Disposal Alternatives Acceptability			
Type	Final Effluent				Other Criteria					Costs		Comments				
	BOD	SS	N	P	Sludge Disposal	Noise	Odour	Disinfection	Monitoring Alarms Telemetry	Capital	Maintenance (pa)		Ocean Outfall	Streamflow	Infiltration	Woodlot
Super Treat (CWT) Continuous aeration process.	<10	<15	<20	<05	Annually by tanker transport.	Blowers 75 dBA	Nil	Ozone Gas <2 cpv/100ml	Blowers, p dosing pump and ozone gas can be remotely controlled.	Stage 1 $0.5 mil Total $1 mil	$40,000	Pump to treatment plant and wood lot.	Yes	No	Yes	Yes
South Fremantle Engineering Co.	<20	<30	<60	<10	Three times per year.	Blowers 72 dBA		Cl Tablets	Can be remotely monitored.	$1.09 mil			No	No	No	Yes
Philcor IDEA	<5	<10	<5	<5	Dry removed.	?		Cl	Control sensors transmitters.	$1.76 mil	$85,000		Yes	Yes	Yes	Yes
Henry Walker IDEA	<10	<15	<15	<1	Liquid to WWTP. once/month	?	low to nil		available	Stage 1 $0.5 mil $1 mil	$70,000		Yes	Yes	Yes	Yes
SEPA WWT	<20	<30	<60	<10	3 time per year required.	72 dBA	Nil	Cl liquid or tablet.	Remote monitoring available.	$1 mil	$50,000		No	No	No	Yes
Environmental Solutions International - SBR Process	<10	<15	<15	<10 <1 with Alum	Dried Annually	acceptable	Low to nil	Cl	Remote monitoring available	$ 1 mil	$7,300 Power $40,000		Yes	Yes	Yes	Yes