Shoalhaven City Council
Strategic Planning & Infrastructure Group

JERBERRA ESTATE, TOMERONG

STRATEGIC ONSITE EFFLUENT DISPOSAL ASSESSMENT

Prepared by
Eric Hollinger MSc (Hons)(UWS) BAppSc (SCU)

December 2011

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SUMMARY

Introduction

The Jerberra Estate was registered in the Land Titles Office on 30 June 1922 under the provisions of the Local Government Act, 1919. The subdivision comprised 166 lots ranging in size from <1,000 m^2 to 1.7 ha.

Since the Shoalhaven's first landuse planning scheme was introduced on 28 February 1964, the land's rural zoning has effectively meant that Council does not have the legal ability to approve dwellings on the individual lots (as they are less than 40 hectares).

Following repeated requests by the landowners, on 15th December 1992, Council resolved to prepare a draft local environmental plan (LEP) over the Estate. A significant amount of work was completed by Council on the rezoning investigations in the following years. In 2000 despite the then advanced consideration of the rezoning, and a previous commitment that the rezoning could continue, the State government advised Council that it had placed a moratorium on the progression of any rezonings in the Jervis Bay area until completion of the Jervis Bay Settlement Strategy (JBSS). Just prior to this, Council had commissioned an effluent disposal study by Coffey Geosciences which had concluded that each lot would require a minimum effluent disposal area of 1,500 m^2 and recommended a minimum lot size of 2,500 m^2.

The Jervis Bay Settlement Strategy (JBSS) was completed by Council and endorsed by the State Government in 2003. The JBSS identifies Jerberra Estate as an opportunity for rural residential settlement, and specifically states:

> *"The development potential for rural residential development will be investigated through a review of lot sizes and configuration in order to accommodate on site effluent management and meet the guiding principles and policy actions of this Strategy."*

In 2005 Council commissioned a desktop study by Martens & Associates Pty Ltd to review current onsite effluent disposal technology and any implications for Jerberra Estate. This review identified the need for additional constraints mapping and more detailed water and nutrient balance calculations.

The purpose of this assessment is to provide a strategic assessment of the subject land's effluent disposal capability and to provide the information requirements identified in the desktop review.

Methodology

The relationship between lot size and the area available for effluent disposal was determined by preparing hypothetical site plans for a selection of the existing lots. The site plans incorporated a building footprint, driveway, and the relevant minimum setback requirements required by AS1547 for both above ground spray irrigation and subsurface trickle irrigation. The minimum setbacks were determined in accordance with detailed contour information derived from a LiDAR survey.

Monthly water and nutrient balances were calculated in accordance with the NSW guidelines ('the silver book') and AS1547. Further soil sampling was undertaken with the soil terrain units identified as being suitable for effluent disposal in the Coffey Geosciences report, and the soil attributes were factored into the nutrient balance calculations.

Recommendations and conclusions

It is concluded that onsite effluent treatment and disposal on the developable lots (as identified in the Planning Proposal) is achievable provided the following recommendations are adhered to:

- Treatment is provided to tertiary treatment standard, e.g. by aerated wastewater treatment system (AWTS) or equivalent.
- Treated effluent is disposed of via subsurface pressurised irrigation.
- The onsite effluent disposal area should be no smaller than as follows:

No. of bedrooms	Minimum effluent disposal area (m^2)
3	583
4	777
5	972

  For a 4-bedroom dwelling the minimum effluent disposal area required is 777 m^2 equating to a lot area of approximately 2000 m^2.

- Full water reduction fixtures are to be installed in each dwelling as an added factor of safety. It may be possible to further reduce household hydraulic load by incorporating greywater reuse systems and/or dry composting toilets. Any such proposal would need to be accompanied by a detailed design at development application stage.
- Individual onsite effluent disposal assessments should be submitted at development application stage. Nutrient balance calculations should also be provided where any variation to the calculations provided in this report is proposed.
- Alternative subsurface disposal methods such as sand mounds or amended earth mounds could be considered subject to provision of design details at development application stage. Any sand or amended earth mounds should be installed appropriately and in particular, the base of the mound should not extend below the 'B' horizon (subsoil).
- An organic soil mix should be spread over the effluent disposal area to a minimum depth of 100 mm. The imported soil should be spread uniformly over the effluent disposal area and can be blended into the upper 50 mm of native soil. The soil mix should conform to AS4419 (2003) 'Soils for landscaping and garden use – Organic soil'.
- Appropriate vegetation should be selected for the effluent disposal areas and should be established before systems are commissioned.
- The areas available for effluent disposal should be protected from ingress of surface and subsurface moisture through the provision of appropriate stormwater diversion measures such as grassed swales or cut-off trenches.

GLOSSARY

aerated wastewater treatment system (AWTS): a wastewater treatment process typically involving:
- settling of solids and flotation of scum
- oxidation and consumption of organic matter through aeration
- clarification - secondary settling of solids, and
- disinfection of wastewater before surface irrigation unless disposed of sub-surface, in which case disinfection may not be required.

aerobic: dissolved or free oxygen is present

amended earth mound system: primary treated effluent flows or is pumped to one of two amended earth 'cells' comprising a blend of sand and industrial slag. Phosphorus is adsorbed/absorbed by the slag. The mound is underlain by an impervious barrier and is covered by a veneer of sand and topsoil into which grasses/shrubs are established.

anaerobic digestion: decomposition of effluent in the absence of free oxygen

biochemical oxygen demand (BOD): a measure of the dissolved oxygen required for the breakdown of organic material in the effluent; usually refers to a 5-day test (BOD5), which typically represents 70 - 80% of the total BOD in a sample; expressed in milligrams per litre (mg/L)

biological film: (zoogloeal film) gelatinous-like film that forms on the surfaces of inert materials, forming the media in a biological filter; it can contain bacteria, protozoa and fungi, and is the site where organic matter in the wastewater is oxidised or degraded biosolids: primarily organic solid product produced by wastewater treatment processes. The solids become biosolids when they come out of a digester or other treatment process and can be beneficially used. Until such solids are suitable for beneficial reuse they are defined as wastewater solids

denitrification: transformation of nitrate into the gaseous NO and N forms; denitrification is an anaerobic process carried out by micro-organisms; it can occur only if the soil becomes oxygen deficient (for example, as a result of waterlogging)

disinfection: a process that destroys, inactivates or removes pathogenic micro-organisms

evapotranspiration: removing water from soil by evaporation and from plants by transpiration

faecal coliforms (fc): a type of bacteria that live only in the gut of warm-blooded animals. Can be detected in the general environment if that environment is contaminated with human excreta, and therefore can act as an indicator of recent faecal contamination

horizontal flow wetlands: wastewater flows horizontally through a bed of gravel into which reeds have been planted.

hydraulic load: the amount of liquid applied to land over a specified time interval. Can be expressed as either a depth or a volume

land application area: (effluent disposal area, irrigation area) the area over which treated wastewater is applied

membrane filtration: filtering effluent through a membrane, usually in combination with biological processes. Produces high quality effluent but has high capital and maintenance costs at small scale. Small package plants capable of treating effluent from three households are more economic.

nitrification: transformation of inorganic ammonium (NH_4+) into nitrate (NO3-)

nutrients: chemical elements that are essential for sustained plant or animal growth; the major nutrients essential for plant growth are nitrogen (N), phosphorus (P) and potassium (K); in excess, N and P are potentially serious pollutants encouraging nuisance growths of algae and aquatic plants in waters and (in the case of nitrate) posing a direct human health risk

pathogens: micro-organisms that are potentially disease-causing; these include but are not limited to bacteria, protozoa and viruses

reticulated water supply: the provision by a water authority of water for potable and non-potable uses to households through a network of pipes

sand filters (recirculating and single pass): provides further treatment of pre-treated wastewater by percolation through graded sand.

sludge: mainly organic semi-solid product produced by wastewater treatment processes

suspended solids (SS): in wastewater analysis: solids retained after filtration through a glass fibre filter paper followed by washing and drying at 105oC, or by centrifuging followed by washing and removal of the supernatant liquid; expressed in milligrams per litre (mg/L)

total Kjeldahl nitrogen (TKN): nitrogen chemically bound in organic molecules such as proteins, amines, and amino acids; plus ammonia nitrogen

total nitrogen (TN): the sum of all nitrogen species (nitrate, nitrite, ammonia and organic nitrogen)

total phosphorus (TP): Total phosphorus (TP)" means the total phosphate content of water or wastewater including all of the ortho-phosphates and condensed phosphates, both soluble and insoluble, and organic and inorganic species

vertical flow wetlands: wastewater passes downwards through a bed of sand in a largely aerobic environment of sand or gravel into which reeds have been planted.

Watercourse: any river, creek, stream or chain of ponds, whether artificially modified or not, in which water usually flows, either continuously or intermittently, in a defined bed or channel, but does not include a waterbody (artificial).

wet composting system/biological treatment system: Uses the principle of aerobic composting to break down the solid waste; the liquid component is directed to a land application system after passing through filter media inoculated with micro-organisms, worms etc.

1. INTRODUCTION

1.1 Background

Jerberra Estate is a ‘paper’ subdivision located approximately 20 km south of Nowra and 1.5 km east of Tomerong. See Figure 1 - Location of the subject land.

Figure 1 - Location of the subject land

The Jerberra Estate was registered in the Land Titles Office on 30 June 1922, under the provisions of the Local Government Act, 1919. The Estate consisted of 166 lots varying in size from 1,200 m^2 to 1.75 hectares. As a result of the realignment of Pine Forest Road, a number of lots are now <900 m^2. Of the 166 lots, 102 have an area less than 4,000 m^2. The subject land comprises 153 lots of the original subdivision, with a total area of approximately 84.9 ha (including roads).

The subject land comprises the following lots:

- lots 1 to 11 in DP 1088096;
- lots 23 to 36, 39 to 49, & 52 to 166 in DP 11629; and
- lot 501 in DP 1122649 (on which an approved dwelling is located and where no further dwellings are proposed).

The subject land boundary is shown in Figure 2.

Figure 2 - Boundary of subject land.

Since 1986, many of the lots have been bought on speculation that the land would be rezoned to allow dwellings to be constructed on each individual lot. On 15 December 1992, Council resolved to prepare a draft local environmental plan (LEP) over the Estate.

There is one approved dwelling within the subject land (Lot 501 DP 1122649). There are a numerous unauthorised structures, approximately 10 small dams and various other disturbances.

1.2 Current land use zoning

The subject land is currently zoned part Rural 1(b) (Arterial and Main Road Protection) and part Rural 1(d) (General Rural) under the provisions of Shoalhaven Local Environmental Plan 1985 (SLEP 1985). Under SLEP 1985 dwellings cannot be approved on the individual lots as they are less than 40 ha.

The Draft Shoalhaven Local Environmental Plan 2009 (Draft SLEP 2009) was exhibited from 18 July to 14 October 2011. Under Draft SLEP 2009 the land is proposed to be zoned Rural Landscape (RU2) with a 40 ha minimum lot size which retains the status quo under SLEP 1985.

1.3 Jerberra Estate Planning Proposal

A Planning Proposal was submitted to the Department of Planning & Infrastructure (DP&I) in August 2011. The Planning Proposal seeks to eventually amend SLEP 2009 to rezone the subject land to a mix of Environmental Living (E4), Environmental Management (E3) and Environmental Conservation (E2) in conjunction with a reduction in the minimum lot size requirement where housing is proposed to be allowed. The Department of Planning and Infrastructure (DP&I) issued a Gateway Determination on 2 September 2011, allowing Council to place the Planning Proposal on public exhibition, subject to completion of a stormwater assessment and various other matters.

Details of the planning proposal are illustrated in Figures 3 to 5 below. The minimum lot size for most of the proposed E4 area (refer to Figure 4) is based on the findings of this assessment.

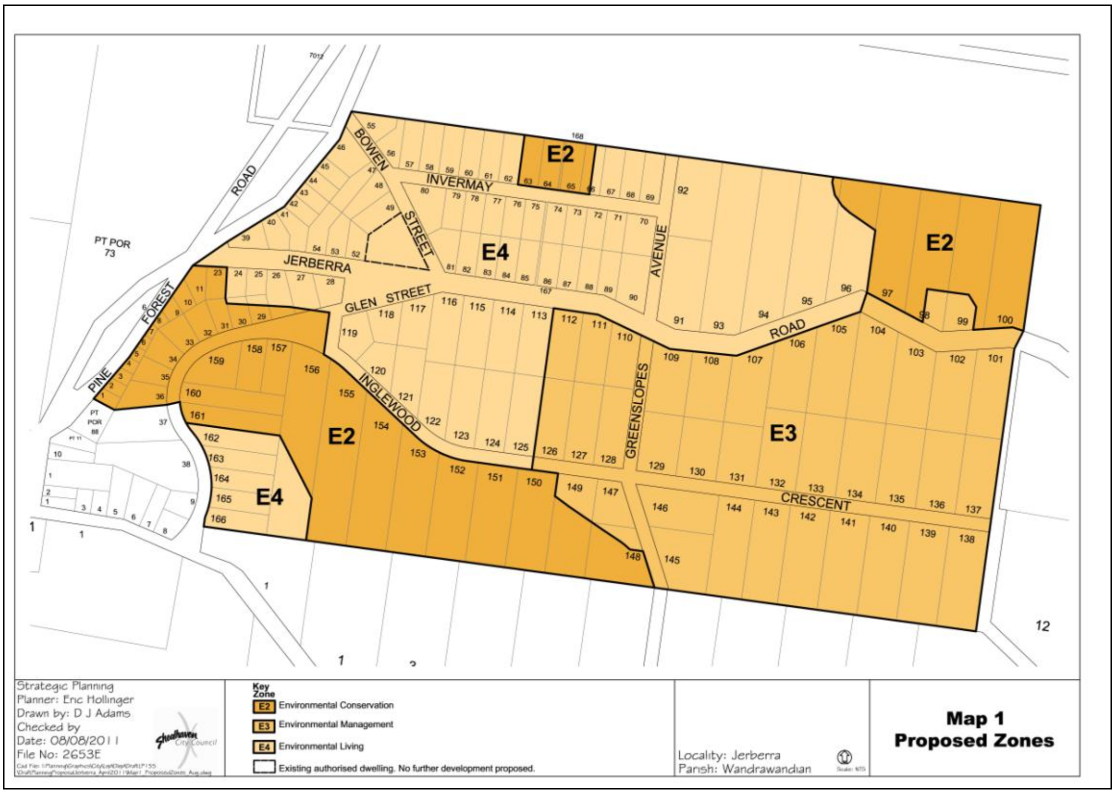

Figure 3 - Planning proposal - zoning

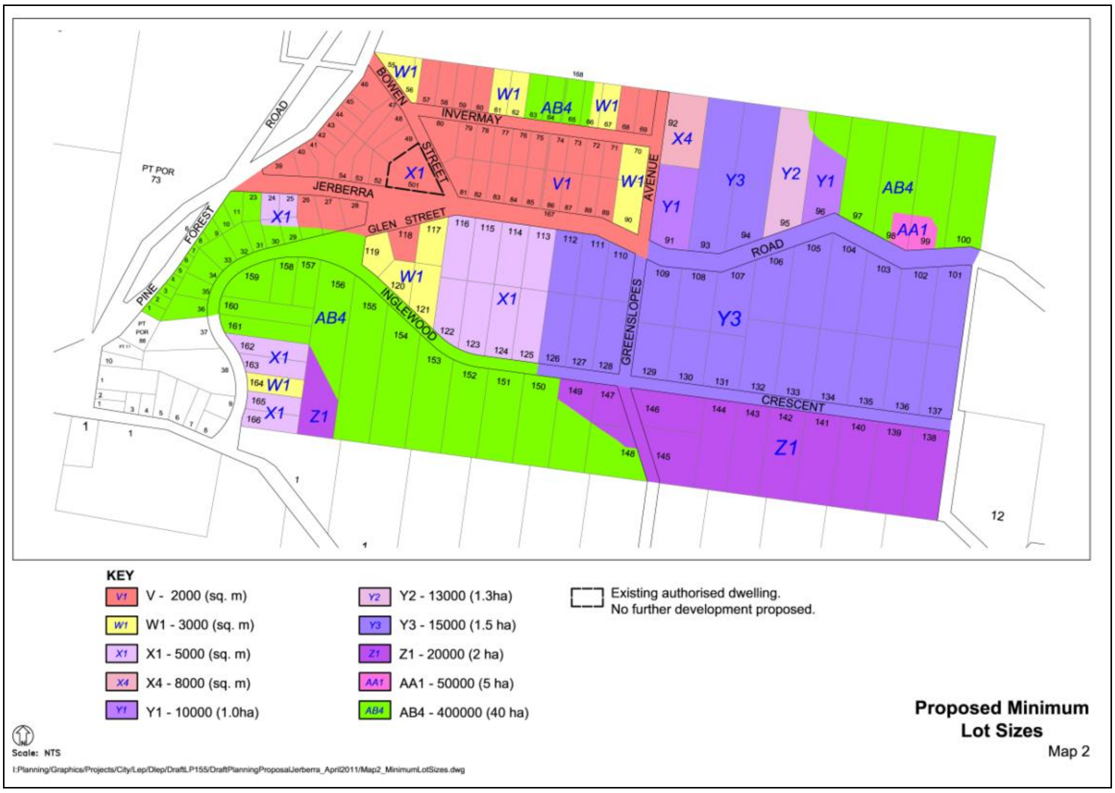

Figure 4 - Planning proposal - minimum lot size

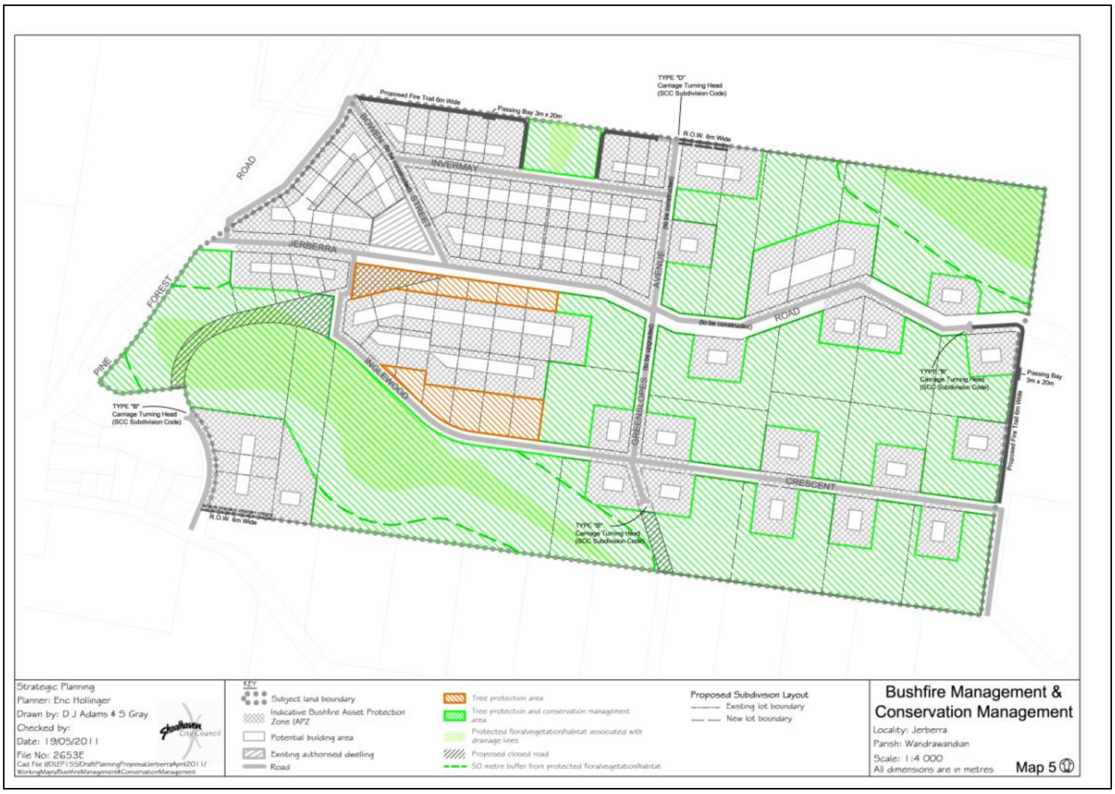

Figure 5 - Planning proposal - bushfire and conservation management areas

1.3.1 Onsite effluent disposal study by Coffey Geosciences, 2000

An effluent disposal study was completed by Coffey Geosciences Pty Ltd in February 2000. The study concluded that:

a. *There are only two feasible options for waste-water disposal. Either individual aerated water treatment system (AWTS) or a common effluent system (CES) for the estate;*

b. *The minimum lot size for a individual AWTS for the estate is about 2,500 m^2 of which about 1,500 m^2 is the minimum area required for irrigation.*

Given that Council will not be pursuing a community title/resubdivision outcome, a common effluent system is highly unlikely.

1.3.2 Review of Best Practice Methods of On-site Sewage Disposal – Jerberra Estate Rezoning Investigations, Martens & Associates, 2006

A desktop review of onsite effluent disposal options for Jerberra Estate was undertaken by Martens & Associates in 2006. Martens' report identified potential onsite effluent disposal options for smaller/more constrained lots if individual systems are to be used. A copy of the Martens report is provided in the Appendices. The Martens report recommends:

1. *A decision will need to be made in relation to whether individual or a communal CES system is to be pursued.*
    a. *In the case of the individual systems, the cost to land owners will be considerable on the smaller allotments where space restrictions require more elaborate and complex on-site sewage management scheme and non-potable re-use will be required. These systems may cost the home owner $20,000 - $25,000 once fully constructed. In the case of the larger allotments where more land is available, a standard AWTS and irrigation system may suffice, costing approximately $8000 per dwelling.*
    b. *In the case of the communal system, 1-3 lots will need to be resumed for the necessary infrastructure including the STP and the wet-weather storage system. Cost for the scheme may be of the order of $15,700 per allotment (comprising of a very preliminary budget of $650 K for the STP which would be for nutrient removal and tertiary filtration and dual disinfection, $150 K for the wet-weather storage facility, $1500 K for sewering and dual reticulation, and $100 K for a pump-station). The cost of resumed lots would need to be added to the above cost estimate.*
2. *A more detailed and precise land capability map should be produced. This will assist in isolating allotments on which various effluent management options (as per Table 2) are feasible or where effluent disposal can not be undertaken. This should account for recommended buffer distances to water courses (see Attachment B) in accordance with the environmental Health Protection Guidelines (1998) and Shoalhaven City Council's DCP 78.*
3. *More detailed water / nutrient balance assessment should be developed to refine the sustainable effluent application rate nominated by Coffey's (ie. DIR = 0.67 mm/d). Our view is that a sustainable rate may be considerably higher than that recommended by Coffey's, particularly in light of the potential for higher effluent quality (with nutrient removal) available from a range of manufacturers. These assessments should be undertaken for a range of dwelling sizes (eg. 2 – 5 bedrooms).*
4. *Following the above, the minimum allotment size recommended by Coffey's should be revisited in the light of the various on-site treatment alternatives. Various minimum performance standards (in terms of water consumption restrictions, effluent quality requirements and re-use requirements) can then be determined for each of the existing allotments.*
5. *In the event that a CES is regarded as one which can pursued, then a dual reticulation system should be constructed such that reclaimed water can be returned to each allotment. A suitable location for the STP and wet-weather storage facility will need to be chosen. Our preliminary view is that this should be in the NE corner of the site, with a pump-station located in the centre-south of the site (to transfer sewage to the STP at the NE of the site). See Attachment A for preliminary location of these structures. Our preliminary view is that some 150 m^2 will need to be provided at each allotment as a designated effluent disposal area within the sites landscaping / gardens. This is made on the assumption that nutrient removal (say N = 10 mg/L and P = 2 mg/L), disinfection and tertiary filtration are provided at the communal STP and would need to be confirmed with more detailed analyses.*

Shoalhaven Water has indicated that the CES option is not favoured.

This report builds upon the review undertaken by Martens & Associates, particularly in respect of:

- Improving the site and soil assessment information
- Refining land capability mapping
- Revising water and nutrient balance calculations in respect of:
  - Number of bedrooms
  - Water reduction fixtures
  - Effluent quality (nutrients in particular)

1.3.3 Previous Consultation

Comments received from the EPA in 1999 and 2000 in response to the Coffey Geosciences study included:

- *"…the EPA has very serious reservations about on-site wastewater management for the site. This is because significant constraints to onsite effluent management are apparent from the information presented in the study. Based on the information presented, and in light of the sensitivity of the receiving environment, the EPA questions the sustainability of the proposal in on-site effluent management is adopted."*

- *Some of the limitations to onsite effluent disposal were understated.*

- *The feasibility of connecting the Estate to sewer (St Georges Basin STP) had not been addressed.*

- *Where town sewerage is not practical the proponents must demonstrate that on-site wastewater management strategies can meet accepted performance objectives to protect the environment and public health (i.e. 'the silver book').*

- *Site limitations inadequately addressed:*

  - *Limitations regarding duplex soils generally;*
  - *Presence of mottling in subsoil indicative of poor drainage – a significant constraint for onsite effluent disposal;*
  - *No chemistry data (P sorption, CEC, ESP) provided for topsoil – P balance underestimates irrigation area; and*
  - *Concerns about the practicality of a large wet weather storage requirement (53 m^3 for each household)*

- *The EPA preferred a common effluent system (CES) over individual aerated wastewater treatment systems (AWTS). In respect of the CES option however, the capacity of the subdivision to accommodate a CES has not been demonstrated. In particular:*
  - *Effluent disposal proposed over whole lots as well as roads.*
  - *Adequate buffer distances not considered.*
  - *Ownership/management of CES not considered.*
  - *No nutrient balance provided.*
  - *Proposed CES capable of accommodating effluent from 85 houses.*

- *In regard to individual AWTS:*

- *Concerns about the chemical and physical attributes of the duplex soil, in particular the topsoil, in Units 1 and 2.*
- *Given the constraints posed by the site and the large number of lots, further assessment of the viability of the AWTS option is required. Council must fully appreciate the deficiencies of AWTS and consider the cumulative environmental impacts.*

1.4 Aims

The objective of this report is to assess the suitability of the subject land for onsite effluent disposal. The aims are to:

- review the site and soil constraints for the subject land and address information deficiencies outlined in the 2006 report by Martens & Associates;
- ascertain the minimum lot size to meet environmental and health objectives;
- provide recommendations to ensure the development meets environmental and health objectives; and
- review onsite effluent disposal technologies for environmentally sensitive areas.

2. LEGISLATIVE & POLICY FRAMEWORK

2.1 State Environmental Planning Policy (SEPP) No. 14 – Wetlands

The subject land drains to Moona Moona Creek via Duck Creek. Moona Moona Creek flows into Jervis Bay between the townships of Huskisson and Vincentia. The lower reaches of Moona Moona Creek support an extensive wetland system, which is located approximately two (2) km east of the subject land. The wetland is protected under State Environmental Planning Policy No. 14 (SEPP 14 wetland No. 325). A basic description of Wetland No. 325 is provided in Winning and Brown (1994) which states that it is tidal with mangroves, saltmarsh (*Juncus*, *Sarcocomia*, *Sporobolus*) and *Casuarina*.

Figure 6 shows the location of the subject land in relation to the Moona Moona Creek catchment.

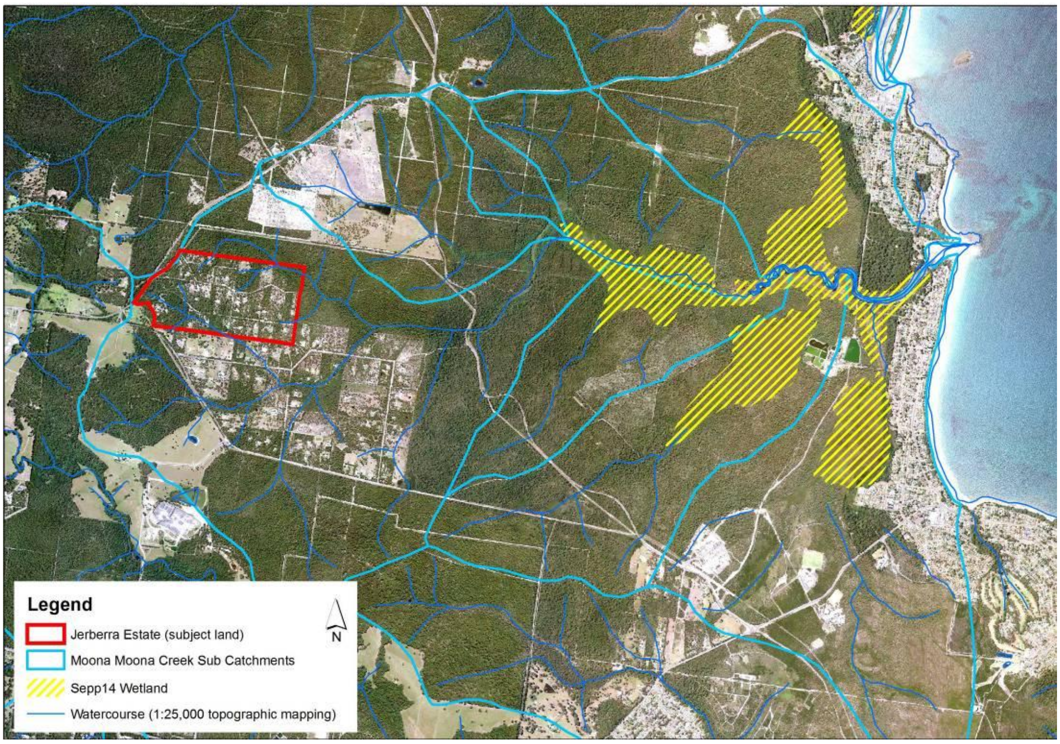

Figure 6 - Location of subject land within Moona Moona Creek catchment

2.2 South Coast Regional Strategy (SCRS)

In relation to development proposal within the catchments of SEPP 14 wetlands (refer to above) the SCRS states that:

> *"Future development in these catchments will need to demonstrate no net impact on the hydrology, water quality or ecology of these wetlands."*

In terms of onsite effluent disposal assessment, water, nitrogen and phosphorus balance calculations are calculated to determine the land application area(s) needed to assimilate wastewater constituents. Hence, in respect of onsite effluent disposal, the recommendations and findings of the assessment are considered capable of meeting the requirements of the SCRS.

Wastewater treatment and disposal is just one aspect of development of the site that would have the potential to impact on the values of Currambene Creek and the SEPP 14 wetland. State Government agency input may be needed to clarify the requirements of the SCRS.

2.3 Jervis Bay Regional Environmental Plan (JBREP)

The subject land is affected by the Jervis Bay Regional Plan gazetted by the NSW Government in 1997.

The subject land forms part of the Moona Moona Creek catchment, a waterbody to which clause 11 – catchment protection of JBREP applies. Currambene Creek is mapped as *'a two use waterbody, protection of aquatic ecosystems; and primary contact recreation'*.

Clause 11 states that a proposal must:

(a) for the water quality in any waterbody it may affect, either:
- *sustain uses identified on map 2 and as defined by the Australian National Water Quality Guidelines for Fresh and Marine Water 1992, or*
- *demonstrate how the water quality will be maintained or improved, if the water quality in those waterbodies does not at that time sustain the uses identified on map 2, and*

(b) outline a water quality management strategy for surface water to demonstrate how paragraph (a) will be achieved, and
(c) rehabilitate and restore any degraded areas along a waterbody on the site, and
(d) provide sewerage for all new development (unless the development is within an existing unsewered area). If alternate systems of sewage disposal have been approved by health and environment protection authorities, they may be provided, and
(e) protect ecosystems and natural habitats, including waterbodies, from degradation.

JBREP will be repealed when SLEP 2009 is gazetted. Draft SLEP 2009 includes provisions in relation to protection of sensitive water bodies. Refer to below.

2.4 Jervis Bay Settlement Strategy (JBSS)

The Jervis Bay Settlement Strategy (JBSS) was released in 2003. In relation to the Jerberra Estate, the JBSS states:

> *"Jerberra Estate will be investigated to provide for rural residential living opportunities. In order to achieve this, it will be necessary to finalise detailed environmental investigations that have commenced into the appropriate size and configuration of allotments and their ability to accommodate on-site effluent disposal."*

Map 10D also identifies the adjacent land to the south and southeast known as Port Jervis Estate as one of the existing rural residential deferred areas for which the following action applies:

> *"The potential for the existing rural residential deferred areas to accommodate increased densities will be resolved in accordance with the guiding principles and policy actions outlined in this Strategy. In order to achieve increased densities, an understanding of the baseline environmental condition should be investigated and the potential cumulative impacts should be addressed."*

Section 9.1 'Water Quality and Flow' includes several actions that are broadly relevant, including action i) which requires that "*All development will meet the statutory requirements of the Jervis Bay Regional Environmental Plan 1996 in respect of clause 11 – Catchment Protection*." More specifically, action iii) requires that "*New development will be designed so that domestic effluent management does not have a detrimental impact on water quality and flow, meets the interim Environmental Objectives for the Jervis Bay Catchment (EPA 1999) and is consistent with relevant State government guidelines.*"

Section 9.4 'Soils' states that "*The calculation of development density will only be made following an assessment of soil attributes of the land, and some lands may be totally excluded from development on the basis of their soil attributes*."

2.5 Shoalhaven Local Environmental Plan 1985 (SLEP)

The land is currently zoned part Rural 1(d) General Rural and part Rural 1(b) Arterial and Main Road Protection under the provisions of SLEP. As outlined in section 1.2, Council does not have the legal ability under SLEP 1985 to approve dwellings on the individual lots as they are less than 40 ha in size.

Clause 26(2) of SLEP states that:

> *'In deciding whether arrangements for drainage of stormwater and other surface water and the treatment and disposal of effluent are satisfactory, the Council must take into account whether the proposed systems can be accomplished in a manner which meets the following objectives:*
> *(a) economic feasibility and practicality in terms of design, installation and maintenance;*
> *(b) protection of public health;*
> *(c) protection of surface water;*
> *(d) protection of ground water;*
> *(e) encouragement of the utilisation of wastewaters as a resource rather than a waste for disposal;*
> *(f) protection of a community amenity.'*

2.6 Draft Shoalhaven Local Environmental Plan 2009

As outlined in section 1.2, Draft SLEP 2009, as exhibited, would retain the status quo under SLEP 1985. The Jerberra Estate Planning Proposal seeks to eventually amend SLEP 2009.

2.7 Development Control Plan No. 78 Onsite Sewage Management

DCP No. 78 was adopted by Council in 1998 and amended in 2005 and 2009 (Shoalhaven City Council 2009). Relevant aspects of the DCP include various setback requirements, provisions in relation to flooding, reserve area requirements, and policies on pump-out and common effluent system. These are summarised below.

2.7.1 Minimum buffer distances

<u>All land application systems</u>

- 100 metres to permanent surface waters (e.g. river, streams, lakes, etc).
- 250 metres to domestic ground water wells.
- 40 metres to other waters (e.g. farm dams, intermittent waterways and drainage channels, etc).

<u>Surface spray irrigation</u> (Tertiary treated effluent) (Irrigation systems to conform to AS 1547)

- 6 metres if area up-gradient and 3 metres if area down-gradient of driveways and property boundaries.
- 15 metres to dwellings.
- 3 metres to paths and walkways.
- 6 metres to swimming pools and buildings.

<u>Surface drip and trickle irrigation</u> (Tertiary treated effluent)

- 6 metres if area up-gradient and 3 metres if area down-gradient of swimming pools, property boundaries, driveways and buildings, including dwellings.

<u>Sub-surface irrigation</u> (Secondary treated effluent or higher)

- 6 metres if area up-gradient and 3 metres if area down-gradient of swimming pools, property boundaries, driveways and buildings, including dwellings.

<u>Absorption system</u> (Primary treated effluent or higher)

- 12 metres if area up-gradient and 6 metres if area down-gradient of property boundary
- 6 metres if area up-gradient and 3 metres if area down-gradient of swimming pools, driveways and buildings, including dwellings.

2.7.2 Flooding

All wastewater treatment systems and application areas must be located above the 1 in 20 year flood level. Systems with electrical components must be located above the 1 in 100 year flood level.

2.7.3 Reserve effluent disposal area

A reserve effluent disposal area is generally recommended for contingencies in the case of system failure and/or for expansion.

<u>Comments</u>

Primary treatment and soil absorption systems have a much higher failure rate than secondary treatment and pressurised irrigation systems. If pressurised irrigation systems are correctly sized, designed and installed, and the treatment system is correctly maintained and operated, the risk of system failure is considerably lower. If problems do occur, corrective action would generally involve servicing or replacing the distribution system, and not necessarily establishing a new effluent disposal area.

2.7.4 Pump-outs

Effluent disposal by regular tanker pump-out can be costly for property owners and can result in illegal discharges and overflows of effluent. The resulting health and environmental problems are a major concern and Council will generally not consider providing additional pump out systems.

2.7.5 Common effluent systems (CES)

Common effluent systems (CES) can provide significant technical and financial advantages over individual onsite systems. The fragmented ownership of the subject land is a major impediment to this option. Where multiple owners are concerned, Community Title subdivision would be more suited to a CES approach. However, community title has been ruled out due to a lack of landowner support.

A community title scheme is not proposed and it is beyond the scope of this report to assess the feasibility of CES options.

2.8 Protection of the Environment Operations Act (POEO Act) 1997

The relevant objects of the Act include: "…*to protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development*…" Hence, Council has a statutory obligation to consider the potential cumulative impacts of onsite effluent disposal in Jerberra Estate on the Moona Moona Creek catchment and associated ecosystems.

2.9 Local Government (General) Regulation 2005

Under the provisions of Division 4 (Sections 40 and 41) Local Government (General) Regulation 2005, a local council must not approve of the installation of certain sewage management facilities unless they have been accredited by the NSW Department of Health.

The types of sewage management facilities to which accreditation applies include septic tanks, collection wells, aerated wastewater treatment systems, greywater treatment systems, composting toilets and incinerating toilets which are available for purchase by retail. This only includes sewage management facilities which treat sewage of a domestic nature from premises occupied by 10 persons or less or where the average daily flow is <2000 litres.

Accreditation does not apply to any drains which are connected to the facility nor to any land application or soil absorption system. Accreditation also does not apply to models under test or if the facility is purpose designed for a specific situation.

2.10 AS1547 Onsite Domestic Wastewater Management

AS1547 (Standards Australia 2000) provides the requirements for primary and secondary onsite treatment and land application systems. Any land application system within the subject land must be designed and installed in accordance with this standard to ensure long term sustainability and performance.

AS1547 states:

> *"Where there is likely to be uncertainty in the outcome of the design and its installation, sufficient factors of safety must be available to ensure that the long-term performance objectives are met."*

The above principle has been adopted in this strategic assessment.

2.11 Environment & Health Protection Guidelines: On-site Sewage Management for Single Households

The Environment and Health Protection Guidelines "On-site Sewage Management for Single Households (NSW Health 1998) is colloquially known as the 'silver book''. The silver book sets out the following long term performance objectives for onsite systems:

- prevention of public health risk, particularly in respect of bacteria, viruses, parasites and other disease-causing organism
- protection of lands
- protection of surface waters
- protection of groundwaters
- conservation and reuse of resources
- protection of community amenity

In respect of rural residential subdivision, the silver book states:

> *"If on-site sewage management is determined to be the best long-term option for an area, appropriate development standards, including minimum lot sizes, should be established before the land is released. When setting the development standards, factors such as climate, soil, geography, environmental sensitivity, and risks to public health should be taken into account.*
>
> *An EPA model has been developed for estimating land requirements for effluent irrigation, based on eliminating impacts on soils, waters, and public health (NSW Environment Protection Authority 1995). Assessments with the model in many areas of the State have shown that new subdivisions for residential development involving on-site sewage management require a minimum of 4000 - 5000 m2 total area per household to reduce impacts in the medium to long term."*

The silver book sets out methodologies for estimating the land application area based on water, nutrient and organic matter balances. The 'nominated area' method detailed in Appendix 6 has been used in this assessment. While there are many areas of overlap between the silver book and AS1547 and these are generally consistent, the silver book provides more detailed guidance on estimating nutrient balances. Further details are provided in section 5.

2.12 NSW Health accreditation for Sewage Management Facilities (SMF)

NSW Health operates an accreditation scheme that is mandatory for certain types of sewage management equipment sold in NSW (NSW Health 2005). Accreditation does not apply to the drains which are connected to the facility nor to any land application system. Accreditation is also not required for systems installed for research, development or testing purposes, for non-standard systems designed for a particular site, or for systems constructed to individual designs. The types of sewage management facilities (SMF) to which accreditation apply currently include:

- Aerobic Sand Filter Systems
- AWTS
- Biological Filter Systems
- Greywater Diversion Devices
- Greywater Treatment Systems
- Incinerating Toilets
- Septic Tanks and Collection Wells
- Sewage Ejection Pump Stations
- Waterless Composting Toilet Systems
- Wet Composting Closet Systems

The number and range of onsite effluent treatment systems has expanded considerably in recent years.

2.12.1 Minimum water quality standards

Section 6.2.2 of the *'Sewage Management Facility – Sewage Treatment Accreditation Guideline'* (NSW Health 2005) provides the following treatment standards for accreditation of standard secondary treatment sewage management facilities (SMF):

(a) 90% of the samples taken over the three test periods shall have a BOD5 less than or equal to 20 mg/L with no sample greater than 30 mg/L;
(b) 90% of the samples taken over the three test periods shall have TSS less than or equal to 30 mg/L with no sample greater than 45 mg/L;
(c) 90% of the samples taken over the three test periods shall have a thermotolerant coliform count not exceeding 30 cfu/100 ml with no sample exceeding 100 cfu/100 ml;
(d) 90% of the samples taken over the three test periods shall have a total kjeldahl nitrogen (TKN) of no more than 20 mg/L;
(e) Where chlorination is the disinfection process, the free residual chlorine concentration shall be greater than or equal to 0.2 mg/L and less than 2.0 mg/L in all samples taken.

A series of testing programs that involved 143 aerated wastewater treatment systems (AWTS) and 48 septic tank systems undertaken by the Sydney Catchment Authority (SCA) found that AWTS generally performed to the accreditation guidelines (Charles *et al*., 2005).

In contrast, effluent from septic tanks which is only treated to primary level was generally poorer quality than guideline and literature values of 50 mg/L SS and 150 mg/L BOD (Charles et al. 2005).

2.12.2 Water quality standards for sensitive environments

The SMF accreditation guidelines (NSW Health 2005) suggest additional criteria for environmentally sensitive areas, namely:

a) The total nitrogen (total N) concentration shall be less than or equal to 20 mg/L in all samples taken; and
b) The total phosphorus (total P) concentration shall be less than or equal to 10 mg/L in all samples taken.

Testing of total N and total P to achieve NSW Health SMF accreditation is optional and has not been carried out for all systems. It should also be noted that accreditation testing is carried out a sewage treatment facility, not under field conditions.

Having undertaken some testing of onsite systems around Sydney, Charles et al. (2005) concluded that there is insufficient effluent treatment data to assess sustainable nutrient loads.

In the US, the EPA and the National Sanitation Foundation (NSF) developed an Environmental Technology Verification (ETV) protocol, under which proprietary systems can undergo a minimum 12 month testing program to demonstrate an effluent standard of 20 mg/L total N (Washington State Department of Health 2005).

An equivalent program to the ETV protocol in Washington has not been established in Australia, but a similar testing program commenced in New Zealand was reported by Fletcher (2007). The results of the New Zealand trial show that some AWTS are able to achieve median total N concentrations of <20 mg/L.

In the absence of independently verified N and P data, the veracity of claims made by manufacturers should be closely scrutinised. Requests made to manufacturers of NSW accredited AWTS revealed that relatively few manufacturers have gone to the expense of obtaining total N and total P removal data. The data that was obtained suggests that in controlled conditions, some AWTS do potentially satisfy the 20 mg/L for total N and 10 mg/L for total P criteria.

3. SITE & SOIL ASSESSMENT

3.1 Catchment description

The subject land drains to Moona Moona Creek via Duck Creek. Moona Moona Creek flows into Jervis Bay between the townships of Huskisson and Vincentia. The lower reaches of Moona Moona Creek support an extensive wetland system, which is located approximately two (2) km east of the subject land. The wetland is protected under State Environmental Planning Policy No. 14 (SEPP 14 wetland No. 325). Refer to Figure 6.

The subject land makes up less than 3% of the Moona Moona Creek catchment which has an area of 28.05 km^2. The subject land is currently subject to a range of disturbances including:

- Numerous unauthorised structures, many of which are believed to have sub-standard onsite effluent disposal systems.
- Varying degrees of vegetation clearing on a number of the properties.
- Informal vehicle tracks, many of which are severely eroded, exposing the erodible subsoils.
- Construction of approximately 10 small dams.

3.2 Topography

The subject land is characterised by undulating slopes and broad drainage depressions. As shown in Figure 7, the elevation ranges between 13 and 51 metres Australian Height Datum (AHD). The subject land comprises two main sub-catchments separated by a broad ridge that has a north-west south-east alignment.

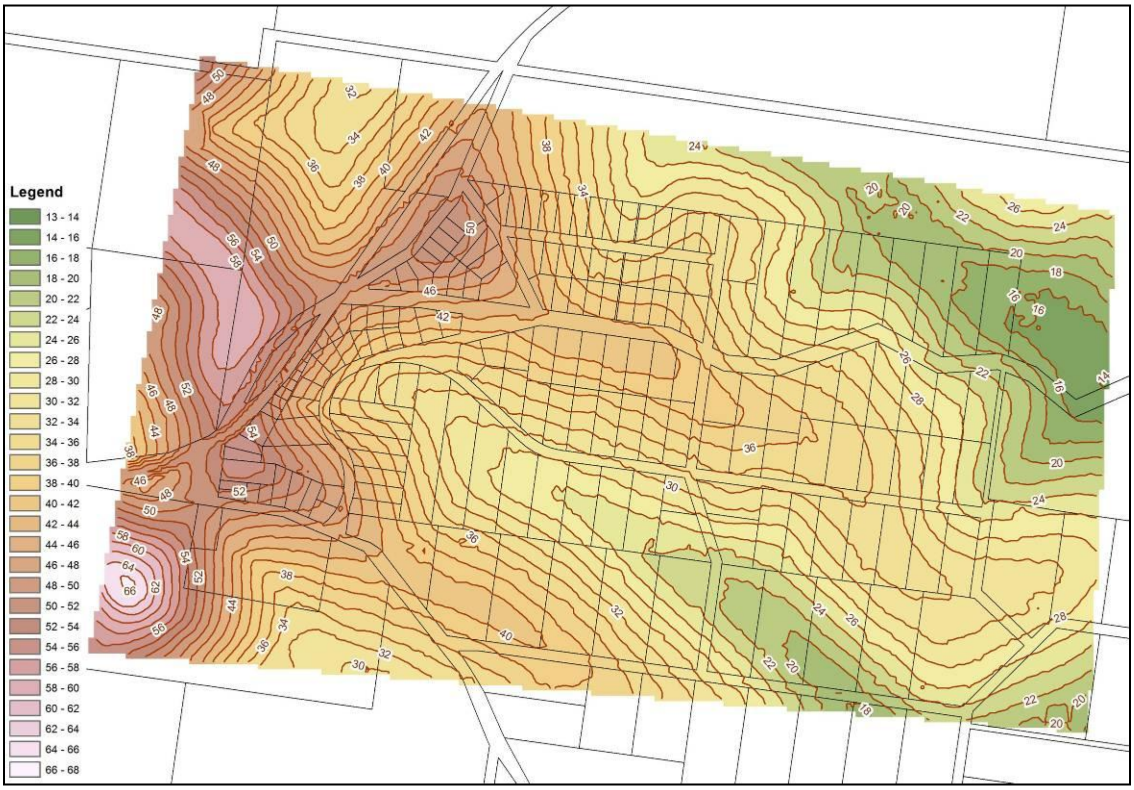

Figure 7 - Elevation of subject land (Source: SCC LiDAR data)

As shown in Figure 8, the majority of the subject land has a slope of <7% (4 degrees). At the western end of the proposed Environmental Living (E2) areas, the slope is 7-9% (4-5 degrees).

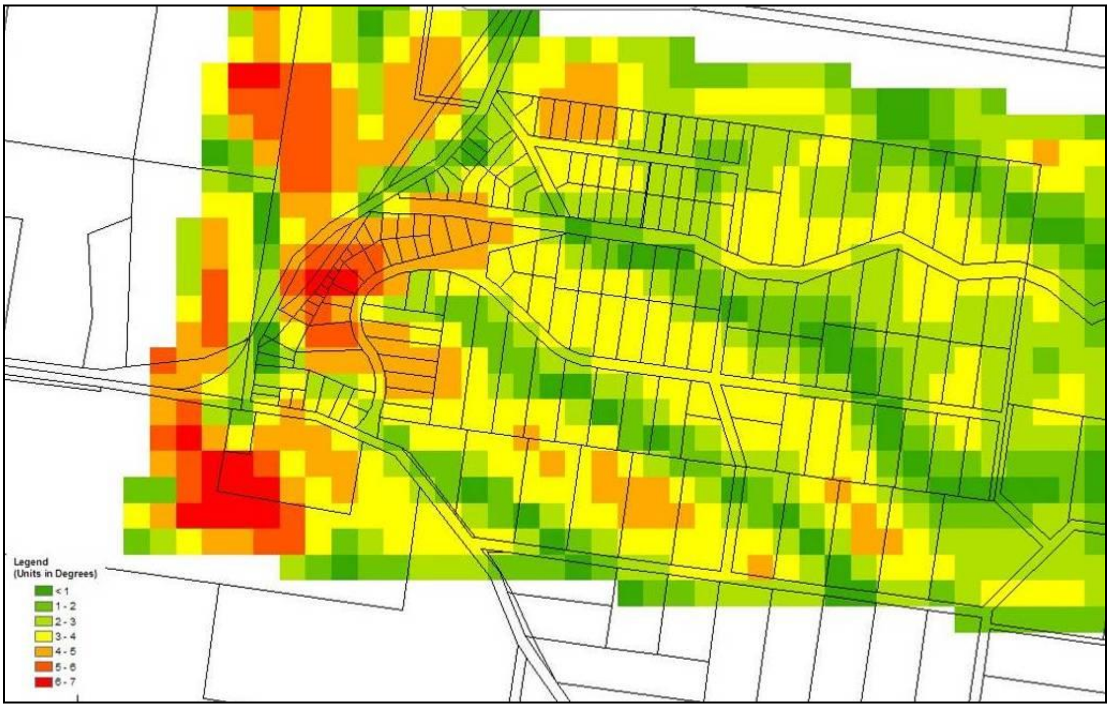

Figure 8 - Slope analysis (50 m tiles). Source: SCC LiDAR data

The Huskisson 1:25,000 topographical map sheet indicates that the subject land is dissected by a number of intermittent watercourses all of which are unnamed and flow to Duck Creek and thence to Moona Moona Creek. However, as clearly shown in Figure 7, the upper reaches of these are better described as *open depressions* associated more with sheet flow than channelised flow.

There are two main drainage lines: one in the southern and one in northern part of the subject land. Both of these drainage lines are associated with Swamp Sclerophyll Forest vegetation which are included in the areas proposed to be zoned “E2 - Environmental Conservation” (refer to section 3.4). The proposed E2 area generally includes a vegetative buffer which has an average width of approximately 50 metres.

There are approximately 10 small dams in the subject land. Effluent should not be applied within 40 metres upslope of any dams that are retained. This should be evaluated on a lot-by-lot basis at DA stage.

3.3 Soils & Geology

The locality is underlain by Permian Wandandian Siltstones which form part of the Shoalhaven Group (Ulladulla 1:250,000 sheet).

Mitchell McCotter (1994) described two soil types in the subject land, namely:

- Duplex (textural contrast) soils comprising clayey sand / sandy loam topsoils (A horizon) over sandy clay loam / clay subsoil (B horizon). The average depth of the topsoil was 15 cm.
- Gradational soils (with a less pronounced transition between topsoil and subsoil) located in the low-lying areas and drainage depressions.

Coffey Geosciences (2000) described three terrain units, namely:

- Unit 1 Ridgeline. Clayey sand A horizon over a silty clay B horizon.
- Unit 2 Sideslopes. Similar soil profile to unit 1 but deeper B horizon.
- Unit 3 Low lying land with seasonally variable groundwater. Unsuitable for effluent disposal.

The terrain unit map produced by Coffey Geosciences is shown in Figure 9.

The main difference in soils between terrain Units 1 and 2 was the greater depth of the subsoil (B horizon) in Unit 2 compared to Unit 1.

The duplex soils in Jerberra Estate are described by Cowman Stoddart Pty Ltd (2009) as:

> "*…a shallow sandy topsoil overlying a bleached A2 horizon with a yellowish brown medium clay subsoil and general fertility is low, with a deep A2 horizon which is weak in structure and hardsetting. The area is subject to severe soil erosion, due to the poor road design, lack of maintenance, wide nature of the road, and the concentration of runoff on the road.*"

3.3.1 Soil sampling

Sampling undertaken by Coffey Geosciences in 1999

Coffey Geosciences undertook soil descriptions and soil testing on sub-surface soil horizon ('B' horizon). The results of this testing are summarised in Table 1.

Table 1. Summary of Coffey Geosciences' soil test results

Terrain Unit	Soil horizon	texture	Emerson class number	pH	EC (µS/cm)	P sorption (mg/kg)	ESP (%)	CEC meq (%)
1	A	Sandy clay loam – sandy clay	nt	nt	nt	nt	nt	nt
1	B	Medium to heavy clay	2, 6	4.7 – 5.1	0.04 – 0.56	550	2.9	7.5
2	A	Sandy clay loam	nt	nt	nt	nt	nt	nt
2	B	Sandy clay – medium to heavy clay	5	5.2 – 5.3	0.03 – 0.07	560 - 600	2.0	6.0 – 8.0
3	A	Sandy clay loam	nt	nt	nt	nt	nt	nt
3	B	Fine sandy clay loam	nt	nt	nt	400	0.9	2.3

nt = not tested

Laboratory testing was not carried out on the A horizon. This deficiency was noted by the EPA in their response to the Coffey Geosciences report.

Sampling undertaken by Council in 2006

Surface soil sampling was undertaken by Council in 2006 to address the deficiency identified in the work by Coffey Geosciences. This additional sampling was limited to terrain units 1 and 2, as terrain unit 3 would be excluded from effluent disposal.

The A horizon was sampled at eight (8) locations across terrain units 1 and 2. A composite sample from each terrain unit was sent to a NATA registered laboratory for analysis (DNR Scone Research Service Centre). The results are summarised in Table 2 and provided in full in the Appendices.

Table 2 - Soil laboratory results from composite A horizon samples in terrain units 1 and 2.

Terrain Unit	Texture	EC (dS/m)	pH	Cation Exchange Capacity (CEC) & exchangeable cations (me/100g)						P sorption capacity (mg/kg)	P sorption index	Emerson Aggregate Test (EAT)
				CEC	Na	K	Ca	Mg	Al			
1	Sandy loam	0.03	5.2	7.8	0.3	0.6	2.1	1.4	1.3	321	2.6	8/3(1)
2	Sandy loam	0.02	5.4	6.6	0.2	0.4	1.3	1.1	1.2	293	2.4	8/3(1)

3.3.2 Interpretation of soil results

The results indicate that the soil characteristics are relatively uniform across terrain units 1 and 2. The A horizon is shallow, the depth ranging from 0.05 to 0.2 m indicating that a good quality soil blend should be spread over the individual effluent disposal areas to improve the overall depth of the topsoil. Soil parameters relevant to effluent disposal are summarised below.

Emerson Aggregate Test (EAT)
The EAT results indicate that the A horizon is prone to dispersion if mechanically disturbed when moisture levels are high. According to Coffey Geosciences (2000) the B horizon in terrain units 1 and 2 is moderately erodible. This is evident within the road reserves in the subject land where the A horizon has been removed, exposing the B horizon to rill and gully erosion.

Acidity/alkalinity
The A and B horizons are very strongly acid to strongly acid, limiting the availability of several nutrients to plant uptake. The application of agricultural lime or dolomite within the effluent disposal areas would provide more favourable conditions to plant growth.

Cation Exchange Capacity (CEC)
The CEC is the capacity of the soil to hold and exchange cations. CEC effects soil structure, nutrient availability and the soil's response to additional nutrients. The CEC of the A and B horizons in terrain units 1 and 2 is low. This could be improved by adding gypsum and organic matter.

Calcium to Magnesium ratio (Ca:Mg ratio)
The Ca:Mg ratio in the A horizon is low, bordering on Ca deficient in terrain unit 2. The B horizon in both terrain units is Ca deficient, a characteristic linked to clay dispersion. The addition of gypsum, lime or dolomite may benefit soil structure.

P sorption capacity
The P sorption capacity and P sorption index indicate the capacity of the soil to absorb P. The P sorption index for the A horizon is very low. The higher P sorption capacity in the B horizon can be attributed to the higher clay content.

The P sorption capacity can be expressed as concentration (mg/kg). P sorption values for each soil horizon are used to calculate the total P sorption capacity of the soil profile to an arbitrary depth of 1m, over an area of 1 ha as shown in Table 3.

Table 3. P sorption capacity (kg/ha)

Depth (m)	Average P sorption capacity in samples (mg/kg)	Assumed bulk density	Calculated field P sorption capacity (kg/ha)
0 - 0.15	307	1.4	645
0.15 - 1.0	570	1.4	6783
TOTAL (0 – 1.0 m)			7428

According to the NSW Health Guidelines, a P sorption capacity of >6000 kg/ha is regarded as a 'minor limitation'. The risk of leaching of P through the soil profile increases as the P sorption capacity is reduced and the critical value proposed by the NSW Health Guidelines is one third of the total P sorption capacity. Based on these assumptions, the soil in the subject land could adsorb 2476 kg/ha of P (i.e. ⅓ x 7428 kg/ha) before water quality is adversely impacted.

Correspondence from the EPA in response to the Coffey Geosciences report expressed a view that the P balance should actually be calculated only for the relatively permeable upper soil profile. This view was based on Coffey's soil observations, in particular, Coffey's conclusion that *"…significant percolation to the B horizon is not envisaged"* which was based on observations of the shallow depth of the A horizon, coupled with mottling in the B horizon. However that this suggestion would not be consistent with the methodology provided in the NSW Guidelines for calculating the total P sorption capacity of the soil profile.

Salinity
The soils in the subject land are non-saline.

Sodicity
The soils in the subject land are non-sodic.

3.4 Vegetation

BES (2007) described five native vegetation communities within the subject land:

- Large-fruited Red Mahogany Swamp Forest in the north-east corner of the subject land (approx. 4 ha)
- Blue Gum/Bangalay Hybrid Open Forest occurring in wetter area in south-west portion of the site occupying approximately 4.8 ha.
- Blackbutt Spotted Gum Open Forest in western half of subject land (approx. 38.5 ha) on higher slopes and crests
- Scribbly Gum – Red Bloodwood Woodland on eastern third of the subject land (approx. 23 ha) on drier crest and upper slope positions extending to mid-slope positions.
- Melaleuca Bangalay Swamp Forest occurs in the south-west drainage line (approx. 4.1 ha).

A map showing the distribution of these is provided in Figure 10. The Large-fruited Red Mahogany Swamp Forest and the Melaleuca Bangalay Swamp Forest were collectively classed as Swamp Sclerophyll Forest, an Endangered Ecological Community (EEC) on the NSW Threatened Species Conservation Act, 1995.

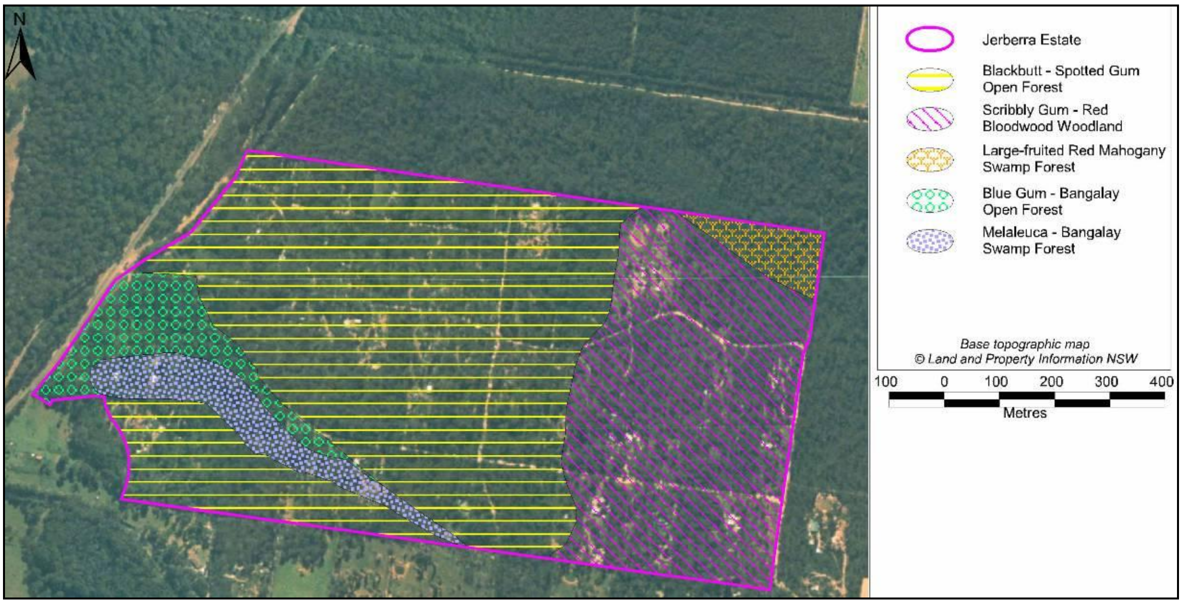

Figure 10 - Vegetation communities (source: BES 2007)

While the tree canopy remains partly intact across most of the subject land, approximately one third to one half of the subject land has been under-scrubbed. Vegetation on a number of lots is still relatively undisturbed.

Some tree removal would be recommended on many of the developable lots to improve sun exposure in the effluent disposal areas during winter (refer to section 3.5).

3.5 Sun and Wind Exposure

Sun and wind exposure influence the effectiveness of evapotranspiration, a key process in the water cycle and important parameter in determining the minimum effluent disposal area.

Sun exposure is affected by topography and vegetation (if it creates shading). Vegetation within the subject land is generally open forest with a shrubby understorey. About one third of the subject land has been under-scrubbed. It is likely that some clearing would be required to meet bushfire asset protection zone requirements, in which case, sun exposure may improve slightly. However to create more optimum sun exposure additional clearing would be required.

Topography, viz., the combination of slope and aspect influence the level of sun exposure. The slope is gently inclined (refer to Figure 8). The aspect of the subject land is shown in Figure 11.

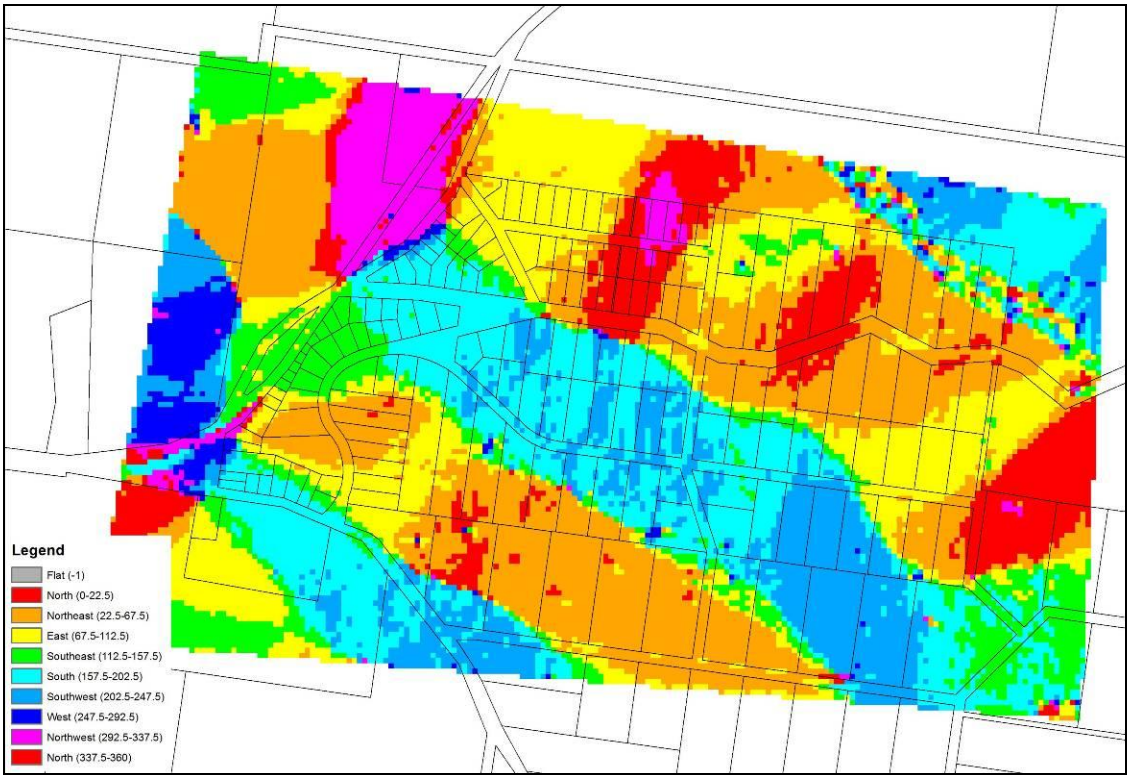

Figure 11 - Aspect of subject land (source: SCC LiDAR data)

The majority of the proposed developable lots (approximately 2/3) would have a favourable aspect (north-west through to north-east).

3.6 Climate

Coffey Geosciences (2000) used rainfall data from the Jervis Bay (Point Perpendicular) weather station in their water balance calculations. However, Point Perpendicular is approximately 19 km east of the subject land. Advice provided by the Bureau of Meteorology in this regard is that Wandandian (stn no. 068222) is more appropriate as it is closer to the subject land (approximately 10 km), and is a similar distance from the coast.

The nearest available evaporation data are from Albatross. Median monthly precipitation (Wandandian) and mean monthly evaporation (Albatross) are illustrated in Figure 12.

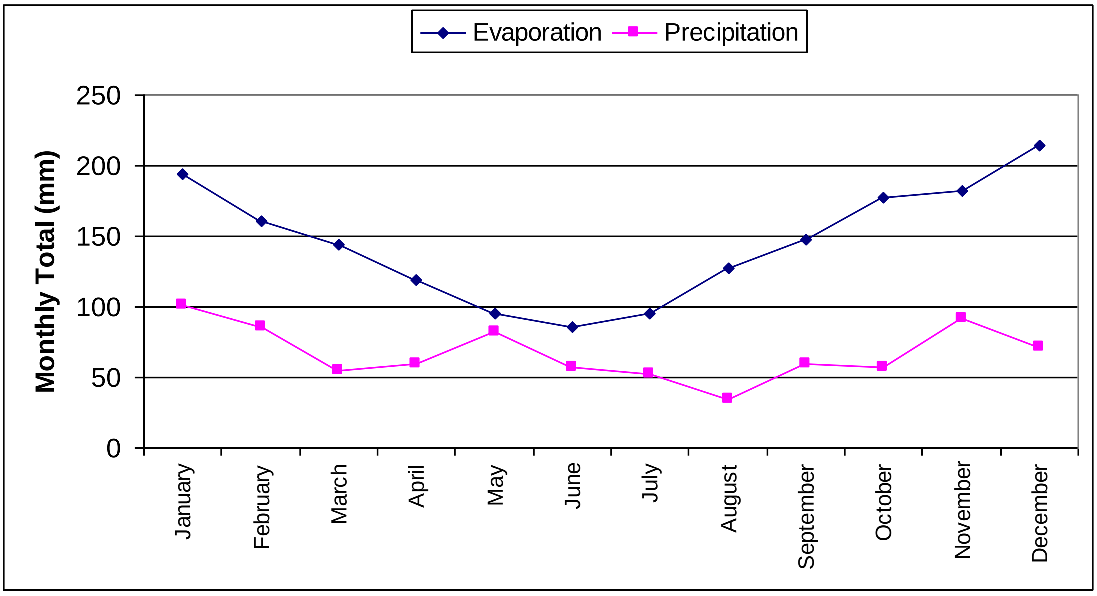

Figure 12 - Comparison of mean monthly evaporation (Albatross) and median monthly rainfall (Wandandian)

The data presented in Figure 12 show that evaporation exceeds precipitation throughout the year. The difference between precipitation and evaporation is least during May and June.

3.7 Summary of site and soil assessment

Site Feature	Limitation category	Implications/comments
Flood potential	minor	Not mapped as flood liable
Sun & wind exposure	moderate	Evapotranspiration may be reduced by shading from trees or southern aspect. May improve as development proceeds, depending on extent of tree removal and solar orientation of effluent disposal systems (will have to be addressed at DA stage).
Slope	minor to moderate	Surface irrigation not recommended for slopes >6%
Runon, groundwater ingress	minor to moderate	Groundwater cut-off trenches or diversion drains should be incorporated into design for individual dwellings at DA stage.
Erosion potential	moderate	Care should be taken to avoid exposing the clay subsoil.
Site drainage	minor	Poorly drained land to be excluded from effluent disposal
Buffer distances	minor to major	Buffer distances from watercourses are provided through provision of buffers to protected flora

		which occur in the main drainage lines (*Melaleuca biconvex* and Swamp Sclerophyll Forest EEC)
Land area	minor to major	A number of the lots are too small to safely accommodate onsite effluent disposal. This will be addressed by requiring the amalgamation of lots through the minimum lot size map.
Rock/rock outcrop	minor	
Geology/regolith	minor	
Other		

Soil Characteristic	**Limitation category**	**Implications/comments**
Depth of topsoil	major	Importation of organic soil recommended.
Depth to bedrock	minor	
Episodic water table depth	moderate	Mottling in B horizon indicates imperfect drainage and may become saturated for extended periods of time.
pH	moderate	Addition of lime/dolomite recommended at 2.5 kg/10 m^2 to optimise plant growth (and utilisation of effluent nutrients)
Electrical conductivity (EC)	minor	
Sodicity	minor	
Cation exchange capacity (CEC)	moderate	Importation of good quality soil recommended.
P sorption	minor	
Soil structure, aggregate stability	moderate	Soil amelioration and/or importation of organic-based soil blend recommended. Addition of gypsum prior to organic matter is recommended.

3.8 Area available for effluent disposal

The area available for effluent disposal would depend on a range of factors including:

- lot size & configuration;
- slope and aspect; and
- size and position of building footprint and other features such as sheds, driveways, paths etc.

Existing lot sizes

As can be seen in Figure 13 below, there is currently a wide variation in lot size in the subject land. 45 properties are less than 0.2 ha and 81 properties are less than 0.3 ha. A number of the smallest lots are within the proposed E2 area (where no development is proposed).

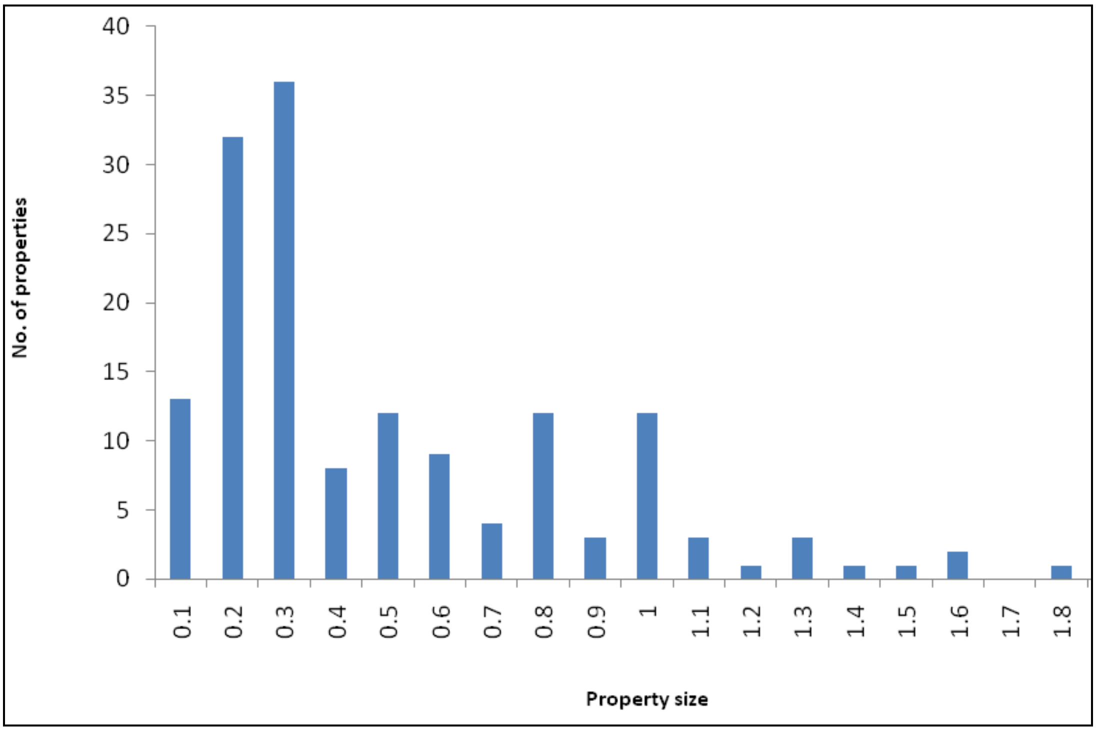

Figure 13 - Histogram of Jerberra Estate property sizes

This strategic assessment concerns the ability of the existing lot configuration to accommodate onsite effluent disposal whilst meeting environmental and health objectives; and whether lot consolidation is necessary to meet these objectives. As the lot size and configuration varies, it is necessary to determine the relationship between lot size and the area available for effluent disposal.

The area available for onsite effluent disposal on individual lots was determined for nine (9) 'case study' lots ranging in size and configuration. A site plan was drawn for each lot, showing a building envelope (15 metres x 20 metres) set back at least 10 metres from the front boundary and with a 3 metre wide driveway access. The accepted minimum setbacks were applied to these features.

The area available for effluent disposal also varies depending on whether the method of application is surface or subsurface. In the case of surface spray irrigation, a 15 metre setback is required from dwellings, whereas the setback for drip or trickle irrigation is between 3 and 6 metres depending on slope. Thus, the area available for drip or trickle irrigation would be expected to be greater than for surface spray irrigation. For each lot, two scenarios were calculated:

1. Area available for above-ground spray irrigation; and
2. Area available for sub-surface drip irrigation.

An example of one of the prepared site plans is provided in Figure 14. All of the case study site plans are provided in the Appendices. This analysis was undertaken prior to the planning proposal being prepared and some of the lots are not proposed to be developed. Nevertheless the data allows the relationship between the lot size and the area available for effluent disposal to be established.

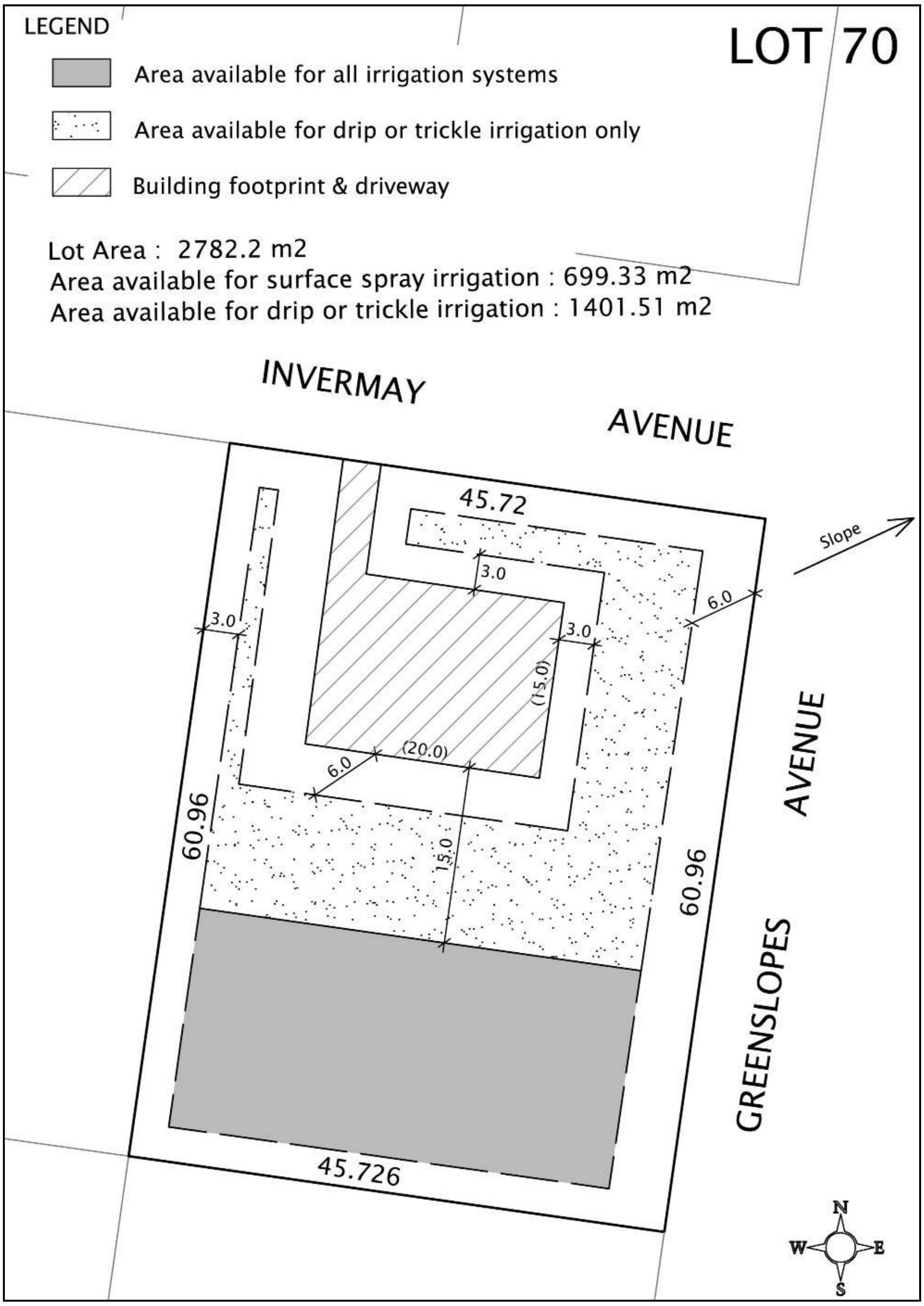

Figure 14 - Sample site plan showing building envelope, driveway & effluent disposal area

The lot size and area available for onsite effluent disposal, including for drip/trickle irrigation or surface spray irrigation, are provided in Table 4 and Figure 15.

Table 4 - Areas available for effluent disposal on case study site plans

Lot area (m^2)	Area available for drip or trickle irrigation (m^2)	Area available for surface irrigation (m^2)
1188	269	51

1226	211	0
1802	646	160
1935	530	282
2320	974	607
2561	1520	231
2782	1402	699
3465	1912	1147
4844	3142	2110

The data shown in Table 4 is shown graphically in Figure 15.

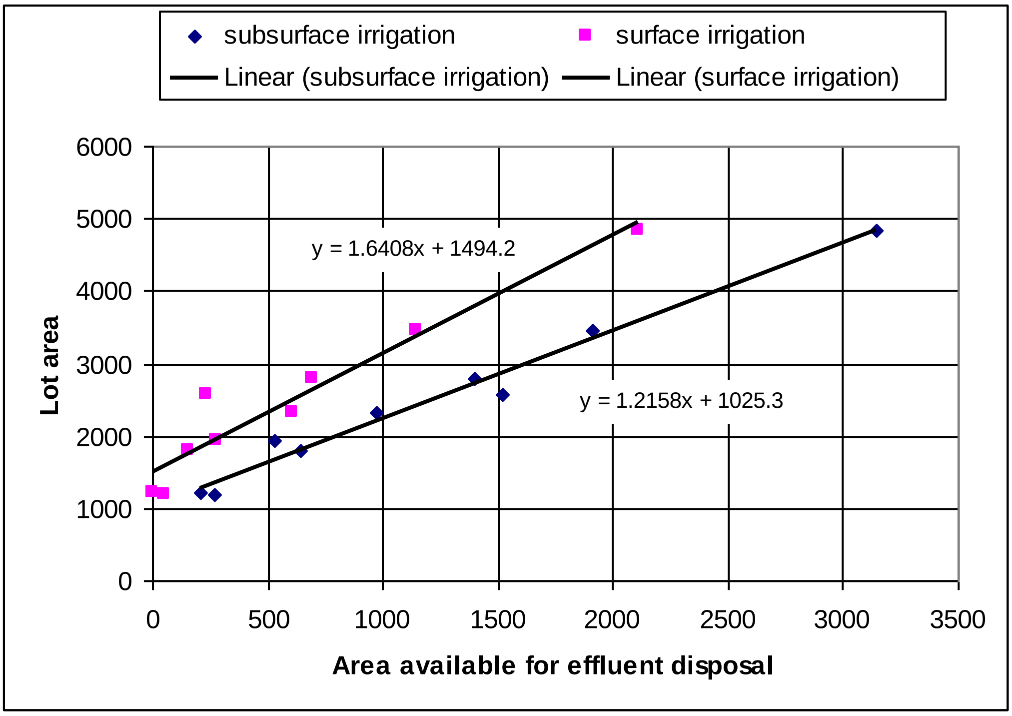

Figure 15. Relationship between lot size and onsite effluent disposal area

The regression equations can be used to calculate the lot size that would be required for a given effluent disposal area, where:

LS = lot size

EDA = effluent disposal area

For example, the lot size required to provide 1,500 m^2 for effluent disposal (including reserve area) would be:

<u>Minimum lot size equation 1 - spray irrigation</u>

$$LS = 1.6408 \times EDA + 1494$$
$$= 1.6408 \times 1{,}500 + 1494$$
$$= 3{,}955 \text{ m}^2$$

<u>Minimum lot size equation 2 - subsurface irrigation</u>

$$LS = 1.2158 \times EDA + 1025$$
$$= 1.2158 \times 1{,}500 + 1025$$
$$= 2{,}849 \text{ m}^2$$

Any additional setback requirements, for example if other sheds or other structures are located outside of the building envelope would mean that less land is available for onsite effluent disposal.

4. LITERATURE REVIEW

4.1 *Characteristics of domestic wastewater*

Household wastewater includes blackwater, which contains human excreta and water grossly contaminated with human excreta, and greywater; wastewater from kitchen, bath, shower and laundry. Greywater is also contaminated with human excreta and includes detergents, cleaning agents, fats and oils, food wastes and various other substances including organic wastewater compounds such as surfactant metabolites, steroids, stimulants, antimicrobial agents, and pharmaceutical compounds (Seigrist, et al. 2007).

Characteristics of Typical Untreated Domestic Wastewater are summarised in Table 5.

Table 5 – Constituents of untreated domestic wastewater

Parameter	**NSW guidelines** (NSW Health 1998)	**Literature** (Lowe, et al. 2006)
Biochemical oxygen demand (BOD_5) [mg/L]	200 - 300	343 (30 – 1147)
Suspended solids [mg/L]	200 - 300	293 (18 – 2232)
Total N [mg/L]	20 - 100	63 (44.1 – 189)
Total P [mg/L]	10 - 25	19 (13.0 – 25.8)
Faecal coliforms [cfu/100 mL]	10^3 - 10^{10}	4.9 x 10^5 (10^4 – 10^6)

Domestic wastewater must be treated to prevent damage to the environment and minimise health risks. The main health risks concern pathogens in wastewater including faecal coliforms and viruses.

4.1.1 Pathogens

Pathogens are micro-organisms that can cause diseases. Pathogens include bacteria, protozoa and viruses. Pathogenic organisms are present in high numbers in untreated domestic wastewater. Wastewater treatment, including disinfection, decreases the number of pathogenic organisms present. Faecal coliforms are used as an indicator of pathogenic contamination.

4.1.2 Nutrients

Domestic wastewater contains relatively high concentrations of the elements nitrogen (N) and phosphorus (P), essential macro-nutrients for plant growth.

These elements are present in organic and inorganic forms, derived from urea and human solid wastes, and the decomposition of proteins contained in waste from the household, including cleaning agents. The amount of phosphorus contained in cleaning agents has decreased significantly in recent years.

The discharge of excess N and P can adversely impact on downstream ecosystems in the long term. High concentrations of nitrogen and phosphorus in waterways can be an important contributor to eutrophication. Symptoms of eutrophication may include algal blooms and seagrass decline.

4.2 *Nitrogen in the environment & removal from wastewater*

Nitrogen (N) gas comprises 78 % of the Earth's atmosphere, but most plants and animals cannot use nitrogen gas directly, instead relying on nitrogen to be "fixed" from the air and bonded to hydrogen or oxygen to form inorganic compounds, mainly ammonium (NH_4^+) and nitrate (NO_3^-) (Fields 2004).

The amount of gaseous N being fixed at any given time by natural processes represents only a small addition to the pool of previously fixed nitrogen that cycles among the living and nonliving components of the Earth's ecosystems as shown in Figure 16. Most of non-gaseous N is unavailable, locked up in soil organic matter and plant and animal remains (*ibid.*).

Nitrogen-fixing organisms include a relatively small number of algae and bacteria. Of particular importance are Rhizobia, which form symbiotic relationships with peas, beans, alfalfa and other legumes, growing on nodules on their roots. These bacteria manufacture an enzyme that enables them to convert gaseous N directly into plant-usable forms. A relatively small amount of N is fixed by lightning (*ibid.*).

Nitrogen enters estuarine systems via catchment runoff, tidal transport and fixation of gaseous N from the atmosphere. It is lost from the system mainly by tidal and freshwater flushing and diffusion of gases to the atmosphere (NSW Department of Natural Resources 2009), as shown in Figure 16.

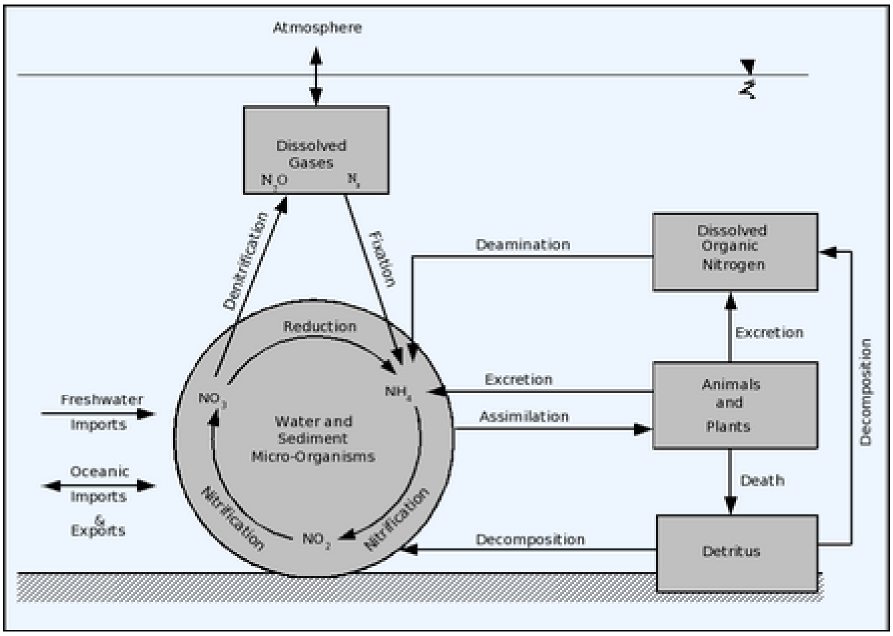

Figure 16 - Nitrogen cycle in context of estuaries (NSW Department of Natural Resources 2009)

Treatment processes for nitrogen removal involve sequential nitrification/denitrification. While there are other removal processes, biological nitrification/denitrification is the only process that has been demonstrated to be economically and technically feasible for onsite N removal (Washington State Department of Health 2005).

Nitrification uses aerobic processes to transform organic nitrogen and ammonia products to nitrate. A variety of treatment devices can be used to aerate the wastewater, such as aerobic treatment units utilising blowers or fans, or more passive trickle devices using sand, gravel or other filter media.

Denitrification requires shifting the wastewater from aerobic to anaerobic (without oxygen, anoxic) to allow the growth of denitrifying bacteria which utilise the nitrate-bound oxygen and organic carbon in the wastewater, and transform the N to gas. An inadequate supply of organic carbon will limit the denitrification process (*ibid.*).

In reality, achieving the correct environmental conditions is complicated by several factors including:

- fluctuating flow rates;
- fluctuating waste strengths;
- temperature;
- acidity and alkalinity; and
- inhibitory compounds.

According to Washington State Department of Health (*ibid.)* removal rates of 50 – 70% can be reached fairly consistently but achieving higher removal rates and consistently low N concentrations requires more complex treatment and more onerous monitoring and maintenance.

Denitrification can account for significant N losses in certain soil conditions, particularly where there is an impermeable B horizon.

4.3 *Phosphorus in the environment & removal from wastewater*

Phosphorus (P) is a naturally occurring element that exists in minerals, soil, living organisms and water. P is the least mobile of the major plant nutrients. The forms of P summarised from Wiederholt and Johnson (2005) include:

- Organic P - the principal form of phosphorus in the manure of most animals. About two-thirds of the P in fresh manure is in an organic form.
- Soluble P - can include small amounts of organic P, as well as 'orthophosphate'. It also is the form subject to loss by dissolution in runoff and to a lesser extent, leaching. Soluble P is the smallest proportion of the total P in most soils.
  When soluble P is added to soil, the soil's pool of soluble P increases and is transformed over time to less soluble (less plant available) forms.
- Attached or "bound" P - inorganic P unavailable for plant uptake. A large amount of the soil's P is bound in compounds that are formed when the anionic (negatively charged) forms of dissolved P become attached to cations, such as iron, aluminium and calcium.

> Attached P includes labile, or loosely bound, and "fixed," or tightly bound, P compounds.

P that is loosely bound to soil particles (labile P) remains in equilibrium with soluble P. When plants take up soluble P, labile P is converted to the soluble form to maintain the equilibrium (*ibid.*).

The concentration and load of particulate and soluble forms of P in waterways reflect the stresses imposed by land uses and land practices in the catchment. All soils naturally release some soluble P into surface runoff. Soil P concentrations affect the concentration of soluble P in runoff. Substantial evidence shows soluble P concentrations in runoff increase linearly with increasing soil P concentrations. However, this linear relationship varies between soil types (*ibid.*).

Damann et al. (1998) reported that in a controlled trial of alternate nutrient removal systems in Florida, P sorbing materials in a lined irrigation bed performed best in terms of P removal with <1 mg/l total P in treated effluent.

4.4 *Onsite Wastewater Systems (Secondary & Advanced)*

4.4.1 Introduction

This section outlines a range of secondary treatment systems, add-on treatment processes and wastewater reduction/management options that could be considered for the subject land. Potentially, there are numerous types of systems that can be used in isolation or in combination to manage effluent on constrained sites. Secondary treatment systems provide treatment beyond primary settling in a septic tank, incorporating aeration of the wastewater. These generally include AWTS, single pass and recirculating sand/rock filter systems, biological filtration systems. Advanced systems utilise nutrient removal process either for nitrogen and/or phosphorus. Such systems potentially include amended earth mounds, membrane filtration, and optional phosphorus removal processes for AWTS. Various types of systems are described in this section.

4.4.2 Aerated wastewater treatment systems (AWTS)

Aerated wastewater treatment systems (AWTS) incorporate active oxygenation of wastewater to promote aerobic biological processes. Effluent can be oxygenated either mechanically (i.e. using air pumps/blowers) or passively (e.g. trickling filter).

The level of treatment achieved by AWTS depends on a number of factors including maintenance of an adequate microbial biomass in the aeration chamber. Fluctuations in hydraulic load (e.g. caused by intermittent or variable occupancy) and effluent strength can cause fluctuations in microbial conditions and therefore AWTS performance. Microbial populations are also susceptible to the presence of anti-bacterial agents in effluent due to inappropriate use of household cleaning productions, anti-biotic medications and other biocides.

AWTS vary in respect of process used, but consist mainly of attached growth or suspended growth process. Oxygen is supplied to the tank in a number of ways: air diffusers; mechanical mixing or by trickling wastewater through a porous filter media. At least one AWTS manufacturer has an optional P removal process which involves dosing with a flocculating chemical (ferric chloride) to precipitate and bind phosphorus to the sludge which must be periodically removed.

Research commissioned by the SCA involved sampling from 44 operating AWTS. The results generally met NSW Health requirements for the tested parameters as shown in Table 6.

Table 6. Concentrations of nutrients from 44 operating AWTS in the Sydney region (Charles et al. 2005; Charles, pers. comm., 2006)

	Total N [mg/L]	Total P [mg/L]	SS [mg/L]	BOD [mg/L]	Free chlorine [mg/L]
average	22	14	18	11	0.5
80th percentile	32	19	27	15	0.5
NSW Health guideline value	25-50	10-15	<30	<20	0.2 - 2.0

The average concentrations or total N and total P reported above (22 and 14 mg/L respectively) have been included in the nutrient balance calculations.

4.4.3 Biological filter systems

Biological filter systems involve passing effluent over fixed media inoculated with micro-organisms. Effluent is trickled through media inoculated with worms and micro-organisms and is passively aerated in the process. There are currently two manufacturers of accredited biological filter systems. Both of these treat effluent to a sufficient standard to be disposed of via sub-surface drip irrigation.

On constrained sites where nitrogen or phosphorus is the limiting factor, consideration should be given the nutrient removal capability of the specific system. Independent test data for the specific system should be used for nutrient balance calculations.

Biological filter systems generally have lower power requirements to many AWTS and are a viable alternative to AWTS in some situations such as where power is not available or supply is prone to regular disruption.

4.4.4 Membrane filtration

Membrane filtration involves the use of a non-absorbent, porous membrane to trap particles (including bacteria) and filter water. There are four categories of membrane types based on pore size: reverse osmosis; nanofiltration, ultrafiltration; and microfiltration. The pore size dictates the quality of filtered liquid (Mallia and Till 2001). Finer pore sizes produce higher quality effluent but are more prone to fouling.

Pore sizes commonly employed in wastewater treatment are typically 0.1 to 10 microns diameter (microfiltration), filtering a very high proportion of suspended solids and pathogenic organisms.

Membrane filtration is highly energy intensive process especially if pretreatment is inadequate Membranes can be expensive to replace and the cost of installation and servicing may be prohibitive to individual landholders.

Currently, two AWTS accredited by NSW Health incorporate membrane filtration. The certificate of accreditation for one of these provides the following nutrient removal information derived from testing under controlled conditions:

- Total N reduced on average from 45.6 mg/l to 6.19 mg/l; a reduction by 86%;
- Total P reduced on average from 7.6 mg/l to 0.29 mg/l; a reduction by 96%.

The manufacturer of this system indicated that the cost for the system alone would be approximately $10,000, excluding installation and irrigation system costs. The system requires servicing every 6 months (although the certificate of accreditation stipulates quarterly servicing) at a cost of around $600 p.a. The manufacturer indicated that this service fee covers cleaning and eventual replacement of the membranes.

The certificate of accreditation for another membrane system accredited as an AWTS provides the following nutrient removal information:

- Total N reduced on average by 87% with all samples recording less than 20 mg/L total N;
- Total P reduced on average by 89% with all samples recording less than 10 mg/L total P.

Membrane filtration could also be an option for a community-scale or cluster system due to economies of scale.

4.4.5 Sand filters

Sand filters are most commonly used to provide a higher standard of treatment after primary treatment in a septic tank, before sub-surface disposal. They could also be used to provide additional treatment following an AWTS or biological filter system if this was cost effective.

Recirculating filter systems typically use sand, foam, textile or biodegradable media (Pratt, et al. 2004). Currently, one sand filter is accredited by NSW Health.

Sand filters could however be used to ‘polish’ effluent after treatment by AWTS or biological filter system. Sand filters may treat wastewater in a single pass, or may recirculate the wastewater through the sand filter a second or third time.

Recirculating filters may be appropriate in environmentally sensitive areas or where effluent must be treated to a high standard. After the wastewater has passed through the filter for the first time, it is collected and piped to a recirculating tank where it mixes with the septic tank effluent. When the recirculating tank is low, the effluent is recirculated through the filter for a second pass. When the recirculating tank is full, a valve diverts the water to the disposal pipes, to prevent overloading the system (Perkins 1989). The ratio of sand filter effluent that is recirculated should range from 3:1 to 5:1.

Recirculating filter systems are noted for their ability to remove N from effluent following primary treatment. Performance varies significantly, typically between 40% and 75% of influent N is removed, and is largely dependent on an adequate carbon to nitrogen ratio (>5:1) and adequate oxygen supply in the aerobic phase (Damann, et al. 1998; Davison and Herity 2005); Jantrania, et al. 1998; Loomis, et al. 2001; and Pratt, et al. 2004).

4.4.6 Wetlands

In a horizontal sub-surface flow wetland (HFW) wastewater flows horizontally through a bed of gravel into which reeds have been planted. Oxygen transfer from the roots of the reeds creates aerobic micro-sites in a predominantly anaerobic/anoxic environment. Nitrification and denitrification processes can occur simultaneously (Davison et al. Undated).

In vertical flow wetlands (VFW) wastewater flows vertically down through a largely aerobic environment of sand or gravel substrate planted with reeds providing a similar level of treatment to a single pass sand filter.

Research by Davison (*ibid.)* at Lismore on the NSW North Coast has explored the use of various combinations of sand filters, horizontal and vertical flow wetlands to optimise nitrification and denitrification processes for N removal. The report states:

> *It is suggested that a fruitful area for further research in combined vertical flow/horizontal flow systems would be the intentional bypassing of a fraction of primary treated effluent to the horizontal flow device as a way of providing the carbon for denitrification. The fact that, on a number of occasions in this study, solitary HFWs achieved TN load removals in excess of 80% indicates that the added complexity and expense entailed in combined systems may not be warranted (especially in smaller systems) until further light is shone on their nitrogen removal requirements.*

The literature suggests that well designed sand filter/constructed wetland combinations can remove significant portions of nitrogen and phosphorus. The main weakness of these systems appears to be the consistency of performance, which can partly be attributed to substrate material used and influent quality and variability. Particle size and uniformity are critical to the rate at which effluent passes through the system, which strongly influences the degree of treatment achieved.

Removal of both nitrogen and phosphorus may decline after initial establishment of the wetland(s) depending on the system design and materials used. More consistent N removal can be achieved by recycling a portion of the treated effluent back through the system (Brix and Arias 2005; Davison et al. Undated)).

Davison et al. (undated) tested a number of combinations of sand filters and constructed wetlands and obtained variable results. For example Davison reported:

> *Total phosphorus (TP) removals varied from <0% to 90% of influent load in the seven HFWs studied. Removal was highest in those reed beds following a sand filter and therefore having wastewater with a high redox potential. All of the reed beds studied were less than 18 months old at the time of sampling and removal rates are expected to decline as available precipitation and adsorption sites saturate.*

Total nitrogen (TN) load removal by HFWs in both parts of the study exceeded 80% during the period of rapid reed growth. This removal rate declined to closer to 60% after approximately a year, a figure which corresponds to performance found in other local studies. Because of the complexity of nitrogen dynamics in HFWs it is difficult to increase TN removal by increasing residence time alone. The Second Study at the Test Facility highlights the importance of the reeds in the complex nitrogen removal process.

The ability of constructed wetlands to remove phosphorus depends largely on the substrate material used. Mann (1997) trialled 9 substrata in constructed wetlands including 6 steelworks by-products including granulated blast furnace slag, blast furnace slag, steel slag, fly ash, bottom ash and coal wash. Korkusuz et al. (2004) achieved 60% total phosphorus removal in a VFW using granulated blast furnace slag in the substrate compared to 9% for gravel. A review of literature on substrate materials used in wetlands for phosphorus removal was undertaken by Westholm (2006). It is difficult to compare studies on phosphorus removal due to the large range of variables in methods and experimental design. Slag materials were noted for their potential phosphorus removal capabilities, yet it was concluded that in relation to all materials, there is no empirical data on the longevity of phosphorus removal from the use of various substrate materials.

Attempts to find an effective phosphorus sorbing material for use in wetland substrate in Denmark were abandoned in favour of dosing the sedimentation tank with aluminium polychloride to precipitate phosphorus and remove via annual desludging (Brix and Arias 2005).

Constructed wetlands are reputed to be low maintenance, have low power consumption requirements, and be more stable than many other treatment systems.

4.4.7 'Wisconsin' sand mounds

The Wisconsin sand mound was developed in the US in the 1970's to overcome soil and site limitations such as low soil permeability, high groundwater, shallow soils etc. The system normally includes septic tank, dosing chamber and elevated sand mound. Alternatively effluent could be aerobically pre-treated. The mound itself consists of a layer of sand, aggregate, a pressure distribution network and is covered by a layer of topsoil (Blasing and Converse 2004).

Treatment provided within sand mounds is similar to that provided in a single-pass sand filter.

Leakage at the toe of the mound during saturated conditions is the main failure mechanism for this type of system and can be associated with pathogen contamination although it has been argued that this does not pose a health or environmental concern (Blasing and Converse 2004). Blasing and Converse (*ibid.*) reported nitrogen removal efficiencies of 55% from pre-treated effluent to the toe of the mound across a range of mound systems. Other removal efficiencies reported were 80% of total suspended solids and 99.8% of faecal coliforms.

4.4.8 Amended earth mound systems

Amended earth mound systems are similar to Wisconsin sand mounds except that they are lined with an impervious barrier and various materials with nutrient (particularly P) absorbing properties are mixed with the sand. P removal occurs primarily by chemical and physical adsorption and/or complexation and precipitation with Fe, Al or Ca (Pratt, et al. 2004). Materials used to remove P typically include red mud, blast furnace slag, fly ash and lightweight expanded clay aggregate. A system marketed in NSW utilises blast furnace slag which is mixed with sand.

Amended earth mound systems typically comprise:

- a septic tank;
- two 'cells' underlain by an impermeable membrane that are used in rotation; and
- a leach drain is located in the centre of each cell, surrounded by the amended medium which is covered by topsoil and planted with grass and/or shrubs to aid evapotranspiration.

The cells are used alternately at 3-6 month intervals.

Amended earth mounds can operate with little or no power depending on whether effluent enters via gravity or is pumped. However, there is a relatively high capital cost (typically $13,000-$15,000) and the mounds can limit amenity of the area.

Staff in Council's Development & Environmental Services have indicated the incorrect installation of amended earth mounds is not uncommon. In some cases the mounds are installed too deep in the soil profile (in an effort to make them less visible) reducing the potential evapotranspiration.

Amended earth mound systems do not require accreditation in NSW and there is no independent test data for the systems being marketed for individual residences.

A manufacturer of amended earth mounds claims to achieve effluent with 10 mg/l or less of total N and <1 mg/l total P. Available data however suggests less N concentrations can be substantially higher. A study commissioned by the Sydney Catchment Authority (SCA) involving a commercial amended earth mound designed to treat up to 5000 L/day (i.e. larger than a domestic scale system), found P removal varied between 98.3% - 99.6% (20th and 80th percentiles) equivalent to approximately 0.07 mg/L P. P removal was inversely correlated to hydraulic load. N removal was poor at 0 – 69% (20th and 80th percentiles). The average N and P concentrations were 40 mg/L N and 0.07 mg/L P (Charles, et al. 2004).

Hydraulic load and climate are likely to influence to the N removal efficiency. No data is currently available to validate nutrient removal performance of amended earth mounds in the Shoalhaven.

4.5 *Wastewater Reduction Options*

In addition to limiting the scale of development, there are several options for households to reduce water consumption and these should be considered particularly for sites with limited area available for effluent disposal. These options are discussed in the following sections and include:

1. use of dry composting and hybrid toilets to reduce the volume of blackwater;
2. use of water efficient plumbing fixtures which reduce the volume of blackwater and greywater; and
3. reuse of greywater for toilet flushing and laundry use.

4.5.1 Dry Composting Systems & 'Hybrid' Toilets

Composting toilets (also known as humus closets or biological toilets) are systems which rely on the principles of composting by micro-organisms to decompose human waste, paper and other materials into humus. Dry composting systems can consist of either single or multi-chamber systems. The multi-chamber carousel type must be rotated after each chamber is filled. Dry composting systems are typically installed directly below the toilet and treat toilet waste only.

Micro-organisms decompose the material, with around three quarters of it being converted to carbon dioxide and water vapour. Air drawn through an exhaust pipe removes these gases and maintains an aerobic environment. The remaining solids are converted to friable compost. Excess liquid either flows into the greywater stream, which includes all other wastewater generated in the bathroom, kitchen and laundry, or is directed to a separate wastewater treatment system and land application area.

The maintenance of the composting toilet is the responsibility of the owner/occupier and is not normally subject to a maintenance contract. Maintenance varies among composting toilets, and the needs of particular units should be specified clearly in a manual provided by the manufacturer. If maintenance is not undertaken properly there is an increased risk of disease and odour generation. It is recommended that an approved contractor service units annually. The minimum composting period should be 12 months.

Unless otherwise permitted by Council or the NSW Department of Health, all compost from the system must be buried within the boundaries of the premises. The cover of the soil over the deposited humus must be at least 300 mm. Compost must also not be buried in an area used for the cultivation of crops for human consumption, unless:

- compost is placed in a separate lidded composting bin providing aeration for at least three months with no further addition; or
- compost has seasoned underground for at least three months. (Hornsby Shire Council Undated).

Dry composting toilets are generally direct-drop installations. Therefore, their exclusive use in a dwelling is a significant design limitation.

If dry composting toilets are used exclusively in a household, the wastewater load would be reduced by 50-60 litres per person per day compared to a household with standard plumbing fixtures (refer to Table 7) equivalent to 30-40% of total effluent volume. However, with the use of more water efficient toilets (assisted by the introduction of BASIX) the capacity of dry composting toilets to reduce household wastewater generation is less. Refer to section 4.5.2.

The Hybrid Toilet has a drop toilet over a dedicated, water-filled primary anaerobic digestion tank. Displaced effluent then enters a secondary treatment chamber via a series of baffles. Aeration is provided passively through tank ventilation and surface-overflow and micro-organisms are encouraged to grow on plastic pipe media. The toilet can be either zero flush or 'micro' flush (i.e. 0.3 L). The very long solids and liquid detention times provide effective stabilisation. The liquid overflow can then be disposed of appropriately or subject to further treatment. The system requires odour ventilation and must be periodically de-sludged. The system requires at least 1.3 metres of space below floor level which makes it difficult to add to existing dwellings.

4.5.2 Water efficient plumbing fixtures

Wastewater generation can also be markedly reduced by using water efficient plumbing fixtures. This is reflected in the water use figures provided in AS1547 (2000) and a draft revision of AS1547 (DR07920) (Standards Australia 2008) as shown in Table 7.

Table 7 - Wastewater generation rates for rainwater tank supply based on AS1547 (2000) and Draft AS/NZ standard (DR 07920:2008)

Source	Typical wastewater flow allowance (L/person/day)[4]	
	Rainwater tank	Reticulated/town
Households with extra wastewater producing facilities	180	220
Households with no water saving features	180	200
Households with standard fixtures	140	180
Households with standard water reduction fixtures[1]	115	145
Households with full water reduction fixtures[2,3]	80	110
Blackwater only	50	60
Greywater only	90	120

Notes

1 Standard water reduction = 5.5/11 litre dual flush toilets, shower flow restrictors, aerator taps, and "water conserving automatic washing machines".

2 Full water reduction = 3/6 litre dual flush toilets, shower flow restrictors, aerator taps, "front load washing machines", and flow/pressure control valves on all water use outlets.

3 Additionally, full water reduction may be achieved by treatment of greywater and recycling for toilet flushing and washing machines.

4 Number of persons should be based on maximum occupancy.

The Water Efficiency Labelling and Standards (WELS) Scheme requires mandatory water efficiency labels on all showers, toilets, domestic washing machines and dishwashers, urinals and some types of taps, as well as voluntary water efficiency labels on flow control devices (Australian Government 2009). The WELS Water Rating label is similar in appearance to the Energy Rating label (which clothes washing machines and dishwashers are also required to carry).

Toilet cisterns are subject to a mandatory water efficiency requirement of an average of 5.5 L per flush, which for a dual flush, equates to 9/4.5 L per flush. The combined effect of the WELS scheme and BASIX is that new dwellings need to be fitted with 'standard water reduction fixtures' or better as referred to in AS1547. However, additional water generating fixtures such as spas have the potential to offset these efficiency gains.

4.5.3 Greywater reuse

There are two main ways in which household greywater can be reused: either through a greywater diversion device; or through a greywater treatment system and reuse for a beneficial purpose. These are briefly discussed below.

4.5.3.1 Greywater Diversion

Greywater diversion devices divert untreated greywater directly to a subsurface disposal system. They can be either gravity or pump-assisted. Storage for more than 24 hours is not permitted. No treatment is provided prior to application to the irrigation system and in the case of the subject land, could adversely impact on human health and/or the receiving environment.

4.5.3.2 Greywater Treatment & Reuse

Greywater treatment and reuse systems collect, store and treat greywater to a standard suitable for toilet flushing and laundry use. Treatment involves primary settling and flotation, aerobic and anaerobic digestion, clarification and disinfection. A greywater reuse and treatment system would also add significant cost (typically between $5,000 and $15,000) to the household wastewater treatment system.

Several greywater treatment systems are accredited by NSW Health to treat greywater for use in toilet flushing and laundry use (cold water inlet for washing machine) and general garden use. Use of the treated greywater on hardstand areas or for car washing is not permitted.

There are some concerns relating to an accumulation of salts in the greywater if it were reused for laundry purposes. Trends towards the use of low phosphorus detergents have resulted in the replacement of phosphorus with salts in powdered laundry detergents. For example, Whitehead and Patterson (2007) calculated salt and nutrient loads for greywater from a typical household as follows:

- 37.6 kg of salt per year
- 11.6 kg of sodium per year
- 1.4 kg of phosphorus per year

This can be addressed by the use of low/no phosphorus laundry liquids rather than powders.

5. EFFLUENT DISPOSAL CALCULATIONS

The minimum irrigation area is determined by calculating the:

- water balance;
- nitrogen balance; and
- phosphorus balance;

The limiting factor is used to determine the area required for effluent disposal.

5.1 Water Balance

A water balance is based on the following equation:

Design Precipitation + Wastewater Applied = Evapotranspiration + Percolation

The variables in the water balance equation are discussed in detail below.

5.1.1 Water supply, plumbing fixtures and wastewater generation

Reticulated (town) or non-reticulated (rainwater tank) supply?

Reticulated water supply is provided at Tomerong village and a 100 mm main extends from Tomerong along Pine Forest Road to within approximately 1 km of the subject land. It is likely that this existing line would need to be augmented if it were to be extended to the subject land.

Both water supply options have been considered in the water and nutrient balance calculations.

According to AS1547, hydraulic loading rates are 20-30% higher for households which have a reticulated water supply compared to those which rely solely on rainwater tanks (refer to Table 7). This means that households which have a reticulated water supply are likely to generate more wastewater and therefore require a larger effluent disposal area than those which rely on rainwater supply. In effect this means that fewer dwellings could be accommodated if reticulated water supply were to be provided.

AS1547 provides three categories of water reduction fixtures as described in Table 7. The number of equivalent persons for 2, 3, 4 and 5 bedroom dwellings is provided in Table 8.

Table 8 - No. equivalent persons for 2, 3, 4 & 5 bedroom dwellings (AS1547:2000)

# bedrooms	2	3	4	5
equivalent persons	4	6	8	10

Based on the above information, the wastewater generation rates for various combinations of water supply, dwelling size, and water reduction fixtures is provided in Table 9.

Table 9 - Wastewater generation scenarios

Water supply		Town				Tank			
# bedrooms		2	3	4	5	2	3	4	5
Water reduction fixtures	nil	720	1080	1260	1440	560	840	980	1120
	standard	580	870	1015	1160	460	690	805	920
	full	440	660	770	880	320	480	560	640

Recommendation:
Unless otherwise demonstrated in a detailed site and soil assessment report, full water reduction fixtures should be mandatory. This should be stipulated in a Development Control Plan for the subject land.

5.1.2 Evapotranspiration

Evapotranspiration (ET) is calculated by multiplying pan evaporation (E_{pan}) by a crop factor (C).

Handreck and Black (2001) reviewed crop factors for a range of crop types. These are summarised in Table 10.

Table 10 - Crop factors for different vegetation types

Crop/plant type	Crop factor (C) range	
	low	**High**
Trees	0.3	0.8
Shrubs	0.3	0.7
Ground Covers	0.3	0.6
Turf – Cool season grasses (Bentgrass, Bluegrass, Tall Fescue, Ryegrass)	0.65	0.85
Turf – Warm season grasses (Buffalo, Couch, Kikuyu, Zoysia)	0.25	0.7

The crop factor for cool season grass species is generally about 0.3 higher than warm season grasses.

A crop factor of 0.65 is considered appropriate for this assessment. This assumes minimal shading, especially important during winter. It should be noted that additional tree removal would be required on many lots to create more optimal sun exposure.

5.1.3 Percolation Rate/Design Irrigation Rate (DIR)

The percolation rate or design irrigation rate (DIR) should reflect the long term acceptance rate of the soil. AS1547:1994 prescribed various clean water percolation tests which were then converted to the long term acceptance rate. This approach is not espoused by AS1547:2000 and a desktop approach is promoted instead.

There is some inconsistency between DIR recommendations between AS1547:2000 and the NSW Health guidelines. The NSW guidelines refer to a generic percolation rate of 5 mm/week irrespective of soil type. This is conservative by comparison to AS1547 which specifies a Design Irrigation Rate (DIR) of 15 mm/week for medium to heavy clay soils.

Given the presence of mottling in the B horizon, a reasonably conservative DIR of 10 mm/week is considered appropriate for this assessment.

In reality, the long term rate at which effluent can percolate through the soil profile is influenced significantly by effluent quality: the cleaner the effluent, the higher the long term acceptance rate.

It is recommended that a suitable imported landscape soil mix be applied to the effluent disposal area. The imported soil should be spread uniformly over the effluent disposal area to a minimum depth of 100 mm (can be blended into the upper 50 mm of native soil). The soil mix should conform to AS4419 (2003) 'Soils for landscaping and garden use – Organic soil'. If this is not done, a more conservative DIR of 5 mm/week should be used.

5.1.4 Water Balance Calculations

The minimum area required for effluent disposal based on the water balance area for various hydraulic loads is shown in Table 11. The water balance calculations are provided in the Appendices.

5.2 Nutrient Balances

The effluent disposal area required to ensure there is no loss of potentially harmful nutrients to the receiving environment is determined by calculating nitrogen (N) and phosphorus (P) balances. The formula used to determine area requirements based on organic matter and nutrient loads provided in the silver book is as follows:

$$A = \frac{C \times Q}{L_x}$$

Where

A = effluent disposal area (m^2)
C = concentration of nutrient (mg/L)
Q = treated wastewater flow rate (L/d)
L_x = critical loading rate of nutrient ($mg/m^2/d$)

The critical loading rates for N (L_N) and P (L_P) are based on the ability of vegetation to use these nutrients before they pass through the root zone. For example, the L_N for perennial pasture varies between 18 and 36 $mg/m^2/day$, while L_P varies between 2 and 4 $mg/m^2/day$.

Examples of N and P balance calculations are provided respectively in sections 5.2.1 and 5.2.2.

5.2.1 Nitrogen (N)

Denitrification
Evidence suggests that denitrification can be significant on duplex soils where the subsoil is relatively impermeable (e.g. Gardner et al. 2004). Given the presence of a duplex soil at the subject site it is considered appropriate to allow a denitrification rate of 20% in the N balance calculations.

Plant uptake
The NSW guidelines for onsite effluent disposal recommend using N uptake values of between 18 and 36 mg/m^2/day L_N for perennial pasture varies. 27 mg/m^2/ day is considered appropriate for this assessment.

Irrigation area required for N balance
The N balance would be calculated as shown in the following example based on a 4-bedroom dwelling, reticulated water supply, assuming no water reduction, and 22 mg/L of total N in the treated wastewater:

$$A = \frac{22 \text{ mg/L TN} \quad \times \quad 1{,}440 \text{ L/day}}{27 \text{ mg/m}^2\text{/ day } L_N}$$

$$= 1{,}173 \text{ m}^2$$

The minimum area required for effluent disposal based on the N balances for various hydraulic loads is shown in Table 11.

5.2.2 Phosphorus (P)

The P balance also takes into account the P sorption capacity of the soil, i.e. the soil's capacity to adsorb/absorb phosphorus. Based on P sorption results and soil profile data, the mean P sorption capacity across the effluent disposal area is 7,428 kg/ha.

A soil with a P sorption ability of at least 50 years is recommended by the silver book for land application areas.

The potential for P to leach through/across the soil profile is largely dependent on the P sorption capacity of the soil. Using ⅓ of the total P sorption capacity as the nominal value after which leaching can occur through the soil profile, the amount of P that can be sorbed without leaching over 50 years is calculated as follows:

$$\begin{aligned} \text{P sorption} &= 7{,}428 \times \tfrac{1}{3} \\ &= 2{,}476 \text{ kg/ha} \\ &= 0.2476 \text{ kg/m}^2 \end{aligned}$$

Vegetation Uptake
The amount of vegetation uptake over 50 years based on critical loading rate of 3 mg/m^2/day is calculated as follows:

P uptake = 3 x 365 x 50
= 54,750 mg/m^2
= 0.055 kg/m^2

P Generation

The amount of P generated over 50 years from the development would be calculated as shown in the following example based on a 4-bedroom dwelling, reticulated water supply, assuming no water reduction, and 14 mg/L of total P in the treated wastewater:

P generated = Total P [mg/L] x volume of wastewater
= 14 mg P/L x 525,600 litres/year x 50 years
= 367.9 kg

Irrigation area required for P balance

$$A = \frac{\text{P generated}}{\text{P adsorbed} + \text{P uptake}}$$

$$= \frac{367.9}{0.2476 + 0.055}$$

$$= 1{,}216 \text{ m}^2$$

The minimum area required for effluent disposal based on the P balances for various hydraulic loads is shown in Table 11.

5.3 Minimum Effluent Disposal Area & Minimum Lot Size

Table 11 combines water, N and P balance results for rainwater tank supply and reticulated water supply. Results are provided for 2 to 5 bedrooms, for nil, standard and full water reduction fixtures.

Key input variables are provided on the left hand side of both tables. The nutrient balance calculations are based on median concentrations of 22 mg/L total N and 14 mg/L total P in the treated effluent as reported by Charles (pers. com.) for 44 in situ AWTS.

Table 11 - Summary of minimum effluent disposal area calculations for various development scenarios

	Input variables		Number of bedrooms	Rainwater supply nil	Rainwater supply standard	Rainwater supply full	Reticulated supply nil	Reticulated supply standard	Reticulated supply full
Water Balance	crop factor = 0.65 DIR (mm/wk) = 10		2	300	247	172	386	311	236
			3	450	370	257	579	466	354
			4	601	493	343	772	622	472
			5	751	617	429	965	777	590
N Balance	N concentration [mg/L] = 22 N uptake (mg/m²/day) = 27 Denitrification allowance(%) = 20		2	365	300	209	469	378	287
			3	548	450	313	704	567	430
			4	730	600	417	939	756	574
			5	913	750	521	1173	945	717
P Balance	P concentration [mg/L] = 14 P uptake (kg/m²/50yr) = 0.055 total P sorption (kg/ha) = 7,428 Proportion of soil P sorption capacity utilised over 50 yrs = 1/3		2	473	389	270	608	490	372
			3	710	583	406	913	735	558
			4	946	777	541	1217	980	744
			5	1183	972	676	1521	1225	930
Area required based on limiting factor (P balance) (m²)			2	473	389	270	608	490	372
			3	710	583	406	913	735	558
			4	946	777	541	1217	980	744
			5	1183	972	676	1521	1225	930

Advice from DP&I is that the calculations for a 4 bedroom dwelling fitted with standard water reduction fixtures will be used as the basis for determining the minimum lot. Therefore, the minimum effluent disposal area is either:

- 980 m² for reticulated water supply or
- 777 m² for rainwater tank supply.

This translates to the following minimum lot sizes:

Reticulated (town) water supply:

$$LS = 1.2158 \times 980 + 1025$$
$$= \mathbf{2,216\ m^2}$$

Non reticulated (rainwater tank) supply:

$$LS = 1.2158 \times 777 + 1025$$
$$= \mathbf{1,970\ m^2}$$

5.4 Wet Weather Storage

During prolonged wet weather the ability of the soil profile to store applied effluent and evaporation rates are greatly reduced. Under these conditions, the application of effluent poses an increased environmental and health risk. Temporary storage of effluent during wet weather can reduce these risks.

The limiting factor for effluent disposal used in this assessment is the nitrogen balance. No wet weather storage would be required in this case.

There are two main methods for providing wet weather storage:

- Sub-surface in gravel-filled trenches; or
- Storage tanks to which effluent is diverted when triggered by an automated soil moisture monitoring system.

Sub-surface wet-weather storage is a more reliable method for domestic situations as soil moisture control systems are more complex and prone to failure, and effluent stored in a tank for any length of time will become septic and generate odour (Martens 2001). Effluent is applied continuously to micro-trenches via a pressurised sub-surface irrigation line. The trenches are partially lined with an impermeable barrier which stores applied effluent to a design level. Excess soil moisture beyond the design storage capacity is allowed to enter the surrounding soil profile (Martens 2001).

If effluent were to be applied via properly designed and installed sub-surface trickle irrigation in accordance with the recommendations of this report, subsurface wet weather storage would be provided in the natural soil profile. Additional wet weather storage is considered unnecessary. However, should additional wet weather storage be required, storage volumes should be calculated using an established water balance method and a daily time-step. Further information on wet weather storage methods and calculation of volume are provided in Martens (2001).

5.5 *Climate Change*

Climate change is expected to influence the local climate (rainfall, temperature and evaporation) which could have implications for effluent disposal at the subject land. This section assesses the implications of predicted climate change in respect of effluent disposal.

According to the CSIRO (2007), the climate of the Southern Rivers (i.e. from Nowra to Eden, from the coast to the Great Dividing Range) will become warmer and there are likely to be more extreme weather events with increased heat waves, intense storms, extreme winds and bushfire risk. This section outlines the local climate change predictions and considers the potential implications for the subject land’s suitability for effluent disposal.

5.5.1 Temperature & Evaporation

The range of projected temperature increase for Australia in the near term (to 2030) is about 0.5 to 2.0˚C above the 1990 level (CSIRO 2001). For the longer term (to 2070), the CSIRO (ibid.) projected temperature increase is about 1 to 6˚C above 1990.

Higher evaporation rates are predicted during winter and spring (Department of Environment & Climate Change 2008). Table 12 includes projected changes in evaporation for 2030 and 2070.

5.5.2 Rainfall

The east coast of Australia, including the NSW South Coast, has experienced significant drying over the last 50 years, exceeding a decrease of 50mm per decade (CSIRO 2007).

Rainfall projections are less certain than temperature projections (ibid.). Overall, rainfall in the region is distributed relatively evenly throughout the year, although there can be significant short term variation. Projections for the Jervis Bay area published by DECC (2008) suggest that summer rainfall will increase by 20-50%, winter rainfall will increase by 5-10%, and spring and autumn rainfall will increase by 10-20%. This suggests that rainfall will become more summer-dominant due to an increased incidence of storm activity during the warmer months of the year. Table 12 shows the predicted increase in frequency of extreme rainfall events (Department of Environment & Climate Change 2007).

Table 12 - Projected changes in extreme rainfall and evaporation for the Southern Rivers

	Projected Change	
	2030	**2070**
Extreme Rainfall (40 Year 1 day rainfall total)	+7%	+5%
Evaporation	+1% to +13%	+2% to +40%

Source: Department of Environment & Climate Change (2007)

5.5.3 Conclusions

In terms of the water balance calculations used to help determine the minimum area required for effluent disposal, May and June are the limiting months.

Notwithstanding the uncertainties in the climate change predictions, it appears that monthly evaporation rates are likely to exceed any increases in rainfall during these months in the long term. This would mean that a smaller effluent disposal area would be required for effluent disposal based on the water balance alone. In this case however, the nitrogen and phosphorus balances are more limiting, so any reduction in the water balance area would have no effect on the area required for effluent disposal. Therefore, the effect of the predicted changes in climate would have no bearing on the outcome of this assessment and can be ignored.

6. CONCLUSIONS & RECOMMENDATIONS

A detailed site and soil assessment was undertaken for the subject land to determine the feasibility of onsite effluent disposal and ascertain the minimum lot size that would be required to meet environmental and health objectives in respect of onsite effluent disposal.

Monthly water and nutrient balance calculations were undertaken in accordance with the NSW guidelines and AS1547. It is considered feasible to provide onsite effluent treatment and disposal on the developable lots (as identified in the Planning Proposal) provided the following recommendations are adhered to.

- Effluent is treated to tertiary standard as a minimum, e.g. aerated wastewater treatment system (AWTS) or equivalent.

- Treated effluent is disposed of via subsurface pressurised irrigation.

- The onsite effluent disposal area should be no smaller than indicated below.

No. of bedrooms	Minimum effluent disposal area (m^2)
3	583
4	777
5	972

  For a 4-bedroom dwelling the minimum effluent disposal area required is 777 m^2. This equates to a minimum lot area of approximately 2000 m^2.

- The hydraulic and pollutant loads generated from each dwelling should not exceed the assimilative capacity of the area available for effluent disposal on the property, as shown in the water and nutrient balance calculations. Planning controls should be considered to ensure that development does not exceed these limitations.

- Full water reduction fixtures should be required in each dwelling as a factor of safety.

- Individual onsite effluent disposal assessments should be submitted at development application stage. Assessment s should include design details for the effluent application system and maintenance requirements.

6.1 *Alternative design proposals*

- Alternative subsurface disposal methods such as sand mounds or amended earth mounds could be considered subject to provision of design details at development application stage.

- Detailed design should be submitted at development application stage if any variation to the calculations provided in this report is proposed. Nutrient balance calculations should also be provided where any variation to the calculations provided in this report is proposed.

- Any sand or amended earth mounds should be installed appropriately to maximise evapotranspiration. The base of any mounds should not excavated into the ‘B’ horizon (subsoil).

- It may be possible to further reduce household hydraulic load by incorporating greywater reuse systems and/or dry composting toilets. Any such proposal would need to be accompanied by a detailed design and assessment.

6.2 *Landscaping*

- An organic soil mix should be spread over the effluent disposal area to a minimum depth of 100 mm. The imported soil should be spread uniformly over the effluent disposal area and can be blended into the upper 50 mm of native soil. The soil mix should conform to AS4419 (2003) ‘Soils for landscaping and garden use – Organic soil’. It is recommended that gypsum be applied to the soil at a rate of 0.5 to 1 kg per m^2 prior to the addition of the organic soil mix.

- Appropriate vegetation should be selected for the effluent disposal areas.

- Vegetation should be established on the effluent disposal areas before any systems are commissioned.

- The areas available for effluent disposal should be protected from ingress of surface and subsurface moisture through the provision of appropriate stormwater diversion measures such as grassed swales or cut-off trenches.

6.3 *Monitoring*

Given the sensitivity of the receiving environment and site constraints it is recommended that onsite systems should be inspected by Council at least every three years.

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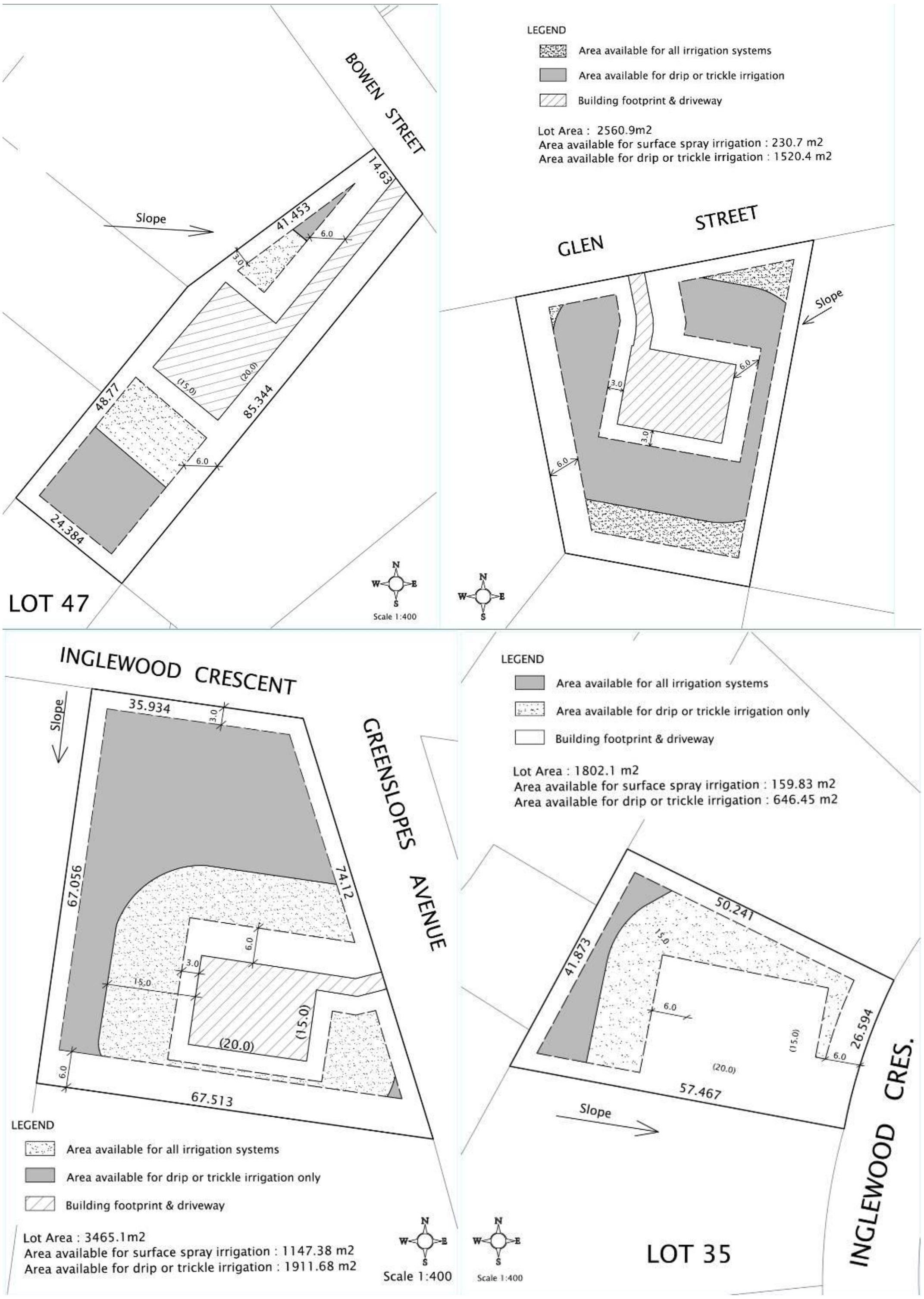
Appendix A – Effluent Disposal Study, Jerberra Estate Prepared by Coffey Geosciences P/L. 2000.

Appendix B – Review of Best Practice Methods of On-site Effluent Disposal – Jerberra Estate Rezoning Investigations (Draft LEP LP155) Prepared by Martens & Associates, 2006

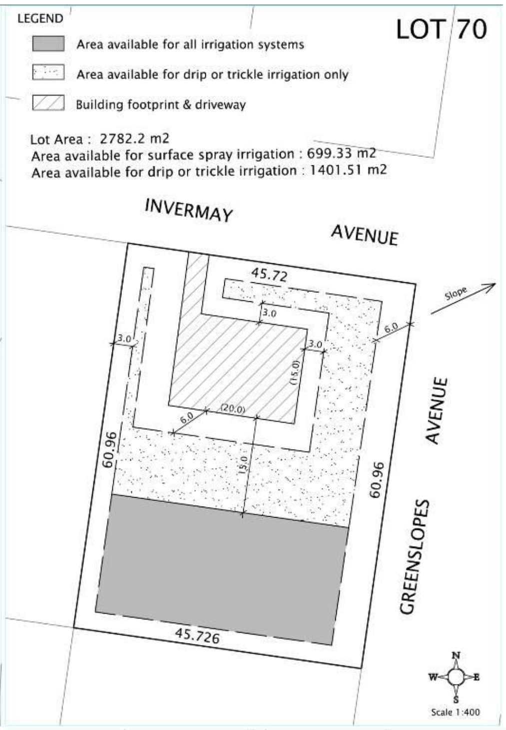
Appendix C – Water & Nutrient Balance Tables

Appendix D – Soil Laboratory Results

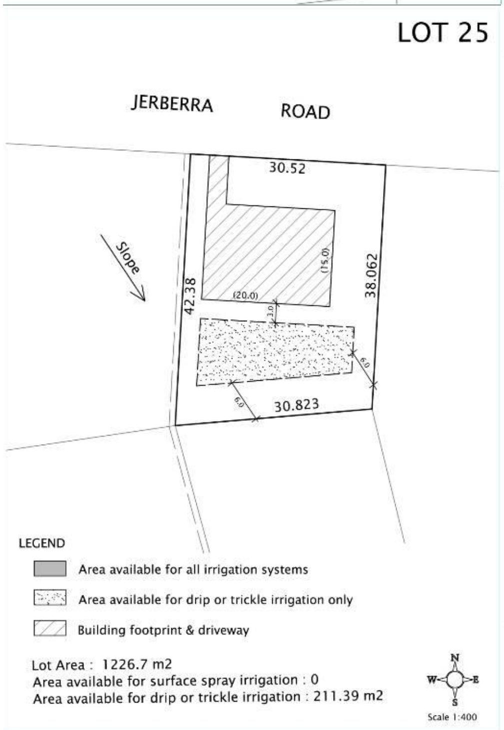
Appendix E – Case Study Site Plans



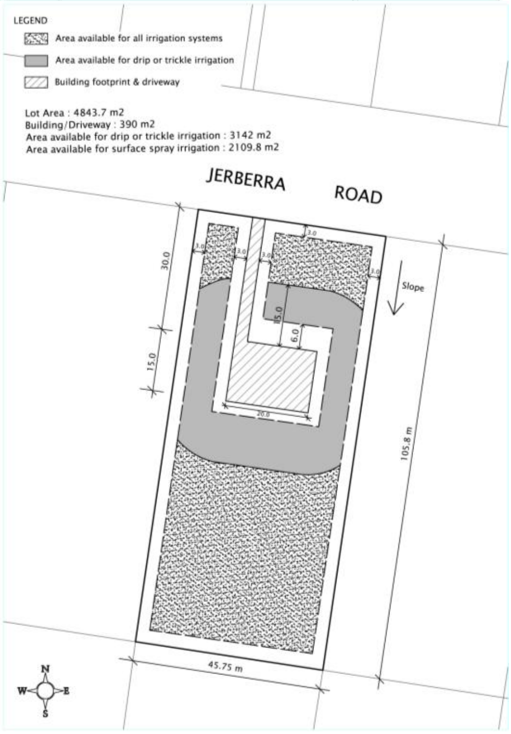
LEGEND
Area available for all irrigation systems
Area available for drip or trickle irrigation only
Building footprint & driveway
Lot Area : 1802.1 m2
Area available for surface spray irrigation : 159.83 m2
Area available for drip or trickle irrigation : 646.45 m2
50.241
41.873
15.0
6.0
(15.0)
26.594
6.0
(20.0)
57.467
Slope
INGLEWOOD CRES.
LOT 35
Scale 1:400



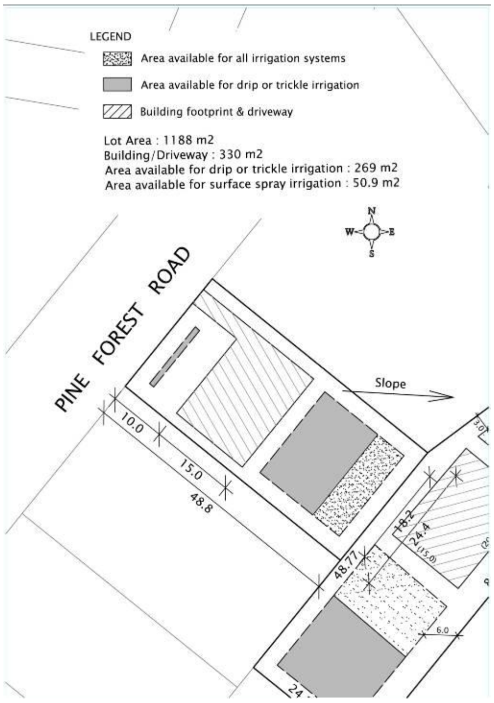
LEGEND
Area available for all irrigation systems
Area available for drip or trickle irrigation only
Building footprint & driveway
LOT 70
Lot Area : 2782.2 m2
Area available for surface spray irrigation : 699.33 m2
Area available for drip or trickle irrigation : 1401.51 m2
INVERMAY
AVENUE
45.72
3.0
3.0
3.0
(15.0)
(20.0)
6.0
6.0
15.0
60.96
60.96
Slope
AVENUE
GREENSLOPES
45.726
Scale 1:400



LOT 25
JERBERRA
ROAD
30.52
Slope
42.38
(15.0)
38.062
(20.0)
3.0
6.0
6.0
30.823
LEGEND
Area available for all irrigation systems
Area available for drip or trickle irrigation only
Building footprint & driveway
Lot Area : 1226.7 m2
Area available for surface spray irrigation : 0
Area available for drip or trickle irrigation : 211.39 m2
Scale 1:400



LEGEND
Area available for all irrigation systems
Area available for drip or trickle irrigation
Building footprint & driveway
Lot Area : 4843.7 m2
Building/Driveway : 390 m2
Area available for drip or trickle irrigation : 3142 m2
Area available for surface spray irrigation : 2109.8 m2
JERBERRA
ROAD
30.0
15.0
Slope
105.8 m
45.75 m


LEGEND
Area available for all irrigation systems
Area available for drip or trickle irrigation
Building footprint & driveway
Lot Area : 1188 m2
Building/Driveway : 330 m2
Area available for drip or trickle irrigation : 269 m2
Area available for surface spray irrigation : 50.9 m2
N
W
E
S
PINE FOREST ROAD
Slope
10.0
15.0
48.8
48.77
18.2
24.4
(15.0)
6.0
3.0

SHOALHAVEN CITY COUNCIL

EFFLUENT DISPOSAL STUDY

JERBERRA ESTATE

ST GEORGES BASIN

G12023/1-AD

27 January 2000

G12023/1-AD LPF;ck
27 January 2000

Shoalhaven City Council
Bridge Road
NOWRA NSW 2541

Attention: Mr Steve Robertson

Dear Sir,

RE: EFFLUENT DISPOSAL STUDY
JERBERRA ESTATE
ST GEORGES BASIN

Coffey Geosciences Pty Ltd (Coffey) are pleased to present five copies of our report at the above site.

Should you require further information regarding the report, please do not hesitate to contact either, Andrew Dawkins in our Sydney office on 9888 7444 or the undersigned.

For and on behalf of
COFFEY GEOSCIENCES PTY LTD

L P Fox

LAURIE FOX
Senior Environmental Geologist

Distribution: Original held by Coffey Geosciences Pty Ltd
1 copy to Coffey Geosciences Pty Ltd
5 copies to Shoalhaven City Council

Unit 1/222 Berkeley Road
Unanderra NSW 2526 Australia
PO Box 346 Unanderra
NSW 2526 Australia
Telephone +61 2 4272 6071
Facsimile +61 2 4272 6075
Email wolgong@coffey.com.au

EXECUTIVE SUMMARY

Coffey Geosciences Pty Ltd (Coffey) were commissioned by Shoalhaven City Council (the Council) to carry out an effluent study at Jerberra Estate, St Georges Basin. The study was commissioned by Council to provide additional information on the suitability of the site for rural residential subdivision. The potential development area is 85 hectares and currently contains one legal and a number of illegal dwellings. The development is understood to contain 153 lots ranging from 860m² to 1.76ha with 102 lots less than 4000m².

The objective of the study is to ascertain whether effluent disposal for rural residential development is feasible and will meet the objective of nil pollutant export from the site The following scope of work was carried out:

- desk study including a review of published information, aerial photographs, Council records and information held on Council files;
- site walkover by a senior environmental geologist;
- field investigation including the excavation of fifteen test pits and the collection of soil samples;
- laboratory analysis of selected samples for a suite of physical and chemical analytes;
- assessment of the data and reporting of the results including a discussion on the suitable lot size for effluent disposal.

The study has identified three terrain units related to landform and soil types. Unit 3, low lying land, is not considered suitable for on-site effluent disposal because of the potential for flooding and the height of the seasonal water table. Unit 3 comprises about 10% of the study area. Unit 1 Ridgeline and Unit 2, Side-slopes are considered suitable with the following major limitations to effluent disposal;

- low soil permeability in clay B horizons;
- erosion potential.

As the effluent disposal system would largely be based on evapotranspiration and nutrient up take in the root zone, significant percolation to the B horizon is not envisaged. To lower the risk of soil erosion, irrigation areas should be well grassed, well drained and preferably located on slopes less than 5° from the horizontal, that is, largely within Unit 1 Ridgeline The potential locations for irrigation fields are indicated on Drawing G12023/1-4.

Based on the preliminary data collected for this study, it is considered that there are only two feasible options for waste-water disposal, either individual aerated water treatment system (AWTS) or a common effluent scheme (CES) for the estate

The recommended minimum lot size for an individual AWTS is about 2,500m² of which about 1500m² is recommended as the minimum area required for irrigation. It should be noted that, because of the site constraints, the AWTS irrigation field would need to be located within those areas indicated on Drawing G12023/1-4. These areas should be regarded as indicative only and would require further field survey to establish more accurate boundaries

The minimum lot size is based on preliminary calculations of the water balance, and assumed nutrient loading (nitrogen and phosphorous), hydraulic loading, the number of people per household and the area of a site devoted to social and recreational use. The minimum area for irrigation represents a nil pollutant export of nutrients from the site based on the available data and assumptions regarding the waste-water quantity and quality. The assumptions on which the lot size and irrigation areas are calculated are anticipated to change with more detailed data.

The responsibility for operation and maintenance of the individual AWTS lies with the householder Generally AWTS are not as suitable for use where occupancy is sporadic (such as a holiday homes) since servicing should be carried out at each start-up. Householders need to be aware of system limitations and correct operating use.

A CES would involve preliminary treatment of sewerage on each individual site, through say a septic tank. The waste-water would then be collected and piped to a centralised treatment plant and a fixed irrigation field Based on the size of the potential irrigation field, as indicated on Drawing G12023/1-4 and assuming a minimum irrigation area of 1500m^2 per household, it is estimated that about 85 households could potentially utilise the CES. These estimates are based on the current data and will be subject to change when more information becomes available.

Preliminary construction and maintenance guidelines for the CES irrigation field include the following:

- the irrigation field should be landscaped, with minimum vegetated buffer distances of:

  - 40m from the edge of drainage;

  - 6m from property boundaries, buildings and swimming pools;

- irrigation fields should not include areas of ponded water or shallow rock exposures unless substantial ground improvements are made;
- sprinklers with a throw of not more than 2m, producing coarse droplets, not a fine mist, should be used to lower the risk of aerosol dispersion and wind drift of effluent. The spray height should not be more than 400mm above the finished level of the surface irrigation disposal area;
- effluent quality should conform to the requirements of Environmental Health Protection Guidelines (1998) and the NSW EPA. This may be superseded if the EPA require the disposal system to be licensed, in which case the effluent quality requirements will be provided;
- effluent should not be used for irrigation of fruit and vegetables;
- disposal areas should be carefully managed to ensure that the infiltration capacity of the soil is maintained as outlined below and that the vegetation cover is well established. Irrigation disposal methods are primarily designed to ensure most of the treated effluent is held in the soil profile, taken up by plants or lost as evaportranspiration with only a small percentage infiltrating below the topsoil. No effluent should be allowed to run-off from the site and it would be necessary to store effluent for several days during prolonged rain events.
- Field grass cuttings should be mowed regularly and removed from site;
- earth bunding to about 0 3m height should be installed around the field to provide temporary storage within the irrigation field. Wet weather storage overflows from the field should be intercepted by a downstream catch drain and diverted into stormwater pond/dam if possible;
- effluent quality should be maintained with regular servicing of the treatment plants This service should be provided by the manufacturer in the form of an ongoing servicing contract. The servicing contract usually requires six monthly or annual maintenance, depending on the systems selected. De-sludging of the plants will also be required from time to time depending on the volume of effluent processed.

To ensure acceptable long term performance of the effluent disposal system, EPA Licensing Agreements generally require monitoring and testing of downstream ground and surface waters adjacent to the disposal areas. Monitoring should be conducted periodically (usually once/year) or after uncontrolled discharges into the rivers/creeks have occurred.

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1 INTRODUCTION

Coffey Geosciences Pty Ltd (Coffey) were commissioned by Shoalhaven City Council (the Council) to carry out an effluent study at Jerberra Estate, St Georges Basin The study was in general accordance with our proposal dated 29 January 1999 (Proposal No GP12532/1-AB).

The study was commissioned by Council to provide additional information on the suitability of the site for rural residential subdivision. The potential development area is 85 hectares and currently contains one legal and a number of illegal dwellings The development is understood to contain 153 lots ranging from 860m^2 to 1.76ha with 102 lots less than 4000m^2.

1.1 Objectives and Scope of Work

The objective of the study is to ascertain whether effluent disposal for rural residential development is feasible and will meet the objective of nil pollutant export from the site.

The following scope of work was carried out:

- desk study including a review of published information, aerial photographs, Council records and information held on Council files;
- site walkover by a senior environmental geologist;
- field investigation including the excavation of fifteen test pits and the collection of soil samples;
- laboratory analysis of selected samples for a suite of physical and chemical analytes;
- assessment of the data and reporting of the results including a discussion on the suitable lot size for effluent disposal.

2. BACKGROUND

The study area was registered as a subdivision in 1922 and individual lots have been bought and sold since that time though there has been no guarantee (from Council) that future development approval would be granted Following submissions from the Pacific Pastures Progress Association the Council commissioned Mitchell McCotter and Associates in 1994 to carry out an Environmental Study of the site to support a rezoning application (Report No 93152RP1) The main conclusions of the report with respect to effluent disposal were:

- there were three practical options for waste-water management, namely:
    - individual on-site disposal systems for each dwelling;
    - collective package treatment plant for all dwellings within the estate;
    - connection to the existing reticulated sewerage system
- for individual on-site systems aerated water treatment systems (AWTS) were preferable with a recommended minimum irrigation area of 470m^2;
- a collective package treatment system was feasible and would require about 14 ha for irrigation.

It should be noted that there is no supporting data regarding the calculations of irrigation area within the copy of the Mitchell McCotter (1994) report supplied to Coffey. The assumptions upon which these calculations are based are therefore unknown and the data cannot be verified.

3. SITE CHARACTERISTICS

3.1 Site Description

The site is located approximately 150km south of Sydney and about 5km from Tomerong, the nearest township. The site is rectangular in shape and has an area of about 85 hectares of which approximately 20% has been cleared. Drawing G12023/1-2 show the locality of the site and Drawing G12023/1-1 shows the current lot layout and street configuration. The majority of the site is without power, town water and sewer.

There are several unsealed roads that traverse the study area. There is evidence of erosion in the form of rilling and minor gullying along the road alignments. Most of the site is timbered apart from some individual lots where clearing has taken place.

3.2 Topography and Drainage

The highest elevation on the site occurs towards Pine Road in the west and is about 50m above Australian Height Datum (AHD). The site slopes gently (< 5 degrees from the horizontal) down towards the east along a broad ridgeline that separates two drainage catchments. The side slopes generally range from about 5 to 10 degrees from the horizontal and comprise north and south facing slopes.

The two catchments form the headwaters of Moona Moona Creek which flows in an easterly direction and eventually discharging to Jervis Bay, some 5km to the east. Drawing G12023/1-2 shows the catchment configuration and the regional setting of the site. The catchment shown on Drawing G12023/1-2 is about 10 km^2 and the study area comprises about 8% of the catchment area. According to Mitchell McCotter (1994) the study site comprises about 2% of the total Moona Moona Creek catchment.

3.3 Soils Geology and Hydrogeology

Published geological information (Ulladulla 1:250,000 sheet) indicates that the site is underlain by rocks belonging to the Wandandian Siltstone formation, part of the Shoalhaven Group. This formation consists of siltstone, silty sandstone and is pebbly in part. This rock type differs from that described in the Mitchell McCotter (1994) Report where Nowra sandstone is given as the underlying geology. Nowra sandstone outcrops further west of the study area.

There is little published information regarding the soil types in the study area. Mitchell McCotter (1994) inferred soil types from the 1:100,000 Kiama Sheet on the assumption that similar geology will produce similar soils. The Wandandian Siltstone does not occur on the Kiama Sheet and therefore inferring soil types from that sheet for the study area is not appropriate.

Site specific soil descriptions found in Mitchell McCotter (1994), give two soil types for the study area, namely:

- duplex soils where the soil texture shows a distinct contrast with depth ie soils where a sand or loam topsoil (A Horizon) overlies a clay subsoil (B Horizon)
- gradational soils where the soil texture shows a gradual change with depth.

Groundwater beneath the study area is expected to occur generally within the weathered rock, between 5m and 10m depth. Groundwater flow would follow the surface topography and discharge zones would most likely occur along drainage depressions eventually providing base flow for Moona Moona Creek

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3.4 Climatic Conditions

Most of the site would receive considerable sun with little sheltered areas. The existing tree cover, however, means that parts of the ground surface would be shaded during each day. As is common along the east cost of southern and central NSW, north facing slopes are generally drier than south facing slopes. This is because of the prevailing southerly wind patterns which would account for the majority of the rainfall within the study area. The south facing slopes would be expected to remain wetter for longer periods of time than the north facing slopes.

Average rainfall in the Jervis Bay region is 1,177mm. The wettest months are January to March and October and November. Evaporation exceeds rainfall in all months except June. Further information on rainfall and evaporation is given in Mitchell McCotter (1994).

4. STUDY METHODOLOGY

4.1 Fieldwork and Mapping

Fieldwork was carried out on 8 and 9 of March 1999 and consisted of a site walkover and mapping by a senior environmental geologist who noted topographic features, drainage characteristics, slope morphology and soils. Fifteen test pits were excavated in selected areas corresponding to the terrain units identified during the field mapping. The test pits were excavated by a rubber tyred backhoe in the full-time presence of an environmental engineer from our Wollongong office.

Test pits were excavated to a maximum depth of 2.5m and samples of both topsoil (A Horizon) and subsoil (B Horizon) were collected for texture classification and later laboratory analysis. Drawing G12023/1-1 shows the approximate location of the test pits and a description of the soils, using the Unified Classification System, is included in Appendix A.

4.2 Laboratory Analysis

4.2.1 Physical Testing

The following physical testing program was implemented:

- Emerson crumb test on four samples;
- pH on four samples; and
- Electrical conductivity on four samples

Samples were dispatched to our Sydney materials testing laboratory who is NATA registered for the tests performed. The original laboratory reports are included in Appendix B1.

4.2.2 Chemical Testing

The following chemical testing program was implemented:

- Phosphorus adsorption on four samples;
- Exchangeable sodium percentage (ESP) on four samples; and
- Cation exchange capacity (CEC) on four samples.

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Samples were dispatched under standard Coffey Chain of Custody documentation to Sydney Analytical Laboratories (SAL) who are NATA registered for the tests performed. The original laboratory reports are included in Appendix B2

5. FIELDWORK AND MAPPING RESULTS

5.1 Terrain Units

Three terrain units were identified from the desk study and the field mapping and are shown on Drawing G12023/1-3. The three units are;

UNIT 1 RIDGELINE	This unit is characterised by gentle slopes, generally less than 5 degrees from the horizontal, shallow soil profiles comprising a clayey sand A horizon overlying a sandy silty clay B horizon Weathered rock is generally encountered within 1.5m depth. Groundwater in this unit would be expected to be at a depth of about 10m or greater. This unit comprises about 30% of the study area.
UNIT 2 SIDESLOPES	Flanking the ridgeline are the side-slopes. These are characterised by slopes of between 5 to 10 degrees from the horizontal and deeper soil profiles (than Unit 1) The soil types are similar to the Unit 1 soils though the B horizon extends to a greater depth Groundwater would be expected to be at a depth of between 5 and 10m. This unit comprises about 60% of the study area.
UNIT 3 LOW LYING LAND	Low-lying land was identified in the north-east corner and then along the southern boundary of the study area This unit is characterised by gently sloping to near level terrain and gradational soils comprising sandy clay A horizons overlying silty clay B horizons. Groundwater would be expected to vary seasonally and be generally less than 3 0m depth This unit comprises about 10% of the study area

5.2 Subsurface Conditions

The subsurface conditions encountered at the test pit locations consisted of:

- Topsoil comprising silty clayey sand, fine grained light grey to a depth of 0.35m (A HORIZON); overlying
- Sandy silty clay and silty clay, medium to high plasticity light grey, mottled red to depth of about 1 9m (B HORIZON); overlying
- Extremely to highly weathered rock comprising weathered sandstone (C HORIZON)

Groundwater was not encountered in the test pits.

5.3 Soil Texture Classification

Ten soil samples were classified according to their texture and principal profile forms (PPF) as described in Northcote (1979). The results are summarised in Table 1.

TABLE 1: TEXTURE CLASSIFICATION

SAMPLE IDENTIFICATION	SOIL HORIZON	TERRAIN UNIT	DESCRIPTION	PRINCIPAL PROFILE FORM[1] (PPF)	ESTIMATED PERMEABILITY[2] m/day
JPT4 0.0-0.15m	A	2	Sandy Clay Loam	Duplex	0.1 to 0.5
0.6-0.7m	B		Medium to Heavy Clay		<0.06
JPT7 0.0-0.15m	A	3	Sandy Clay Loam	Gradational	0.1 to 0.5
0.4-0.5m	B		Fine Sandy Clay Loam		0.1 to 0.5
JPT9 0.0-0.1m	A	1	Sandy Clay Loam	Duplex	0.1 to 0.5
0.4-0.5m	B		Medium to Heavy Clay		<0.06
JPT11 0.0-0.1m	A	1	Sandy Clay	Duplex	0.06 to 0.1
0.4-0.5m	B		Medium to Heavy Clay		<0.06
JPT14 0.0-0.15m	A	2	Sandy Clay Loam	Gradational	0.1 to 0.5
0.4-0.5m	B		Sandy Clay		0.06 to 0.1

Notes:

Principal Profile as per Northcote (1979);

Permeability estimated from Hazelton and Murphy (1992)

The texture classification show that there are two principal profile forms (PPF) namely duplex soils and gradational soils. This confirms earlier data contained in Mitchell McCotter (1994). The estimated soil permeabilities for Terrain Units 1 and 2 are similar and generally range from 0.06 to 0.1m/day for the B horizon clays.

6. LABORATORY RESULTS

6.1 Physical Testing Results

The results of the physical testing are presented in Table 2 below:

TABLE 2: SUMMARY OF PHYSICAL TESTING RESULTS

PARAMETERS/ SAMPLE IDENTIFICATION	SOIL HORIZON/ TERRAIN UNIT	EMERSON CLASS	pH (UNITS)	ELECTRICAL CONDUCTIVITY (mS/cm)
JTP9 (0 4 to 0 5m)	B horizon Unit 1	2	5.1	0.56
JTP12 (0 4 to 0.5m)	B horizon Unit 1	6	4 7	0.04
JPT3 (0.5 to 0 6m)	B horizon Unit 2	5	5 2	0 07
JPT10 (0.4 to 0 5m)	B horizon Unit 2	5	5 3	0 03

The Emerson class number for B horizons in both Terrain Unit 1 and 2 show a moderate erodibility potential. The pH in both units is acidic and the electrical conductivity is low to moderate

6.2 Chemical Testing Results

The results of the chemical testing are presented in Table 3. The results shown are considered representative of the soil profile, including the A horizon, to the depths indicated by the sampling

TABLE 3: SUMMARY OF CHEMICAL TESTING RESULTS

PARAMETER/ SAMPLE IDENTIFICATION	SOIL HORIZON/ TERRAIN UNIT	PHOSPHORUS ADSORPTION CAPACITIES (mg/kg)	EXCHANGEABLE SODIUM PERCENTAGE (ESP) %	CATION EXCHANGE CAPACITY (CEC) meq %
JTP 4 (0 6-0 7m)	B horizon / Unit 2	600	2.0	8 0
JPT 7 (0.4-0 5m)	B horizon / Unit 3	44	0.9	2 3
JTP 11 (0 4-0.5m)	B horizon / Unit 1	550	2 9	7 5
JPT 14 (0.4-0.5m)	B horizon / Unit 2	560	2.0	6.0

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Terrain Unit 1 and 2 show a moderate to high phosphorus adsorption capacity with a low ESP and CEC Based on the chemical results the B horizon clays in units 1 and 2 have relatively low salinity and have a low capacity for metals adsorption.

Terrain unit 3, B horizon clays have a lower phosphorus adsorption capacity, low salinity and low capacity for metals adsorption.

7. PRELIMINARY WATER BALANCE

The following calculations have generally been based on Appendix 6 of the Environmental & Health Protection Guidelines On-Site Sewage Management for Single Households (1998). In compiling the preliminary water balance, the following assumptions have been made:

- each dwelling will have three bedrooms and is expected to accommodate five people and generate 1000 litres of waste-water per day as per the Environmental & Health Guidelines (1998);
- the dwelling is part of a subdivision on land identified as suitable for re-development using on-site sewage management;
- average nutrient loading rates and waste-water concentrations have been taken from Table 14 of the Environmental & Health Protection Guidelines (1998);
- the percolation rate is 5mm/week;
- 520m^2 has been allowed for the dwelling footprint, vehicular access and social and recreational space

The water balance calculations are presented in Appendix C. A summary of the preliminary calculations is provided below:

- Design waste-water flow rate:	1000 l/day
- Recommended Irrigation Area:	1480m^2 (based on nitrogen loading)
- Recommended Wet Weather Storage:	53m^3 (based on hydraulic loading)
- Recommended minimum lot size:	2,500m^2 (1480 + 1020)

The recommended minimum lot size refers to the irrigation area, combined with an assumed area of 1020m^2, comprising a single storey dwelling, vehicular access areas, social and recreational areas. It should be noted that by applying the buffer distances set out in Section 8 1 the minimum lot size may increase

It should be noted that the preliminary water balance indicates that precipitation and irrigation (inputs) exceeds evapotranspiration and percolation (outputs) during five months of the year (ie from February to July). Using this model, there would be periods when irrigation would not be possible, such as during high rainfall events and storage of effluent would be required

8. SITE CONSTRAINTS

8.1 Buffer Distances

The following buffer distances are recommended for on-site disposal systems from the Environmental and Health Protection Guidelines (1998):-

- 100m to permanent surface water – creeks, rivers, lakes;
- 250m to domestic groundwater well;
- 40m to other waters – farm, dams intermittent creeks drainage channels;
- 6m from driveways and property boundaries;
- 15m to dwelling;
- 6m to swimming pool;
- 3m to paths and walkways

8.2 Physical Features

The site specific physical features are presented in Table 4 and have been compared to the rating system given in the Environmental and Health Protection Guidelines (1998)

TABLE 4: PRELIMINARY SITE ASSESSMENT RATING FOR ON-SITE SYSTEM

	FEATURE (UNITS)	RELEVANT DISPOSAL SYSTEM	TERRAIN UNIT	JERBERRA ESTATE	EPH GUIDELINES (1998) [1] LIMITATIONS
1	Depth to rock	Surface and subsurface irrigation	All units	1 0 to 1 5m	Moderate Limitation
		Absorption	All units	1.5m	Minor Limitation
2	Depth to Watertable	Surface and subsurface irrigation	Units 1& 2 Unit 3	+3m * 1-3m *	Minor Limitation **Major Limitation**
		Absorption	All units	same as above	same as above
3	Soil Permeability (m/day)	All land application systems	All units	A horizon - 0.1 to 0 5* B horizon --<0 06 to 0 5 *	Minor Limitation **Major Limitation**
4	pH	All land application systems	All units	5 0 (average)	Moderate Limitation
5	ESP %	Surface and subsurface irrigation (0-0 4m)	All units	2.0 to 2.9	Moderate Limitation
		Absorption (0-1.5m)	All units	same as above	same as above
6	Electrical Conductivity (ds/cm)	All land application system	All units	0.001 to 0.05	Minor Limitation
7	CEC (% meq)	Surface and subsurface irrigation	Units 1 & 2 Unit 3	6 to 8 2	Mod Limitation **Major Limitation**

TABLE 4: PRELIMINARY SITE ASSESSMENT RATING FOR ON-SITE SYSTEM (CONTINUED)

	FEATURE	RELEVANT DISPOSAL SYSTEM	TERRAIN UNITS	JERBERRA ESTATE	EPH GUIDELINES LIMITATIONS
8	Phosphorus sorption (Kg/ha)	All land application systems	All units	7200	Minor Limitation
9	Flood Potential	Al land application systems	Units 1 & 2 Unit 3	above 1 in 20 year * below 1 in 20 years *	Minor Limitation Major Limitation
10	Exposure	All land application systems	All units	High sun & wind exposure	Minor Limitation
11	Slope	All application systems	All units	5-10° from horizontal *	Minor Limitation
12	Landform	All application systems	Unit 1 and 2 Unit 3	Ridges & slopes Floodplain	Minor Limitation **Major Limitation**
13	Erosion Potential	All application systems	All units	Emerson Class 2,5 Evidence of erosion (rills) along roadways	**Moderate to Major Limitation**
14	Site Drainage	All application systems	Unit 1 and 2 Unit 3	Fair to good poor	Minor Limitation **Major Limitation**
15	Land Area	All systems	All units	Land areas available	Minor Limitation
16	Rock & Rock Outcrops	All land application systems	All units	Less than 10% of area*	Minor Limitation

Notes:

Environmental and Health Protection Guidelines for On-site Sewage Management for Single Households (1998)

* - *estimate only.*

The major limitations to the use of on-site effluent treatment systems in Terrain Units 1 and 2 are the following:

- low soil permeability in clay B horizons;
- erosion potential;

In addition to the above Unit 3 has major limitations with respect to landform, site drainage and cation exchange capacity and this unit is not considered suitable for on-site effluent disposal

9. CONCLUSION

The study has identified three terrain units related to landform and soil types. Unit 3, low lying land, is not considered suitable for on-site effluent disposal because of the potential for flooding and the height of the seasonal water table. Unit 3 comprises about 10% of the study area. Unit 1 Ridgeline and Unit 2, Side-slopes are considered suitable with the following major limitations to effluent disposal;

- low soil permeability in clay B horizons;
- erosion potential

As the effluent disposal system would largely be based on evapotranspiration and nutrient up take in the root zone, significant percolation to the B horizon is not envisaged. To lower the risk of soil erosion, irrigation areas should be well grassed, well drained and preferably located on slopes less than 5° from the horizontal, that is largely within Unit 1 Ridgeline. The potential locations for irrigation fields are indicated on Drawing G12023/1-4.

Based on the preliminary data collected for this study, it is considered that there are only two feasible options for waste-water disposal, either individual aerated water treatment system (AWTS) or a common effluent scheme (CES) for the estate

The recommended minimum lot size for an individual AWTS is about 2,500m^2 of which about 1500m^2 is recommended as the minimum area required for irrigation. It should be noted that, because of the site constraints, the AWTS irrigation field would need to be located within those areas indicated on Drawing G12023/1-4. These areas should be regarded as indicative only and would require further field survey to establish more accurate boundaries

The minimum lot size is based on preliminary calculations of the water balance, and assumed nutrient loading (nitrogen and phosphorous), hydraulic loading, the number of people per household and the area of a site devoted to social and recreational use The minimum area for irrigation represents a nil pollutant export of nutrients from the site based on the available data and assumptions regarding the waste-water quantity and quality The assumptions on which the lot size and irrigation areas are calculated are anticipated to change with more detailed data

The responsibility for operation and maintenance of the individual AWTS lies with the householder. Generally AWTS are not as suitable for use where occupancy is sporadic (such as a holiday homes) since servicing should be carried out at each start-up. Householders need to be aware of system limitations and correct operating use.

A CES would involve preliminary treatment of sewerage on each individual site, through say a septic tank. The waste-water would then be collected and piped to a centralised treatment plant and a fixed irrigation field Based on the size of the potential irrigation field as indicated on Drawing G12023/1-4 and assuming a minimum irrigation area of 1500m^2 per household, it is estimated that about 85 households could potentially utilise the CES These estimates are based on the current data and will be subject to change when more information becomes available.

Preliminary construction and maintenance guidelines for the CES irrigation field include the following:

- the irrigation field should be landscaped, with minimum vegetated buffer distances of:

  - 40m from the edge of drainage;

- 6m from property boundaries, buildings and swimming pools;

- irrigation fields should not include areas of ponded water or shallow rock exposures unless substantial ground improvements are made;
- sprinklers with a throw of not more than 2m, producing coarse droplets, not a fine mist, should be used to lower the risk of aerosol dispersion and wind drift of effluent. The spray height should not be more than 400mm above the finished level of the surface irrigation disposal area;
- effluent quality should conform to the requirements of Environmental Health Protection Guidelines (1998) and the NSW EPA. This may be superseded if the EPA require the disposal system to be licensed, in which case the effluent quality requirements will be provided;
- effluent should not be used for irrigation of fruit and vegetables;
- any disposal areas should be carefully managed to ensure that the infiltration capacity of the soil is maintained as outlined below and that the vegetation cover is well established. Irrigation disposal methods are primarily designed to ensure most of the treated effluent is held in the soil profile, taken up by plants or lost as evaportranspiration with only a small percentage infiltrating below the topsoil. No effluent should be allowed to run-off from the site and it would be necessary to store effluent for several days during prolonged rain events
- Field grass cuttings should be mowed regularly and removed from site;
- earth bunding to about 0.3m height should be installed around the field to provide temporary storage within the irrigation field. Wet weather storage overflows from the field should be intercepted by a downstream catch drain and diverted into stormwater pond/dam if possible;
- effluent quality should be maintained with regular servicing of the treatment plants. This service should be provided by the manufacturer in the form of an ongoing servicing contract. The servicing contract usually requires six monthly or annual maintenance, depending on the systems selected. De-sludging of the plants will also be required from time to time depending on the volume of effluent processed

To ensure acceptable long term performance of the effluent disposal system, EPA Licensing Agreements generally require monitoring and testing of downstream ground and surface waters adjacent to the disposal areas. Monitoring should be conducted periodically (usually once/year) or after uncontrolled discharges into the rivers/creeks have occurred

The following analytical suite is recommended:

- biological oxygen demand (BOD);
- suspended solids;
- pH, electrical conductivity (EC), Total Dissolved Solids (TDS);
- ammonia, total keldahl nitrogen, and nitrate; and
- total Phosphorous.

The frequency of testing may change with results. Baseline data of existing surface and groundwaters would also be required prior to the operation commencing.

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10. LIMITATIONS

The findings contained in this report are the result of discrete/specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site in question. Under no circumstances, however, can it be considered that these findings represent the actual state of this site at all points

In preparing this report, Coffey has relied upon certain verbal information and documentation provided by the client and/or third parties. Coffey did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions in this report are based in whole or in part on such information, they are contingent on its validity. Coffey assume no responsibility for any consequences arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to Coffey

For and on behalf of

COFFEY GEOSCIENCES PTY LTD

LP Fox

LAURIE FOX

Senior Environmental Geologist

APPENDIX A

Test Pit Logs

Soil Description

Explanation Sheet

Coffey

DEFINITION:
In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil

Other materials are described using rock description terms

AS1726-1993
The descriptive terms used by Coffey are given below They are broadly consistent with AS1726-1993

UCS & SOIL NAME
Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on the following page

MOISTURE CONDITION

Dry Looks and feels dry Cohesive and cemented soils hard, friable or powdery Uncemented granular soils run freely through hands

Moist Soil feels cool and darkened in colour. Cohesive soils can be moulded Granular soils tend to cohere

Wet As for moist but with free water forming on hands when handled

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH Sµ (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort
Soft	12 – 25	A finger can be pushed into the soil to about 25mm depth
Firm	25 – 50	The soil can be indented about 5mm with the thumb but not penetrated
Stiff	50 – 100	The surface of the soil can be indented with the thumb but not penetrated
Very Stiff	100 – 200	The surface of the soil can be marked but not indented with thumb pressure
Hard	>200	The surface of the soil can be marked only with the thumbnail
Friable	–	Crumbles or powders when scraped by thumbnail

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	9 – 15
Loose	15 – 35
Medium Dense	35 – 65
Dense	65 — 85
Very Dense	85 – 100

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2 36 mm
	medium	200 µm to 600µm
	fine	75 µm to 200 µm

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: ≤ 5% Fine grained soils: ≤ 15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component	Coarse grained soils: 5 – 12% Fine grained soils: 15 – 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous exposure or sample	Weakly cemented	Easily broken up by hand in air or water
Lenses	Discontinuous layers of lenticular shape	Moderately cemented	Effort is required to break up the soil by hand in air or water
Pockets	Irregular inclusions of differential material		

SOIL STRUCTURE

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible
Residual soil	Structure and fabric of parent rock not visible

TRANSPORTED SOILS

Aeolian soil	Deposited by wind
Alluvial soil	Deposited by streams and rivers
Colluvial soil	Deposited on slopes (transported downslope by gravity)
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils
Lacustrine soil	Deposited by lakes
Marine soil	Deposited in ocean basins bays beaches and estuaries

Coffey Geosciences Pty. Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no: JTP1
sheet 1 of 1

client:	SHOALHAVEN CITY COUNCIL	office job no:	G12023/1
principal:		pit commenced:	30-03-99
project:	EFFLUENT DISPOSAL STUDY	pit completed:	30-03-99
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	logged by:	DMF
		checked by:	
equipment type and model:	BACKHOE	R L Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide, orientation:	datum:	

method	penetration 1 2 3 4	support	water	samples, tests etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E		NIL	O	D				SC	CLAYEY SAND: fine grained, light grey-white with some silt and some fine roots	D	L		TOPSOIL leaf litter on surface
				D				CH	SANDY SILTY CLAY: medium to high plasticity, orange mottled white & red with sand fine to medium grained	<Wp	H		RESIDUAL
				D		1			SANDY SILTY CLAY: medium plasticity, orange red & white with sand fine to medium grained				EXTREMELY WEATHERED ROCK
				D		2			SANDSTONE: fine grained, orange, red, & white with ironstained sections highly weathered				HIGHLY WEATHERED ROCK
						3			Pit JTP1 Terminated at 2.20 m				
						4							

COFEXCA VERSION B4. 18 / 5/99 12 : 8 :43

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- O none observed
- ✱ not measured
- water level
- water outflow
- water inflow

SAMPLES TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

Coffey Geosciences Pty Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no JTP2
sheet 1 of 1

office job no:	612023/1
pit commenced:	30-03-99
pit completed:	30-03-99
logged by:	DMF
checked by:	

client:	SHOALHAVEN CITY COUNCIL
principal:	
project:	EFFLUENT DISPOSAL STUDY
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)
equipment type and model:	BACKHOE
excavation dimensions:	4 m long 0.45 m wide
orientation:	
R.L. Surface:	NOT MEASURED
datum:	

method	penetration 1 2 3 4	support	water	samples tests etc	R.L.	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics colour secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E		NIL	D	D				SC	CLAYEY SAND: fine grained, light grey-grey with some silt and some fine roots	M W	L		TOPSOIL some leaf litter
				D				CH	SILTY CLAY: medium to high plasticity, orange, mottled red, with a trace to some sand fine grained	<Wp	H	X	RESIDUAL
				D		1		CI	SILTY CLAY: medium to high plasticity, light grey-white, & red, mottled with red ironstained sections and a trace of sand fine grained				RESIDUAL
				D		2			SILTY CLAY: medium plasticity, light grey-white & red mottled with red ironstained sections				EXTREMELY WEATHERED ROCK (fissured structure)
						3			Pit JTP2 Terminated at 2.40 m				
						4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
X not measured
water level
water outflow
water inflow

SAMPLES, TESTS ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

COFEXCA VERSION 84. 18 / 5/99 12:32:15

Coffey Geosciences Pty Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no JTP3

sheet 1 of 1

office job no: G12023/1

client:	SHOALHAVEN CITY COUNCIL	pit commenced:	30-03-99
principal:		pit completed:	30-03-99
project:	EFFLUENT DISPOSAL STUDY	logged by:	JWF
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	checked by:	LPH
equipment type and model:	BACKHOE	R.L. Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide orientation:	datum:	

method	penetration 1 2 3 4	support	water	samples tests etc	R.L.	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics colour secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E		NIL	O	D				SC	CLAYEY SAND: fine grained light grey with some silt and some roots	M	L		TOPSOIL
								CI	SANDY SILTY CLAY: medium plasticity orange, with some light grey sand fine grained some fissuring	<Wp	H		RESIDUAL
						1			SANDSTONE: Highly Weathered fine grained orange & light grey				HIGHLY WEATHERED ROCK
						2							
									Pit JTP3 Terminated at 2.20 m				
						3							
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- O none observed
- X not measured
- water level
- water outflow
- water inflow

SAMPLES TESTS ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

COFEXCA VERSION 84. 18 / 5/99 12 : 9 :41

Coffey Geosciences Pty. Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no: JTP4
sheet 1 of 1

office job no: G12023/1

client:	SHOALHAVEN CITY COUNCIL	pit commenced:	30-03-99
principal:		pit completed:	30-03-99
project:	EFFLUENT DISPOSAL STUDY	logged by:	JMF
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	checked by:	

equipment type and model:	BACKHOE	R L Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide	orientation:	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa	structure and additional observations
E		NIL	O	D			SC	CLAYEY SAND: fine grained, light grey-grey with some silt and some roots throughout	M W	L		TOPSOIL
							CH	SILTY CLAY: medium to high plasticity, orange, mottled red with some sand fine to medium grained old tree roots in western end of pit from 0 3m to 1 1m	=Wp	VSt/H		RESIDUAL
						1	CI	SANDY SILTY CLAY: medium plasticity, light grey, mottled orange, & red, sand fine grained, clay has a closely fissured structure with a trace of roots	<Wp	H		
						2		SANDY SILTY CLAY: medium plasticity, light grey mottled orange & red with sand fine grained				EXTREMELY WEATHERED ROCK
						3		Pit JTP4 Terminated at 2 50 m				
						4						

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- O none observed
- X not measured
- water level
- water outflow
- water inflow

SAMPLES TESTS ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

COFEXCA VERSION B4. 18 / 5/99 12 :10 :10

Coffey Geosciences Pty Ltd
ACN 056 335 516

COFFEY

engineering log - excavation

pit no JTP5
sheet 1 of 1

office job no: G12023/1

client:	SHOALHAVEN CITY COUNCIL	pit commenced:	30-03-99
principal:		pit completed:	30-03-99
project:	EFFLUENT DISPOSAL STUDY	logged by:	JMF
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	checked by:	
equipment type and model:	BACKHOE	R L Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide orientation:	datum:	

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E		NIL	D	D				SC	CLAYEY SAND: fine grained, light grey, with some fine roots breaks up in clump with some silt from 0 15m	M	L		TOPSOIL
				D		1		CH	SILTY CLAY: medium to high plasticity light grey, mottled orange & red, with some sand fine grained clay breaks up into 20-50mm pedals fissured rock structure light ironstained former root hairs	<Wp	H		
				D		2		CI	SANDY SILTY CLAY: low to medium plasticity, light grey mottled orange & red with sand fine grained				EXTREMELY WEATHERED ROCK
						3			Pit JTP5 Terminated at 2 50 m				
						4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
X not measured
water level
water outflow
water inflow

SAMPLES TESTS ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

COFEXCA VERSION B4, 18 / 5/99 12 :32 :45

Coffey Geosciences Pty Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no	JTP6
sheet	1 of 1

client:	SHOALHAVEN CITY COUNCIL	office job no:	G12023/1
principal:		pit commenced:	30-03-99
project:	EFFLUENT DISPOSAL STUDY	pit completed:	30-03-99
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	logged by:	JWF
		checked by:	
equipment type and model:	BACKHOE	R L Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide orientation:	datum:	

method	penetration 1 2 3 4	support	water	samples tests etc	R.L.	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics colour secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E		NIL	D	D				SC	CLAYEY SAND: fine grained grey-brown with some silt and fine roots	M	L		TOPSOIL
								CI	SANDY CLAY: medium plasticity orange-brown with sand fine to medium grained clay from 0.2-0.5m breaks up in hard lumps to 0.1m in size	<Wp	H		RESIDUAL
				D				CH	SILTY CLAY: medium to high plasticity light grey mottled orange, & red, with a trace of sand fine grained breaks up into pedals 20-50mm in size				
						1							
								CI	SANDY SILTY CLAY: highly fissured structure low to medium plasticity light grey some red ironstaining sand fine grained				EXTREMELY WEATHERED ROCK
									SANDSTONE: fine grained light grey-orange highly weathered				HIGHLY WEATHERED ROCK
						2							
									Pit JTP6 Terminated at 2.40 m				
						3							
						4							

COFEXCA VERSION B4. 18 / 5/99 12:33:25

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
* not measured
water level
water outflow
water inflow

SAMPLES TESTS ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Geosciences Pty Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no: JTP7

sheet 1 of 1

office job no: G12023/1

client:	SHOALHAVEN CITY COUNCIL	pit commenced:	31-03-99
principal:		pit completed:	31-03-99
project:	EFFLUENT DISPOSAL STUDY	logged by:	DWF
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	checked by:	
equipment type and model:	BACKHOE	R L Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide orientation:	datum:	

method	penetration 1 2 3 4	support	water	samples, tests etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E		NIL	D	D				SC	CLAYEY SAND: fine grained, light grey-grey with some silt and some fine roots	M	L / MD		TOPSOIL
				D				SC	CLAYEY SAND: fine grained, orange, with some low to medium plasticity clay clay content increasing with depth				RESIDUAL
				D		1		CH	SANDY SILTY CLAY: medium to high plasticity light grey, mottled orange & red with sand fine to medium grained clay begins to have a slightly fissured structure from 1.3m with a trace of former roots and red ironstaining	<Wp	H		
				D		2			SANDY SILTY CLAY: medium plasticity light grey with sand fine grained				EXTREMELY WEATHERED ROCK
						3			Pit JTP7 Terminated at 2 40 m				
						4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
X not measured
water level
water outflow
water inflow

SAMPLES TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Geosciences Pty Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no: JTP8
sheet 1 of 1

client:	SHOALHAVEN CITY COUNCIL	office job no:	G12023/1
principal:		pit commenced:	31-03-99
project:	EFFLUENT DISPOSAL STUDY	pit completed:	31-03-99
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	logged by:	AMF
		checked by:	
equipment type and model:	BACKHOE	R L Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide	orientation:	datum:

method	penetration 1 2 3 4	support	water	samples, tests etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
E		Nil	D	D				SC	CLAYEY SAND: fine grained, brown, with some silt and fine roots, breaks up in 50mm pedals	M	L		TOPSOIL
				D				SC	CLAYEY SAND: fine grained, orange, with a trace of silt and occasional medium to coarse angular and rounded quartz gravel		MD		
								CI	SANDY SILTY CLAY: medium to high plasticity, orange with sand fine grained	>Wp	VSt		RESIDUAL
				D				CI	SANDY CLAY: medium plasticity orange with some angular sandstone gravel		St		
						1, 2, 3, 4			Pit JTP8 Terminated at 0.60 m Backhoe refusal at 0.6m on moderately weathered sandstone				

COFEXCA VERSION B4. 18/5/99 12:34:11

METHOD	PENETRATION	SAMPLES, TESTS ETC	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION	CONSISTENCY/DENSITY INDEX
N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R bulldozer ripper E excavator HA hand auger HT hand tools	1 2 3 4 little resistance ranging to very slow progress	U undisturbed sample (mm) D disturbed sample Bs bulk sample E environmental sample VS vane shear DP dynamic penetrometer FD field density WS water sample	based on unified classification system	VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense
SUPPORT SH shoring SC shotcrete Nil no support RB rockbolts	WATER D none observed X not measured water level water outflow water inflow		MOISTURE D dry M moist W wet Wp plastic limit Wl liquid limit	

Coffey Geosciences Pty Ltd
ACN 056 335 516

COFFEY

pit no JTP9

sheet 1 of 1

engineering log - excavation

office job no: G12023/1

client:	SHOALHAVEN CITY COUNCIL	pit commenced:	31-03-99
principal:		pit completed:	31-03-99
project:	EFFLUENT DISPOSAL STUDY	logged by:	
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	checked by:	
equipment type and model:	BACKHOE	R L Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide orientation:	datum:	-

method	penetration 1 2 3 4	support	water	samples tests etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
E		NIL	D	D				SC	CLAYEY SAND: fine grained light grey with some fine roots	D M	L		TOPSOIL
				D				CH	SILTY CLAY: high plasticity, orange, with a trace of sand fine grained, massive structure	=Wp <Wp	H VSt H		RESIDUAL
				D		1			SANDY SILTY CLAY: low to medium plasticity, orange with brown layering sand fine to medium grained				EXTREMELY WEATHERED ROCK
				D		2			SANDSTONE: Highly weathered fine grained, orange-brown, with some extremely weathered bands				HIGHLY WEATHERED ROCK
						3			Pit JTP9 Terminated at 2 40 m				

METHOD	PENETRATION	SAMPLES, TESTS, ETC	CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION	CONSISTENCY/DENSITY INDEX
N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R bulldozer ripper E excavator HA hand auger HT hand tools SUPPORT SH shoring SC shotcrete Nil no support RB rockbolts	1 2 3 4 little resistance ranging to very slow progress WATER D none observed X not measured water level water outflow water inflow	U undisturbed sample (mm) D disturbed sample Bs bulk sample E environmental sample VS vane shear DP dynamic penetrometer FD field density WS water sample	based on unified classification system MOISTURE D dry M moist W wet Wp plastic limit Wl liquid limit	VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense

COFEXCA VERSION B4. 18 / 5/99 12 :34 :29

T88-239

Coffey Geosciences Pty Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no	JTP10
sheet	1 of 1

client:	SHOALHAVEN CITY COUNCIL	office job no:	G12023/1
principal:		pit commenced:	31-03-99
project:	EFFLUENT DISPOSAL STUDY	pit completed:	31-03-99
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	logged by:	JWF
		checked by:	LPA

equipment type and model: BACKHOE — R L Surface: NOT MEASURED

excavation dimensions: 4 m long 0.45 m wide — orientation: — datum:

method	penetration 1 2 3 4	support	water	samples, tests etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E		Nil	D					SC	CLAYEY SAND: fine grained, light grey with some silt and roots	D M	L MD		TOPSOIL
								CH	SILTY CLAY: medium to high plasticity, orange, with a trace to some sand fine grained with slight fissuring and a trace of roots	<Wp	H		RESIDUAL
						1			SANDY SILTY CLAY: light grey, mottled orange, some red fissured structure breaks up into 20-50mm pedals gravelly from 0 8-0 9m				EXTREMELY WEATHERED ROCK
						2			SANDSTONE: fine grained light grey mottled orange highly weathered				HIGHLY WEATHERED ROCK
									Pit JTP10 Terminated at 2 40 m Practical refusal with backhoe at 2 4m				
						3							
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- D none observed
- X not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

COFEXCA VERSION B4. 18 / 5/99 12 :16 :12

TB9-239

Coffey Geosciences Pty. Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no JTP11
sheet 1 of 1

office job no: G12023/1

client:	SHOALHAVEN CITY COUNCIL	pit commenced:	31-03-99
principal:		pit completed:	31-03-99
project:	EFFLUENT DISPOSAL STUDY	logged by:	
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	checked by:	
equipment type and model:	BACKHOE	R.L. Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide orientation:	datum:	

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
E		NIL	0	D				SC	CLAYEY SAND: fine grained light grey with some silt and roots	D / M	L		TOPSOIL
				D				CH	SILTY CLAY: medium to high plasticity, orange, mottled red, with a trace to some sand fine grained		VSt/H		RESIDUAL
									becoming light grey from 1.1m		H		
						1			SILTY CLAY: medium plasticity, light grey fissured structure withsome sand fine grained				EXTREMELY WEATHERED ROCK
									SANDSTONE: fine grained light grey-orange, highly weathered				HIGHLY WEATHERED ROCK
						2							
									Pit JTP11 Terminated at 2.20 m slow progress on highly to moderately weathered sandstone				
						3							
						4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
X not measured
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

COFEXCA VERSION B4. 18 / 5/99 12:17:11

Coffey Geosciences Pty Ltd
ACN 056 335 516

COFFEY

engineering log - excavation

pit no: JTP12
sheet 1 of 1

office job no: G12023/1

client:	SHOALHAVEN CITY COUNCIL	pit commenced:	31-03-99
principal:		pit completed:	31-03-99
project:	EFFLUENT DISPOSAL STUDY	logged by:	DWS
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	checked by:	
equipment type and model:	BACKHOE	R L Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide	orientation:	datum:

method	penetration 1 2 3 4	support	water	samples, tests etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E		NIL	D	D				SC	CLAYEY SAND: fine grained, light grey with some silt and some fine roots breaks up in hard lumps up to 200mm from 0.1m depth	D M			TOPSOIL
								CH	SILTY CLAY: medium to high plasticity, orange-brown & red, with a trace of sand fine grained slight fissuring	<Wp	H		RESIDUAL
						1			SANDY SILTY CLAY: medium to high plasticity, light grey mottled orange, & red highly fissured breaks into pedals of 20-50mm with red ironstaining in some fine root hairs				EXTREMELY WEATHERED ROCK
						2			SANDSTONE: fine grained, light grey-orange with some extremely weathered sections				HIGHLY WEATHERED ROCK
						3			Pit JTP12 Terminated at 2.50 m				
						4							

COFEXCA VERSION B4. 18 / 5/99 12 :19 :49

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
X not measured
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Geosciences Pty Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no	JTP13
sheet	1 of 1
office job no:	G12023/1

client:	SHOALHAVEN CITY COUNCIL	pit commenced:	31-03-99
principal:		pit completed:	31-03-99
project:	EFFLUENT DISPOSAL STUDY	logged by:	DME
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	checked by:	

equipment type and model:	BACKHOE	R L Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide	orientation:	datum:

method	penetration 1 2 3 4	support	water	samples tests etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics; colour; secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
E		NIL	D	D				SC	CLAYEY SAND: fine grained light grey with fine roots and a trace to some silt	M	L		TOPSOIL
				D				CI	SILTY CLAY: medium plasticity orange & light grey mottled		VSt / H		RESIDUAL
				D		1			SANDY SILTY CLAY: medium plasticity, light grey, mottled orange, with some red ironstaining highly fissured structure with fine root hairs				EXTREMELY WEATHERED ROCK
				D		2			SANDSTONE: fine grained, light grey-orange with some extremely weathered sections				HIGHLY WEATHERED ROCK
						3			Pit JTP13 Terminated at 2.60 m				
						4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
X not measured
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Coffey Geosciences Pty Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no	JTP14
sheet	1 of 1

client:	SHOALHAVEN CITY COUNCIL	office job no:	G12023/1
principal:		pit commenced:	31-03-99
project:	EFFLUENT DISPOSAL STUDY	pit completed:	31-03-99
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	logged by:	JMF
		checked by:	
equipment type and model:	BACKHOE	R.L Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide	orientation:	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics colour secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E		NIL	D	D				SC	CLAYEY SAND: fine grained light grey, with low plasticity clay with some silt and fine roots	M	L		TOPSOIL
				D				CI	SILTY CLAY: medium plasticity orange with a trace to some fine grained sand	>Wp	VSt		RESIDUAL
				D		1			SANDY SILTY CLAY: medium plasticity, light grey, some red ironstaining fissured structure in places	<Wp			EXTREMELY WEATHERED ROCK moist in places
						2			contains some highly weathered ironstone bands from 1.9m				
				D									
						3			Pit JTP14 Terminated at 2.70 m				
						4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT hand tools

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
D none observed
* not measured
water level
water outflow
water inflow

SAMPLES TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

COFEXCA VERSION B4. 18 / 5 / 99 12 :22 :9

Coffey Geosciences Pty. Ltd
ACN 056 335 516

engineering log - excavation

COFFEY

pit no	JTP15
sheet	1 of 1

client:	SHOALHAVEN CITY COUNCIL	office job no:	G12023/1
principal:		pit commenced:	31-03-99
project:	EFFLUENT DISPOSAL STUDY	pit completed:	31-03-99
pit location:	JERBERRA ESTATE, ST GEORGES BASIN (REFER TO DRAWING)	logged by:	DVE
		checked by:	
equipment type and model:	BACKHOE	R L Surface:	NOT MEASURED
excavation dimensions:	4 m long 0.45 m wide	orientation:	datum:

method	penetration 1 2 3 4	support	water	samples tests etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E		NIL	D	D				CH	ORGANIC CLAY: medium plasticity, dark grey with fine roots and organic spongy material	>Wp			TOPSOIL
				D				CH	SILTY CLAY: high plasticity, grey-brown with fine roots slightly fissured structure	>Wp	St	x	ALLUVIUM
				D		1			becoming light grey brown mottled orange massive structure			x	
						2						x	
									Pit JTP15 Terminated at 2.60 m			x	
						3							
						4							

COFEXCA VERSION B4. 18 / 5/99 12 :37 :54

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT hand tools

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- D none observed
- x not measured
- water level
- water outflow
- water inflow

SAMPLES TESTS ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

APPENDIX B

Laboratory Reports

B2: Chemical Laboratory Reports

SYDNEY ANALYTICAL LABORATORIES

Office:
PO BOX 48
ERMINGTON NSW 2115

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8903
Fax: (02) 9838 8919
A.C.N. 003 614 695
NATA Reg. 1884

COFFEY ... INTERNATI... PTY LTD
RE... ED
28 APR 1999
SYDNEY
APD

ANALYTICAL REPORT for:

COFFEY GEOSCIENCES PTY LTD

PO BOX 125
NORTH RYDE 2113

ATTN: ANDREW DAWKINS

JOB NO:	SAL7628
CLIENT ORDER:	G12023/1
DATE RECEIVED:	08/04/99
DATE COMPLETED:	16/04/99
TYPE OF SAMPLES:	SOILS
NO OF SAMPLES:	4

National Association of Testing Authorities, Australia
NATA Endorsed Test Report

Issued on 23/04/99
Lance Smith
(Chief Chemist)

SYDNEY
ANALYTICAL
LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL7628
CLIENT ORDER: G12023/1

	SAMPLES	*PHOSPHORUS SORPTION mg/kg	ESP %	CEC MEQ%
1	JTP4/0.6-0.7	600	2.0	8.0
2	JTP7/0.4-0.5	400	0.9	2.3
3	JTP11/0.4-0.5	550	2.9	7.5
4	JTP14/0.4-0.5	560	2.0	6.0
MDL		1	0.1	0.1
Method Code		S9	C35	S7
Preparation		P5	P5	P5

SYDNEY
ANALYTICAL
LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL7628
CLIENT ORDER: G12023/1

	SAMPLES	EXCHANGEABLES					
		Na MEQ%	K MEQ%	Ca MEQ%	Mg MEQ%	Mn MEQ%	Al MEQ%
1	JTP4/0.6-0.7	0.16	0.12	0.23	3.45	<0.01	3.8
2	JTP7/0.4-0.5	0.02	0.02	0.34	0.70	<0.01	1.0
3	JTP11/0.4-0.5	0.22	0.04	1.45	4.05	<0.01	2.1
4	JTP14/0.4-0.5	0.12	0.06	0.10	2.75	<0.01	2.7
	MDL	0.01	0.01	0.01	0.01	0.01	0.1
	Method Code	S7	S7	S7	S7	S7	S7
	Preparation	P5	P5	P5	P5	P5	P5

SYDNEY ANALYTICAL LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL7628
CLIENT ORDER: G12023/1

	SAMPLES	SOLUBLES Na MEQ%	K MEQ%	Ca MEQ%	Mg MEQ%	Mn MEQ%	Al MEQ%
1	JTP4/0.6-0.7	0.32	0.03	<0.01	0.10	<0.01	<0.1
2	JTP7/0.4-0.5	0.10	0.06	0.01	0.17	<0.01	<0.1
3	JTP11/0.4-0.5	0.24	0.42	0.04	0.45	<0.01	<0.1
4	JTP14/0.4-0.5	0.22	0.17	<0.01	0.31	<0.01	<0.1
	MDL	0.01	0.01	0.01	0.01	0.01	0.1
	Method Code	S7	S7	S7	S7	S7	S7
	Preparation	P5	P5	P5	P5	P5	P5

RESULTS ON DRY BASIS

SYDNEY ANALYTICAL LABORATORIES

ANALYTICAL REPORT

JOB NO: SAL7628
CLIENT ORDER: G12023/1

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory.

P5	Sample dried, split and crushed to -150um
*S9	Phosphorus Sorption - Dept of Agriculture Standard Method Determined by APHA 4500F
C35	Exchangeable Sodium Percentage - Silver Thiourea Extract Determined by APHA 3500D
S7	Cation Exchange Capacity & Exchangeable/Soluble Cations Determined by Silver Thiourea Method

*The laboratory's NATA registration does not cover performance of this service

A preliminary report was faxed on 16/04/99

B1: Physical Laboratory Reports

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
142 Wicks Road, North Ryde, NSW, 2113
Ph: (61 2) 9888 7444 Fax: (61 2) 9878 8155

Coffey

determination of emerson class number

client : *SHOALHAVEN CITY COUNCIL*
principal :
project : *EFFLUENT DISPOSAL STUDY*
location : *JERBERRA ESTATE, ST GEORGES BASIN*

job no : *G12023/1*
laboratory : *SYDNEY*
date : *15/04/99*
test report :

test procedure : *AS1289.3.8.1-1997*
sample identification: *JTP9 (0.4 - 0.5m)*
Sample supplied by CG-Wollongong on the 9/4/99.

test data

air dried crumbs

time start of test:	*12/4/99 15:26*
time dispersion commences:	*12/4/99 15:27*
time dispersion completed:	*Not Observed*

remoulded material

time start of test:	-
time dispersion commences:	-
time dispersion completed:	-

material description

(CI/CH) CLAY - medium to high plasticity,light brown.

type of water used: *Distilled*

water temperature: *20.5°*

immersion of air dried crumbs

- does not slake ☐
  - swell ☐ 7
  - does not swell ☐ 8
- slakes ☒
  - complete dispersion ☐ 1
  - partial dispersion ☒ 2
  - no dispersion ☐

immersion of remoulded material

- disperses ☐ 3
- does not disperse ☐
  - calcite or gypsum
    - present ☐ 4
    - absent ☐
      - vigorous shaking
        - disperses ☐ 5
        - flocculates ☐ 6

Emerson class number	2

NATA

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This document shall not be reproduced except in full without the prior approval of the laboratory.

J RUSSELL 16/4/99

Authorised Signature James Russell

NATA No 431

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
142 Wicks Road, North Ryde, NSW, 2113
Ph: (61 2) 9888 7444, Fax: (61 2) 9878 8155

Coffey

determination of emerson class number

client :	*SHOALHAVEN CITY COUNCIL*	job no :	*G12023/1*
principal :		laboratory :	*SYDNEY*
project :	*EFFLUENT DISPOSAL STUDY*	date :	*15/04/99*
location :	*JERBERRA ESTATE, ST GEORGES BASIN*	test report :	

test procedure : *AS1289.3.8.1-1997*
sample identification: *JTP3 (0.5 - 0.6m)*
Sample supplied by CG-Wollongong on the 9/4/99.

test data

air dried crumbs

time start of test: *12/4/99 15:27*

time dispersion commences: -

time dispersion completed: -

remoulded material

time start of test: *13/4/99 11:50*

time dispersion commences: -

time dispersion completed: -

material description

(CI) CLAY - medium plasticity, light brown orange.

type of water used: *Distilled*

water temperature: *20.5°*

immersion of air dried crumbs

- does not slake ☐
  - swell ☐ (7)
  - does not swell ☐ (8)
- slakes ☒
  - complete dispersion ☐ (1)
  - partial dispersion ☐ (2)
  - no dispersion ☒

immersion of remoulded material

- disperses ☐ (3)
- does not disperse ☒
  - calcite or gypsum
    - present ☐ (4)
    - absent ☒
      - vigorous shaking
        - disperses ☒ (5)
        - flocculates ☐ (6)

Emerson class number	5

NATA

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J. RUSSELL 16/4/99
Authorised Signature
NATA No 431

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management
142 Wicks Road, North Ryde, NSW, 2113
Ph: (61 2) 9888 7444, Fax: (61 2) 9878 8155

Coffey

determination of emerson class number

client :	*SHOALHAVEN CITY COUNCIL*	job no :	*G12023/1*
principal :		laboratory :	*SYDNEY*
project :	*EFFLUENT DISPOSAL STUDY*	date :	*15/04/99*
location :	*JERBERRA ESTATE, ST GEORGES BASIN*	test report :	

test procedure : *AS1289.3.8.1-1997*
sample identification: *JTP10 (0.4 - 0.5m)*
Sample supplied by CG-Wollongong on the 9/4/99

test data

air dried crumbs

time start of test: *12/4/99 15:25*

time dispersion commences: -

time dispersion completed: -

remoulded material

time start of test: *13/4/99 11:45*

time dispersion commences: -

time dispersion completed: -

material description

(CI) CLAY - medium plasticity,orange brown, some fine to medium sand

type of water used: *Distilled*

water temperature: *20.5°*

immersion of air dried crumbs

- does not slake ☐ → swell ☐ (7) / does not swell ☐ (8)
- slakes ☒
  - complete dispersion ☐ (1)
  - partial dispersion ☐ (2)
  - no dispersion ☒

immersion of remoulded material

- disperses ☐ (3)
- does not disperse ☒
  - calcite or gypsum
    - present ☐ (4)
    - absent ☒
      - vigorous shaking
        - disperses ☒ (5)
        - flocculates ☐ (6)

Emerson class number	5

J. RUSSELL 16/4/99

Authorised Signature James Russell

NATA No 431

Coffey Geosciences Pty Ltd A.C.N 056 335 516

Geotechnical Resources Environmental Technical Project Management
142 Wicks Road, North Ryde, NSW, 2113
Ph: (61 2) 9888 7444, Fax: (61 2) 9878 8155

determination of emerson class number

client : SHOALHAVEN CITY COUNCIL
principal :
project : EFFLUENT DISPOSAL STUDY
location : JERBERRA ESTATE, ST GEORGES BASIN

job no : G12023/1
laboratory : SYDNEY
date : 15/04/99
test report :

test procedure : AS1289.3.8.1-1997
sample identification: JTP12 (0.4 - 0.5m)
Sample supplied by CG-Wollongong on the 9/4/99.

test data

air dried crumbs

time start of test: 12/4/99 15:28

time dispersion commences: -

time dispersion completed: -

remoulded material

time start of test: 13/4/99 11:52

time dispersion commences: -

time dispersion completed: -

material description

(CI) CLAY - medium plasticity, red brown, trace of fine sand.

type of water used: Distilled

water temperature: 20.5°

immersion of air dried crumbs

does not slake ☐
slakes ☒

swell ☐ (7)
does not swell ☐ (8)

complete dispersion ☐ (1)
partial dispersion ☐ (2)
no dispersion ☒

immersion of remoulded material

disperses ☐ (3)
does not disperse ☒

calcite or gypsum
present ☐ (4)
absent ☒

vigorous shaking
disperses ☐ (5)
flocculates ☒ (6)

Emerson class number	6

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J. RUSSELL 16/4/99
Authorised Signature
NATA No 431

Coffey Geosciences Pty Ltd A.C.N. 056 335 516

Geotechnical Resources Environmental Technical Project Management

142 Wicks Road, North Ryde, NSW, 2113
Ph: (61 2) 9888 7444 Fax: (61 2) 9878 8155

Coffey

test results

client : *SHOALHAVEN CITY COUNCIL*
principal :
project : *EFFLUENT DISPOSAL STUDY*
location : *JERBERRA ESTATE, ST GEORGES BASIN*

job no : *G12023/1*
laboratory : *SYDNEY*
date : *15/04/99*
test report :

test procedure : *AS1289 4.3.1*
test date : *13/4/99*

Sample Identification	pH Units
JTP3 (0.5 - 0.6m)	*5.2*
JTP9 (0.4 - 0.5m)	*5.1*
JTP10 (0.4 - 0.5m)	*5.3*
JTP12 (0.4 - 0.5m)	*4.7*

remarks : *Samples supplied by CG-Wollongong on the 9/4/99.*

NATA

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with the terms of accreditation. This document shall not be reproduced except in full without the prior approval of the laboratory.

J RUSSELL 16/4/99
Authorised Signature
NATA No 431
James Russell

Coffey Geosciences Pty Ltd A.C.N 056 335 516

Geotechnical Resources Environmental Technical Project Management

142 Wicks Road, North Ryde, NSW, 2113
Ph: (61 2) 9888 7444, Fax: (61 2) 9878 8155

Coffey

test results

client : *SHOALHAVEN CITY COUNCIL*
principal :
project : *EFFLUENT DISPOSAL STUDY*
location : *JERBERRA ESTATE, ST GEORGES BASIN*

job no : *G12023/1*
laboratory : *SYDNEY*
date : *15/04/99*
test report :

test procedure : *Prepared in accordance with AS1289 4.3.1 test method*
test date : *13/4/99*

Sample Identification	Electrical Conductivity Units us/cm
JTP3 (0.5 - 0.6m)	*0.07*
JTP9 (0.4 - 0.5m)	*0.56*
JTP10 (0.4 - 0.5m)	*0.03*
JTP12 (0.4 - 0 5m)	*0.04*

remarks : *Samples supplied by CG-Wollongong on the 9/4/99.*

Form Number L1.0R1 Version 4.0

APPENDIX C

Preliminary Water Balance Calculations

JERBERRA ESTATE ST GEORGES BASIN
EFFLUENT STUDY
PRELIMINARY WATER BALANCE

Design Water Flow	1000	Q
Design percolation Rate	5	R

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Days in Month	D		days	31	28	31	30	31	30	31	31	30	31	30	31	
Precipitation	P		mm/month	88	71	80	52	72	62	41	38	48	72	84	70	777
Evaporation	E		mm/month	195	160	146	120	96.1	87	96.1	127	150	177	180	214	1748
Crop Factor	C			0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
Inputs																
Precipitation	P		mm/month	88	71	80	52	72	62	41	38	48	72	84	70	777
Possible Effluent Irrigation	W	(ET + B) - P	mm/month	90	77	59	65	27	29	58	86	94	92	81	123	H = 881
Actual Effluent Production	I	H/12	mm/month	73	73	73	73	73	73	73	73	73	73	73	73	
Inputs		(P + I)	mm/month	162	144	153	126	146	136	114	111	121	145	158	143	1669
Outputs																
Evapotranspiration	ET	E X C	mm/month	156	128	117	96	77	70	77	102	120	141	144	171	1398
Percolation	B	(R / 7) X D	mm/month	22	20	22	21	22	21	22	22	21	22	21	22	
Outputs		ET + B	mm/month	178	148	139	117	99	91	99	124	141	164	165	193	1659
Storage	S	(P + I) - (ET + B)	mm/month	-17	-3	14	8	47	45	15	-13	-20	-18	-8	-50	
Cumulative Strorage	M		mm	0	-3	11	20	66	111	126	113	93	75	67	17	

Irrigation Area	L	365 X Q / H	m2	414
Storage	V	Largest M	mm	129
		(V X L)/1000 m3		53

Coffey Geosciences Pty Ltd ACN 056 335 516

Coffey

Computations

Job No 912023/1
Sheet 1 of 2

Client Shoalhaven City Council
Office
Principal
Date 30 April 1999
Project Effluent Study
By LPT
Location TOMERONG JERBERRA ESTATE
Checked

Water Balance Calculations

(1) NUTRIENT BALANCE

$$A = \frac{C \times Q}{L_s}$$

A = land area m^2
C = nutrient conc. (mg/L)
Q = wastewater flow rate
L_x - critical loading rate

A phosphorous (average) 527.5 mg/kg assume 1500 kg soil/m^3

0.7913 g/m^3

7912 kg/ha/m of soil

Assumptions
~~CR~~ · Total phosphorous conc (TP) = 12 mg/L in wastewater

critical loading rate (L_p) = 3 mg/m^2/day

phosphorous sorption capacity = 7900 kg/ha

(1) Amount of phosphorous that can be absorbed ~~xx~~ without ~~Pabsorbed~~ leaching over 50 years

Pabsorbed = 7900 × 1/3

= 2631 kg/ha/m

= 0.26 kg/m^2

(2) Determine amount of vegetation uptake over 50 years

P uptake = 3 × 365 × 50

= 54,750 mg/m^2

= 0.055 kg/m^2

(3) Determine amount of phosphorous generated in 50 years

= 12 × 1000 × 365 × 50

= 219 kg

$$\text{Irrigation area} = \frac{P_{generated}}{P_{absorbed} + P_{uptake}}$$

$$= \frac{219}{0.26 + 0.055}$$

$$= 695\,m^2$$

B NITROGEN

Assumptions (based on Table 14 of E&H 1999 Guidelines)

- 37 mg/L nitrogen concentration in wastewater
- 25 mg/m²/d critical loading rate

$$A = \frac{C \times Q}{L_x}$$

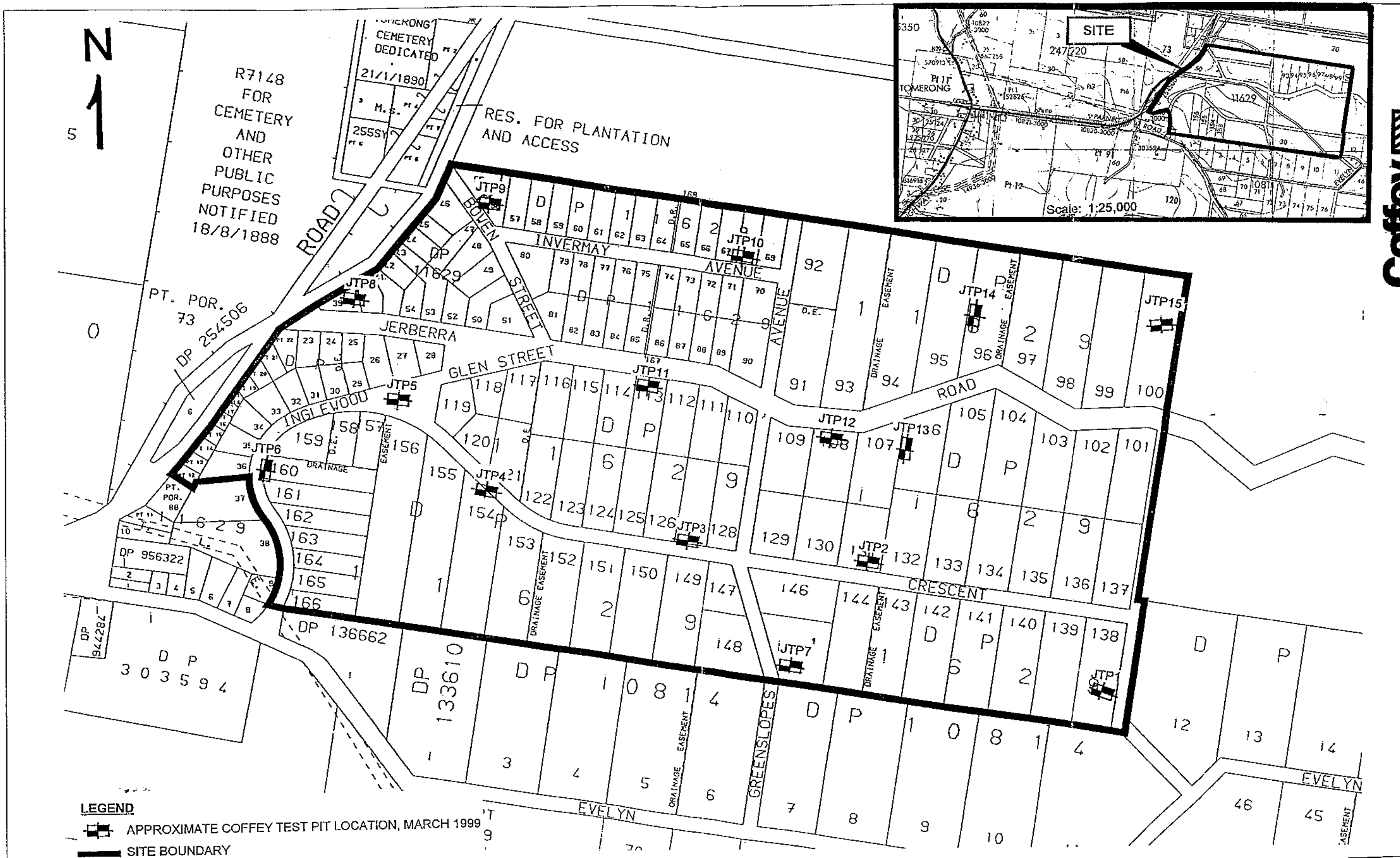
where A = irrigation area in m
C = concentration of nutrient
Q = wastewater flow rate
L_x = critical loading rate

$$A = \frac{37 \times 1000}{25}$$

$$= 1480\,m^2$$

APPENDIX D

Drawings



Coffey Geosciences Pty Ltd ACN 056 335 516

Geotechnical | Resources | Environmental | Technical | Project Management

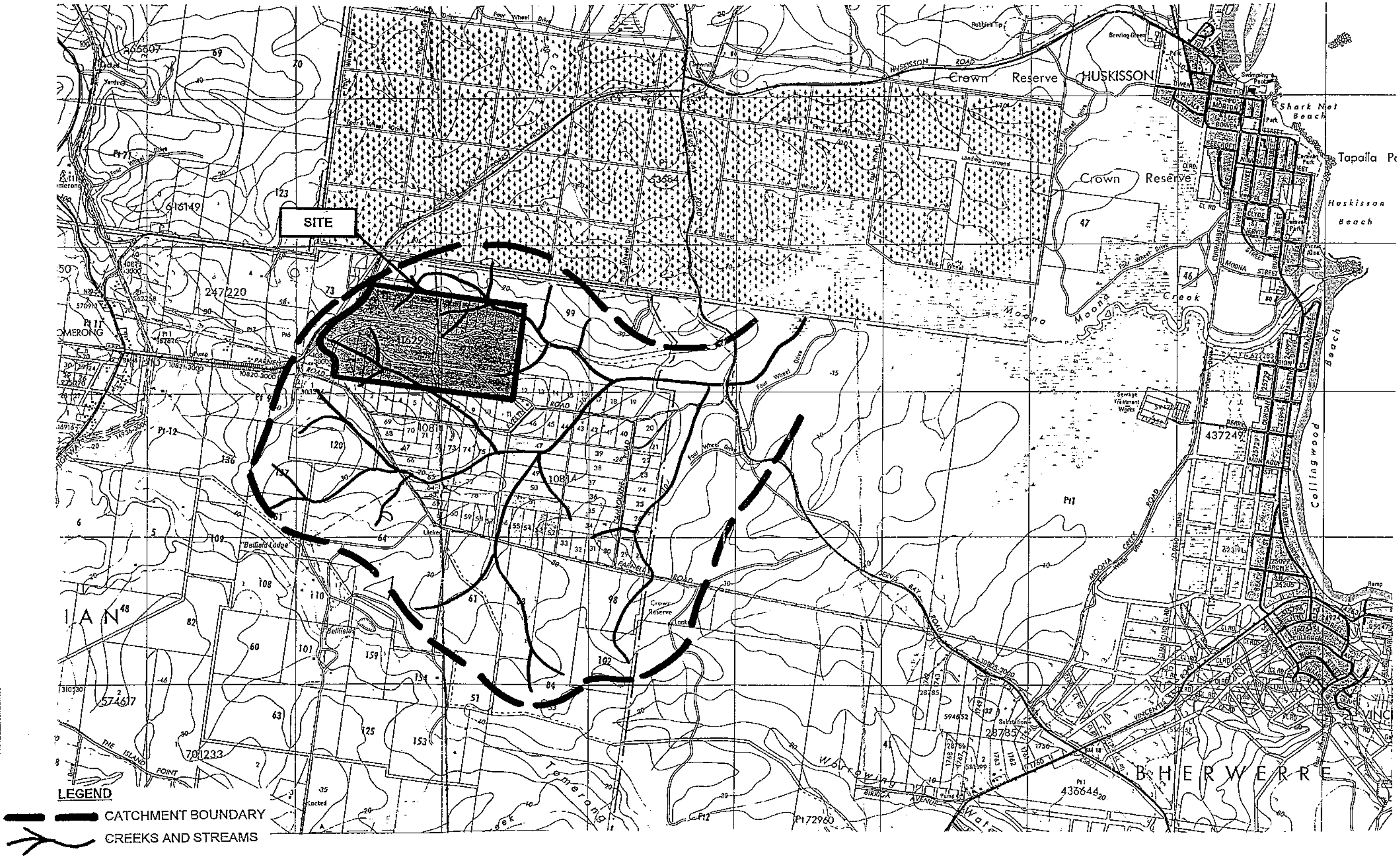
Scale (metres) 1:5000	Revision	Description	Drawn	Approved	Date
50 0 50 100 150 200 250					

Drawn	JMF
Checked	LP
Date	13-04-99

SHOALHAVEN CITY COUNCIL
EFFLUENT DISPOSAL STUDY
JERBERRA ESTATE, ST GEORGES BASIN
APPROXIMATE SAMPLING LOCATIONS

Drawing no: G12023/1-1

Job no: G12023/1



Coffey Geosciences Pty Ltd ACN 056 335 516

Geotechnical | **Resources** | Environmental | **Technical** | Project Management

Scale (metres): 25 0 25 50 75 100 125

1:25,000 (at A3)

Revision	Description	Drawn	Approved	Date

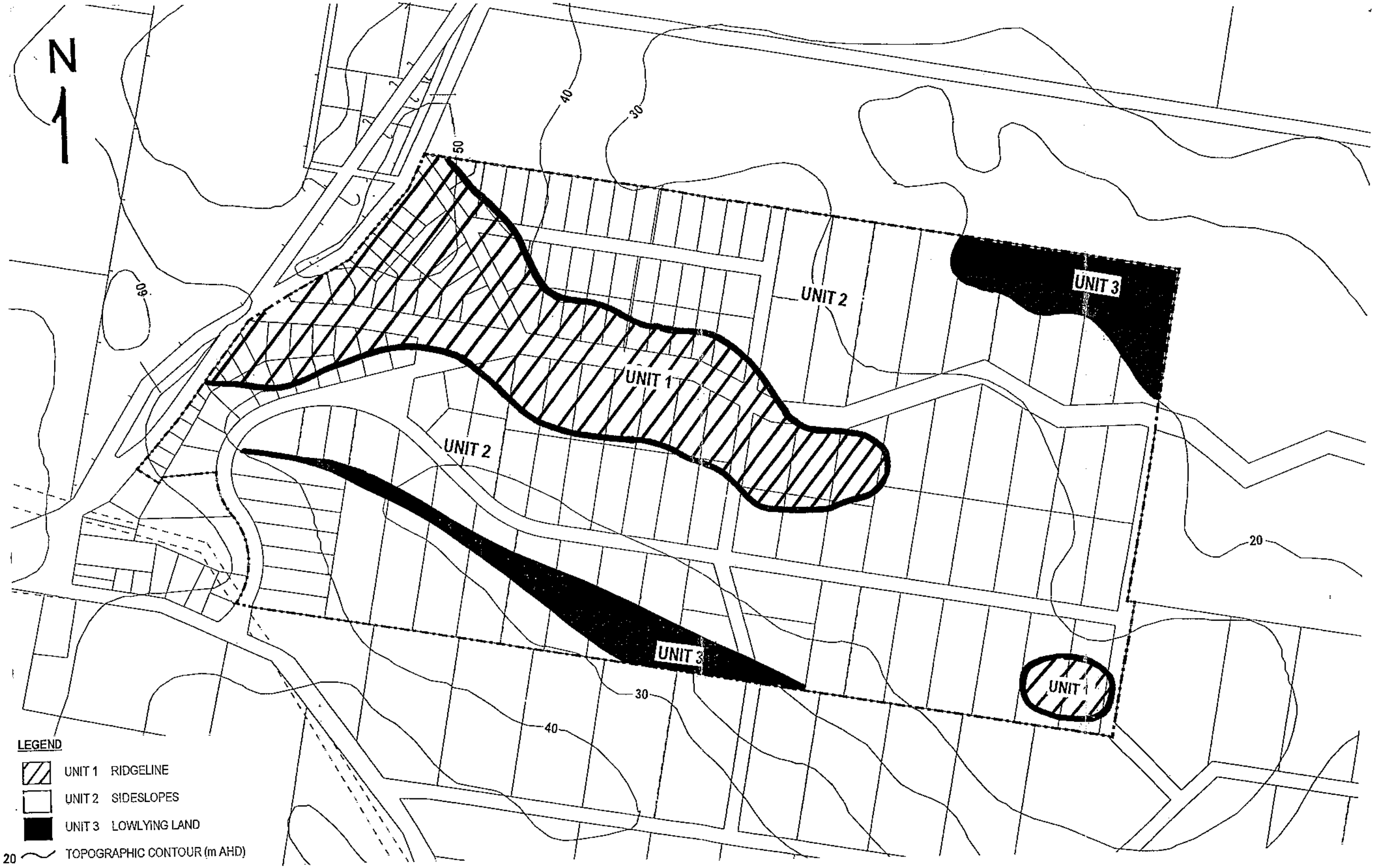
Drawn	JMF
Checked	LPA
Date	18-05-99

SHOALHAVEN CITY COUNCIL
EFFLUENT DISPOSAL STUDY
JERBERRA ESTATE, ST GEORGES BASIN
CATCHMENT CONFIGURATION

Drawing no: G12023/1-2

Job no: G12023/1

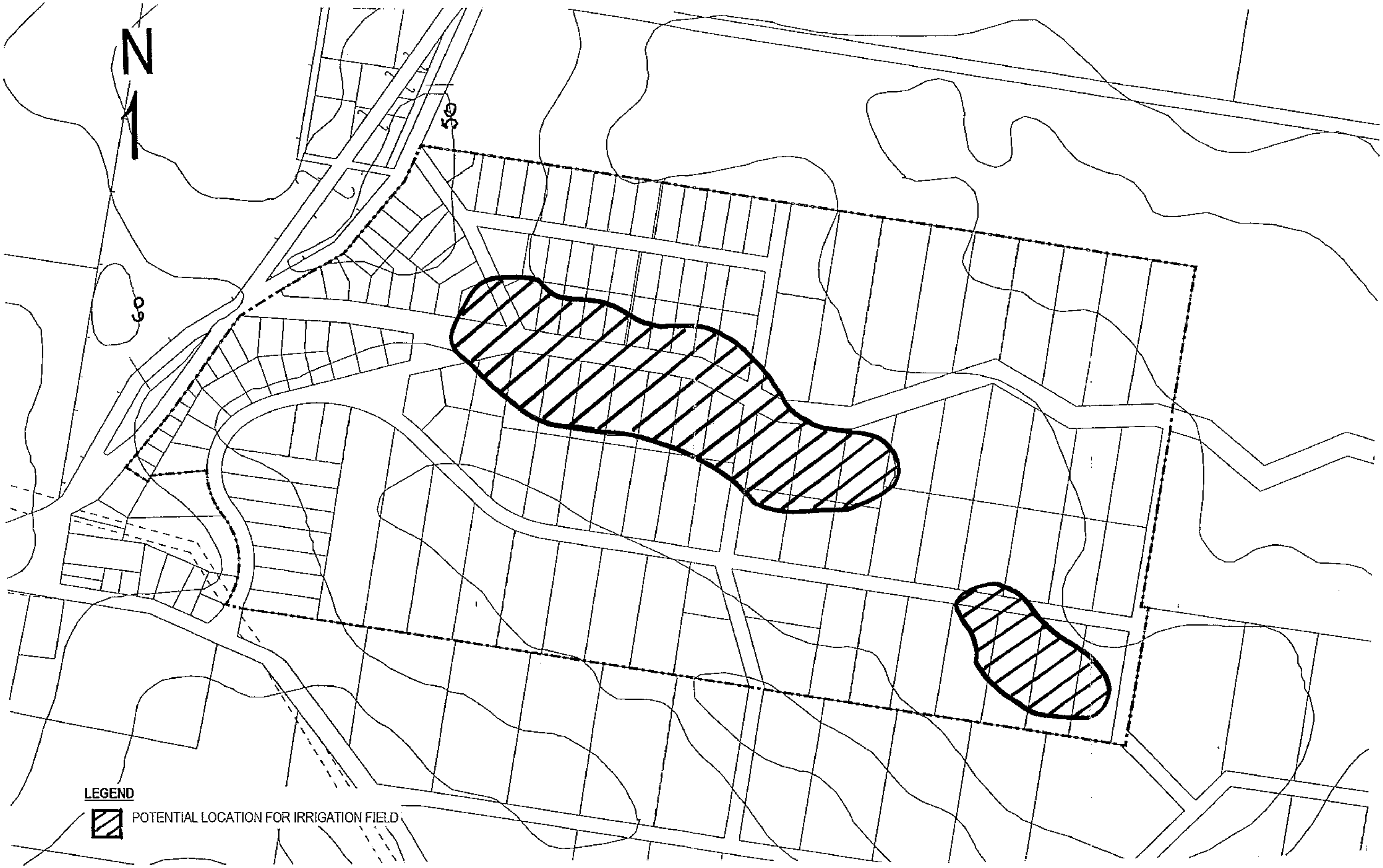
Coffey



Coffey

Coffey Geosciences Pty Ltd ACN 056 335 516 | Geotechnical | Resources | Environmental | Technical | Project Management

1:5000 Scale (metres)	Revision	Description	Drawn	Approved	Date	Drawn	JMF	SHOALHAVEN CITY COUNCIL EFFLUENT DISPOSAL STUDY JERBERRA ESTATE, ST GEORGES BASIN TERRAIN UNITS	Drawing no: G12023/1-3
						Checked	LP7		
						Date	30-04-99		Job no: G12023/1



Coffey Geosciences Pty Ltd ACN056335516

Geotechnical | Resources | Environmental | Technical | Project Management

1:5,000 Scale (metres)	Revision	Description	Drawn	Approved	Date	Drawn	JMF	SHOALHAVEN CITY COUNCIL EFFLUENT DISPOSAL STUDY JERBERRA ESTATE, ST GEORGES BASIN POTENTIAL LOCATION FOR IRRIGATION FIELD	Drawing no: G12023/1-4
						Checked	LPF		
						Date	23-09-99		Job no: G12023/1

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By Hand	
Contact:	Dr D. Martens
Our Ref:	P0501093JC1_v3.doc
Pages:	12
cc.	-

3 April 2006

Shoalhaven City Council
Eric Hollinger (Strategic Project Planner)
PO Box 42
Nowra, NSW 2541

Dear Eric,

RE: REVIEW OF BEST PRACTICE METHODS OF ON-SITE SEWAGE DISPOSAL – JERBERRA ESTATE REZONING INVESTIGATIONS (DRAFT LEP LP155)

BACKGROUND AND SCOPE

We provide the following review of on-site effluent management alternatives for the study area within the context of existing environmental information, this being:

1. ERM Mitchell McCotter (1994) Local Environmental Study.

2. Coffey (2000) Effluent Disposal Study, Jerberra Estate, St. Georges Basin.

Key aspects of our review include:

1. The adequacy of effluent disposal requirements discussed in the Coffey (2000) report, within the context of current standards.

2. Assessment of and recommendations for best practice on-site wastewater treatment alternatives for the site, taking into account spatial variations in soil, gradient and buffer requirements.

EXISTING SITE AND ENVIRONMENT CONDITIONS

The following salient points pertain to on-site effluent management within the study area.

1. The site contains 153 allotments ranging between 860 – 17,600 m^2, with 102 allotments less than 4000 m^2 in area (some lots adjacent to Pine Forest Road are < 900 m^2 although exact areas have not been determined by survey).

2. Three primary soil units occur on the site:

   a. Moderate depth podzolics of clayey sand (to say 0.3 m depth) overlying silty clay to between 0.9 – 1.5 m depth. These overlay sandstone which is broadly expressed in the NW-SE aligned ridgeline.

   b. Deep podzolics of clayey sand (to say 0.3 m depth) overlying silty clay to between 1.8 – > 2.2 m depth. These broadly occur along the side slopes of

Head Office
Unit 6 / 37 Leighton Place
Hornsby NSW 2077, Australia
Ph 02 9476 8777 **Fax** 02 9476 8767

> mail@martens.com.au
www.martens.com.au
MARTENS & ASSOCIATES P/L
ABN 85 070 240 890 ACN 070 240 890

the NW-SE aligned ridgeline.

c. Poorly drained highly plastic clay soils occurring in low lying land subject to overland flows and flooding. Soil depth in these areas generally exceeds 2.0 m.

3. Two drainage depressions / intermittent water courses occur on the site.

4. Site slopes are generally < 10 % and suitable for a range of effluent re-use methods (see Attachment A).

5. Several unsealed roads traverse the study area.

6. Whilst some buildings have been erected on some of the allotments, much of the study area remains in an unbuilt form and extensively covered with native vegetation. Approximately 65 lots contain unauthorised structures. There is 1 approved dwelling within the estate.

KEY COFFEY RECOMMENDATIONS AND COMMENTS

The following points summarise recommendations of the Coffey (2000) report and our comments:

1. Simple annual nutrient (N and P) balance calculations indicated minimum effluent disposal area of 695 m^2 on the basis of P (using an irrigation P concentration of 12 mg/L) and 1480 m^2 on the basis of N (using an irrigation N concentration of 37 mg/L). The monthly water balance calculations provided by Coffey's indicated a minimum effluent disposal area per house of 414 m^2.

   Our view is that there is considerable discrepancy between the outcomes of the water and nutrient balance calculations. More detailed N and P balance modelling (using say a daily model) is likely to show that smaller areas are required for re-use. Further to this, Coffeys did not investigate the potential of providing a higher quality effluent, which in turn would further reduce the nutrient loads within irrigated effluent and therefore the irrigation area requirement.

2. Two feasible effluent management options were proposed by Coffey's:

   a. Individual AWTS systems servicing each allotment. These would require a minimum allotment size of 2500 m^2 of which 1500 m^2 would be required for effluent disposal. A wet-weather storage of 53 m^3 per site was recommended. An earth bund around each disposal field was recommended to provided storage within the irrigation area.

      Our view is that the effluent application area of 1500 m^2 is probably excessive on the basis of current approaches to wastewater management and the sites reasonable soil effluent renovation potential. Our view is that based on current best practice, both the wet-weather storage and the earth bund proposed around the irrigation field would be unnecessary. Finally, we note that Coffey's did not investigate a range of other alternatives to the AWTS option.

b. A common effluent scheme for the estate. An assumption was made by Coffey's that 1500 m² per lot would be required for effluent disposal. On this basis, Coffey's recommended that the site could only support 85 allotments because effluent could only be disposed of within the ridge line area of the site.

   Our view is that the flaw in the above argument is that the 1500 m² / dwelling assumption is extremely general, does not discuss the considerable differences and benefits offered by a CES, and unlikely accurately reflect engineering practice. Our view is that it is not possible to extrapolate linearly from a single household design to the design of a CES.

   Further to this, it is our view that on the basis of the existing soil data, that many areas of the site outside of that proposed by Coffey's could be used for irrigation by the CES. Coffey's have taken the view that all effluent from the CES would be irrigated within a single area. For a site such as this one, where land has already be sub-divided, the most practical solution when implementing the CES would be to treat effluent centrally and then, through a dual reticulation system, allow for reclaimed water to be re-used on individual allotments.

EFFLUENT TREATMENT STANDARD

The Coffey report does not discuss the implications of applying effluent at a range of treatment / quality standards. Calculations in the Coffey report assume secondary effluent treatment with no further nutrient removal. However, nutrients were the limiting factor in the determination of the 1500 m² recommended for effluent irrigation. This implies that lower nutrient concentrations may result in reduced irrigation areas per lot.

WATER SENSITIVE URBAN DESIGN AND WATER CONSERVATION

The Coffey report does not discuss the implications of BASIX (which was not gazetted at the time of report preparation), standard water reduction devices and re-use opportunities (eg. toilet flushing re-use) for effluent management. In both the water and nutrient balances presented by Coffey's, 1000 L wastewater production has been assumed per dwelling. Using AS/NZS 1547 (2000), the following rates for a five person family (ie. 5 EP dwelling) would apply for a house supplied with reticulated town water:

No water reduction fixtures	900 L/d
Standard water reduction fixtures	725 L/d
Full water reduction fixtures	550 L/d

These values are considerably less than the 1000 L/dwelling assumed by Coffey's. Toilet flushing re-use would account for some 30 % reduction in wastewater production from the above. On the basis of a typical minimum irrigation areas for a 3 and 4 bedroom dwelling are indicated in Table 1 and are based on an example design irrigation rate (DIR) of 20 mm/week. We note that the adopted DIR is for illustrative purposes only.

Table 1: Summary of individual system alternatives.

Category	3 Bedroom Dwelling (5 ep)	4 Bedroom Dwelling (6 ep)
No water reduction fixtures	Flow 900 L/d, Area 315 m^2	Flow 1080 L/d, Area 378 m^2
Standard water reduction fixtures	Flow 725 L/d, Area 254 m^2	Flow 870 L/d, Area 305 m^2
Full water reduction fixtures	Flow 550 L/d, Area 293 m^2	Flow 660 L/d, Area 231 m^2

SINGLE ALLOTMENT SYSTEMS

A range of single allotment systems exist on the current market that may be suitable for the site. These fall into the following broad categories:

1. Standard secondary treatment systems (S)

   These generally include AWTS, single-pass / recirculating sand / rock filter systems and biological systems (eg. Biolytix and Aqua Clarus) which are capable of producing secondary quality effluent. Effluent disposal is by way of irrigation either to surface (if disinfected) or sub-surface (if not disinfected).

2. Water reduction systems (W)

   These generally apply to systems which reduce or remove the blackwater component of the wastestream. Examples include composting toilets and the hybrid toilet. In the case of the hybrid toilet, these differ from composting toilets in that toilet wastewater is discharged into a large water filled chamber with an extended residence time. This process allows for a very long blackwater retention time and high levels of anaerobic digestion prior to discharge. Hybrid toilets either utilise direct drop installations (ie. no blackwater produced) or a mini-flush system (where say 0.3 L/flush is produced).

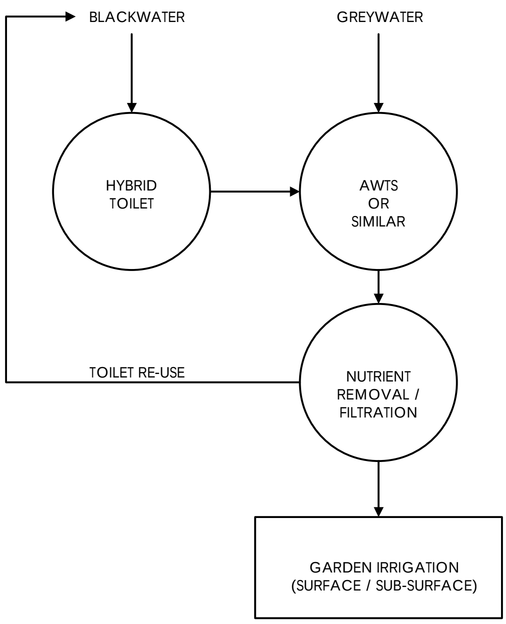
3. Nutrient Removal Systems (N)

   A range of nutrient removal systems for both nitrogen (N) and phosphorus (P) removal exist on the market. These include for example Ecomax, Garden Master (nutrient removal models), BushWater and other AWTS derivatives to name but a few. The use of non-proprietary amended media filters (containing for example BHP blast furnace slag or other products) for advanced nutrient and pathogen removal can also be used downstream of the AWTS.

   Generally, all of the above systems produce high grade effluent with N < 5-10 mg/L and P < 5 mg/L (or better). Any of these systems would be suitable for the study area and would have the benefit of producing higher grade effluent which would result in the reduction of effluent disposal area size and [in some cases] provide the opportunity for toilet flushing re-use.

4. Combination Water Reduction / Nutrient Removal Systems (C)

   These systems involve a combining the benefits of water reduction with advanced nutrient / pathogen removal. An example is given below for a typical arrangement on a single allotment:



A summary of the above system types is provided below in Table 2.

Table 2: Summary of individual system alternatives.

Issue	Standard Secondary Treatment Systems	Nutrient Removal Systems	Combined Water Reduction / Low Nutrient
Requires Power	Yes	Yes	Yes
Maintenance Requirements	3 monthly	3 monthly	3 monthly
Effluent Quality	Secondary[1]	Tertiary[2]	Tertiary[2]
Re-use Potential	Irrigation	Irrigation / Some Possibly Toilet Re-use	Irrigation / Some Possibly Toilet Re-use
Disposal Type	Surface / sub-surface	Surface / sub-surface	Surface / sub-surface
Disposal Area	AS/NZS 1547 + Nutrient balance	AS/NZS 1547	Reduced AS/NZS 1547
Operator Awareness	Must be made aware	Must be made aware	Must be made aware
Robustness	Good	Unknown	Uknown

[1] Secondary treatment refers to BOD_5 < 20-30 mg/L, SS < 30 mg/L, no reference to pathogen levels is normally given. [2] Tertiary treatment refers to an effluent standard better than Secondary. This may include a range of performance criteria such as nutrient removal, additional solids removal, or superior disinfection.

COMMUNITY BASED SYSTEM

We understand that Jerberra Estate is an existing Torrens title sub-division and on this basis a community title approach to managing a common or single sewerage system is not possible (but would be possible if the site presented a 'greenfields' sub-division. On this basis, a community effluent scheme (CES) could only be implemented if the sewer were provided by Shoalhaven Water / Shoalhaven Council. Minimum components of the CES would include:

1. Installation of a gravity sewer system to each allotment.

2. Installation of a sewer pumping station (probably only 1 servicing some 25-30 lots) and rising main (say 100 – 150 m long).

3. Installation of a sewage treatment plant (STP).

4. Installation of a wet-weather detention facility (say 20 - 50 days storage or approximately 1 - 3.25 ML depending on soil types and uptake rates).

5. Installation of a reclaimed water re-use scheme redirecting reclaimed water back to residential allotments for a range of purposes (eg. garden and lawn irrigation, toilet flushing, car washing etc). Alternatively, a dedicated irrigation field could be situated on each allotment such that it received a set-volume of irrigation water each day and the home owner had no uncontrolled access to the reclaimed water.

The CES would not require any easements, but it would involve the purchase of at least 1 – 3 allotments. Given the small scale of the scheme and that there is not direct discharge to receiving waters, an EPA license may not be required (depending on Shoalhaven Water's licensing requirements). Shoalhaven Water would be responsible for operating and maintaining the scheme and design and construction would be in accordance with their standards.

A CES offers several advantages over the on-site treatment / disposal systems, including:

1. Design sewage flow rates can be based on peak populations rather than peak household occupancy as in the case of the individual allotment system. This means that the total EP for the study area would be say 153 x 3EP/dwelling. At say 145 L/EP/d, this would result in a peak daily flow rate of 66.555 KL/d. For the on-site system, the design total for the site would be 110.925 KL/d (ie. 5 EP/dwelling rather than 3 EP/dwelling for the community system).

2. A common and larger STP is capable of more consistently achieving higher effluent performance standards than typical on-site systems. This comes about because of:

    a. Cost of construction and operation reduces with scale of the STP.

    b. Operating funds can be collected from allotment owners by Council (thorugh its rating system). For example at this site, at an annual rate of say $650/year, an annual operating budget of $99,450 can be collected to safely operate and manage the STP and effluent re-use system.

3. There is only one system and therefore total site management requirements are reduced when compared to multiple on-site systems.

4. More of the site allotments are likely to be able to undertake reclaimed water re-use than under the individual allotment scheme.

5. Buffers to internal property boundaries of 3/6 m would not be required given the high quality of water and its supply from a Shoalhaven Water operated facility. This provides for greater flexibility in scheme design and location of nominated re-use areas within individual allotments.

Several issues and / or disadvantages arise in the case of the CES.

1. Allotments will need to be purchased to site the necessary infrastructure.

2. The rate at which the Estate is developed may affect the operation and performance of the STP.

3. The community within the Estate will need to be informed and educated about the schemes operational requirements.

4. Given that the majority of infrastructure will need to be constructed up-front, funding will probably need to come from Council initially and then recovered either through rating or some other mechanism.

SUMMARY RECOMMENDATIONS

1. A decision will need to be made in relation to whether individual or a communal CES system is to be pursued.

    a. In the case of the individual systems, the cost to land owners will be considerable on the smaller allotments where space restrictions require more elaborate and complex on-site sewage management scheme and non-potable re-use will be required. These system may cost the home owner $20,000 - $25000 once fully constructed. In the case of the larger allotments where more land is available, a standard AWTS and irrigation system may suffice, costing approximately $8000 per dwelling.

    b. In the case of the communal system, 1-3 lots will need to be resumed for the necessary infrastructure including the STP and the wet-weather storage system. Cost for the scheme may be of the order of $15,700 per allotment (comprising of a <u>very</u> preliminary budget of $650 K for the STP which would be for nutrient removal and tertiary filtration and dual disinfection, $150 K for the wet-weather storage facility, $1500 K for sewering and dual reticulation, and $100 K for a pump-station). The cost of resumed lots would need to be added to the above cost estimate.

2. A more detailed and precise land capability map should be produced. This will assist in isolating allotments on which various effluent management options (as per Table 2) are feasible or where effluent disposal can not be undertaken. This should account for recommended buffer distances to water courses (see

Attachment B) in accordance with the environmental Health Protection Guidelines (1998) and Shoalhaven City Council's DCP 78.

3. More detailed water / nutrient balance assessment should be developed to refine the sustainable effluent application rate nominated by Coffey's (ie. DIR = 0.67 mm/d). Our view is that a sustainable rate may be considerably higher than that recommended by Coffey's, particularly in light of the potential for higher effluent quality (with nutrient removal) available from a range of manufacturers. These assessments should be undertaken for a range of dwelling sizes (eg. 2 – 5 bedrooms).

4. Following the above, the minimum allotment size recommended by Coffey's should be revisited in the light of the various on-site treatment alternatives. Various minimum performance standards (in terms of water consumption restrictions, effluent quality requirements and re-use requirements) can then be determined for each of the existing allotments.

5. In the event that a CES is regarded as one which can pursued, then a dual reticulation system should be constructed such that reclaimed water can be returned to each allotment. A suitable location for the STP and wet-weather storage facility will need to be chosen. Our preliminary view is that this should be in the NE corner of the site, with a pump-station located in the centre-south of the site (to transfer sewage to the STP at the NE of the site). See Attachment A for preliminary location of these structures. Our preliminary view is that some 150 m^2 will need to be provided at each allotment as a designated effluent disposal area within the sites landscaping / gardens. This is made on the assumption that nutrient removal (say N = 10 mg/L and P = 2 mg/L), disinfection and tertiary filtration are provided at the communal STP and would need to be confirmed with more detailed analyses.

If you require any further information, please do not hesitate to contact the writer.

For and on behalf of

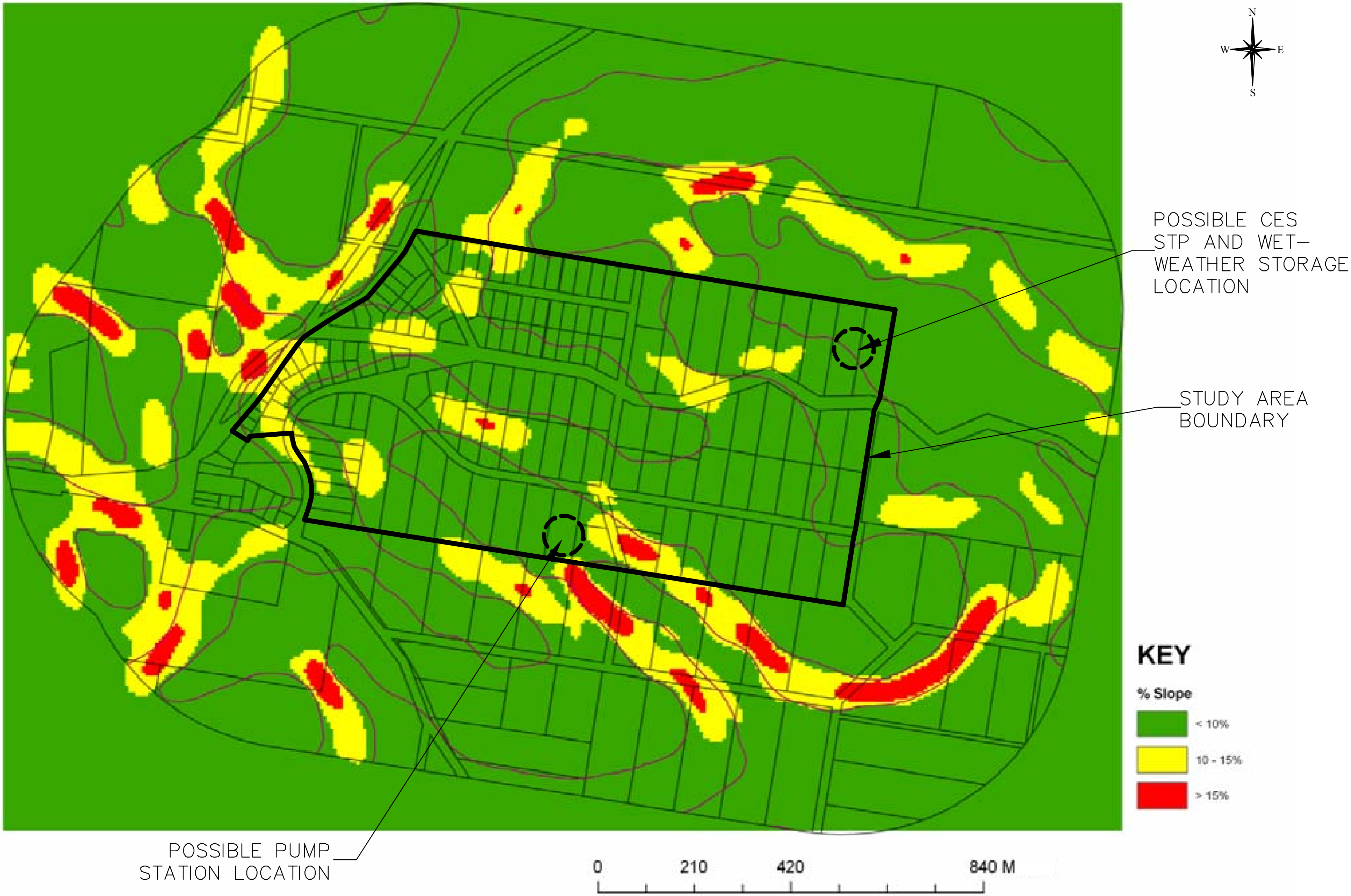
MARTENS & ASSOCIATES PTY LTD

DR DANIEL MARTENS

BSc(Hons1), MEngSc, PhD, MAWA, FIEAust, CPEng, NPER

Manager, Principal Engineer

ATTACHMENT A – JERBERRA ESTATE SLOPE MAP



martens
26A Bay Road
Arcadia, NSW 2159 Australia
Phone: (02) 9655 1417
Fax: (02) 9655 1416
Email: mail@martens.com.au
Internet: http://www.martens.com.au

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CLIENT/PROJECT: JERBERRA ESTATE WASTEWATER MANAGEMENT ASSESSMENT

THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY
All measurements in mm unless otherwise specifiec.

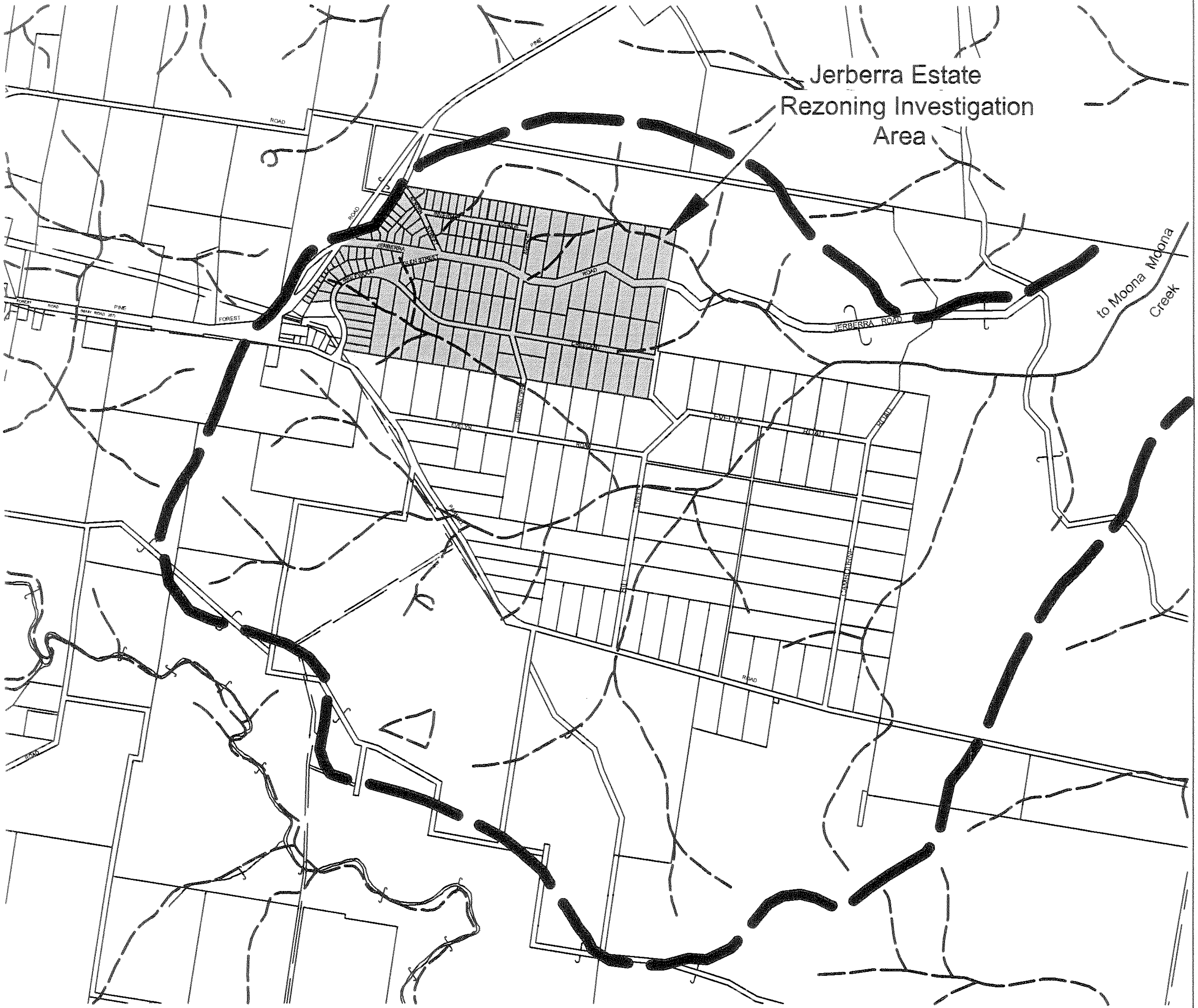
TITLE:

JERBERRA ESTATE SLOPE MAP

PROJECT MANAGER:	DR DANIEL MARTENS
DRAWING FILENAME:	P0501093JD01_v1
PAPER SPACE:	1
DESIGNED:	JF
DRAWN:	JF
REVIEWED:	DM
DATUM:	AHD
HORIZONTAL RATIO:	1:8000
VERTICAL RATIO:	1:8000
SHEET	1 OF 1 SHEETS
PAPER SIZE:	A3

REV.	DESCRIPTION	DATE	ISSUED
1	WASTEWATER MANAGEMENT ASSESSMENT	3/11/05	JF

ATTACHMENT B – JERBERRA ESTATE CREEK MAP



Moona Moona Ck sub-catchment boundary & stream network

LEGEND

- INTERMITTENT WATERCOURSE
- PERENNIAL WATERCOUSE
- SUB-CATCHMENT BOUNDARY

Scale: 1:20000

All dimensions are in metres

Planning Group

Date: 22/11/2005

Cad File: Graphics/Projects/City/Lep/Dlep/DraftLP155/ReportMapNov2005

Shoalhaven City Council

WATER BALANCE

Month	Pan Evaporation (E) (mm)	Crop Factor (C)	Evapo Transpiration (ET) ET=E*C	Precipitation (P) (mm)	Retained Rainfall (r) r=0.75*P	Design Irrigation Rate (DIR) (10 mm/ week) (mm/month)	Disposal rate (mm/month)
Jan	194.4	0.65	126.4	100.6	75.5	44.3	95.2
Feb	161.1	0.65	104.7	86.2	64.7	40.0	80.1
Mar	144.6	0.65	94.0	55.2	41.4	44.3	96.9
Apr	118.7	0.65	77.2	59.3	44.5	42.9	75.5
May	95	0.65	61.8	82.6	62.0	44.3	44.1
Jun	85.8	0.65	55.8	56.9	42.7	42.9	56.0
Jul	94.7	0.65	61.6	51.8	38.9	44.3	67.0
Aug	127.6	0.65	82.9	34	25.5	44.3	101.7
Sep	148.1	0.65	96.3	59.4	44.6	42.9	94.6
Oct	177.4	0.65	115.3	57.7	43.3	44.3	116.3
Nov	182.1	0.65	118.4	91.3	68.5	42.9	92.7
Dec	214.2	0.65	139.2	72	54.0	44.3	129.5

NO water reduction fixtures

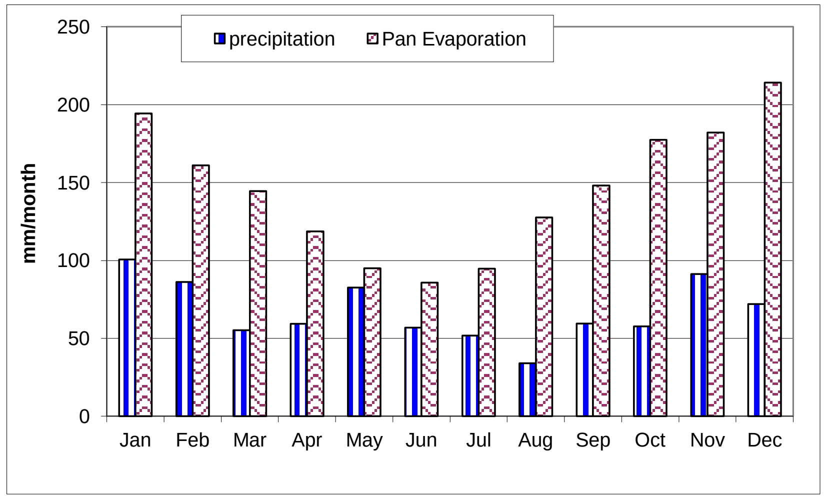
Month	2: litres/day 560 (litres/month)	2: Minimum irrigation area (m^2)	3: litres/day 840 (litres/month)	3: Minimum irrigation area (m^2)	4: litres/day 1120 (litres/month)	4: Minimum irrigation area (m^2)	5: litres/day 1400 (litres/month)	5: Minimum irrigation area (m^2)
Jan	17,360	182	26,040	274	34,720	365	43,400	456
Feb	15,680	196	23,520	294	31,360	392	39,200	490
Mar	17,360	179	26,040	269	34,720	358	43,400	448
Apr	16,800	222	25,200	334	33,600	445	42,000	556
May	17,360	394	26,040	591	34,720	788	43,400	984
Jun	16,800	300	25,200	450	33,600	601	42,000	751
Jul	17,360	259	26,040	389	34,720	518	43,400	648
Aug	17,360	171	26,040	256	34,720	341	43,400	427
Sep	16,800	178	25,200	266	33,600	355	42,000	444
Oct	17,360	149	26,040	224	34,720	298	43,400	373
Nov	16,800	181	25,200	272	33,600	362	42,000	453
Dec	17,360	134	26,040	201	34,720	268	43,400	335

with STANDARD water reduction fixtures

Month	2: litres/day 460 (litres/month)	2: Minimum irrigation area (m^2)	3: litres/day 690 (litres/month)	3: Minimum irrigation area (m^2)	4: litres/day 920 (litres/month)	4: Minimum irrigation area (m^2)	5: litres/day 1150 (litres/month)	5: Minimum irrigation area (m^2)
Jan	14,260	150	21,390	225	28,520	300	35,650	374
Feb	12,880	161	19,320	241	25,760	322	32,200	402
Mar	14,260	147	21,390	221	28,520	294	35,650	368
Apr	13,800	183	20,700	274	27,600	365	34,500	457
May	14,260	323	21,390	485	28,520	647	35,650	809
Jun	13,800	247	20,700	370	27,600	493	34,500	617
Jul	14,260	213	21,390	319	28,520	426	35,650	532
Aug	14,260	140	21,390	210	28,520	280	35,650	350
Sep	13,800	146	20,700	219	27,600	292	34,500	365
Oct	14,260	123	21,390	184	28,520	245	35,650	306
Nov	13,800	149	20,700	223	27,600	298	34,500	372
Dec	14,260	110	21,390	165	28,520	220	35,650	275

with FULL water reduction fixtures

Month	2: litres/day 320 (litres/month)	2: Minimum irrigation area (m^2)	3: litres/day 480 (litres/month)	3: Minimum irrigation area (m^2)	4: litres/day 640 (litres/month)	4: Minimum irrigation area (m^2)	5: litres/day 800 (litres/month)	5: Minimum irrigation area (m^2)	
Jan	9,920	104	14,880	156	19,840	208	24,800	261	31
Feb	8,960	112	13,440	168	17,920	224	22,400	280	28
Mar	9,920	102	14,880	154	19,840	205	24,800	256	31
Apr	9,600	127	14,400	191	19,200	254	24,000	318	30
May	9,920	225	14,880	338	19,840	450	24,800	563	31
Jun	9,600	172	14,400	257	19,200	343	24,000	429	30
Jul	9,920	148	14,880	222	19,840	296	24,800	370	31
Aug	9,920	98	14,880	146	19,840	195	24,800	244	31
Sep	9,600	102	14,400	152	19,200	203	24,000	254	30
Oct	9,920	85	14,880	128	19,840	171	24,800	213	31
Nov	9,600	104	14,400	155	19,200	207	24,000	259	30
Dec	9,920	77	14,880	115	19,840	153	24,800	191	31



Effluent Disposal Area (Nominated Area Method)

Effluent Disposal Area	Input variables		# bed-rooms	Output: level of water reduction fixtures nil	standard	full
Water Balance	crop factor	0.65	2	300	247	172
	DIR (mm/wk)	10	3	450	370	257
			4	601	493	343
			5	751	617	429
N Balance	N conc	22	2	365	300	209
	N uptake	27	3	548	450	313
	Denitrification (%)	20	4	730	600	417
			5	913	750	521
P Balance	P conc	14	2	473	389	270
	P uptake (kg/m2/50yr)	0.055	3	710	583	406
	total P sorp (kg/ha)	7428	4	946	777	541
	% soil P sorp capacity	33.3	5	1183	972	676
Area required (whichever is the largest)			2	473	389	270
			3	710	583	406
			4	946	777	541
			5	1183	972	676

N & P Balances

Standard of water reduction fixtures

	Nil				Standard				Full			
# bedrooms	**2**	**3**	**4**	**5**	**2**	**3**	**4**	**5**	**2**	**3**	**4**	**5**
Wastewater ' (l/day)	**560**	**840**	**1120**	**1400**	**460**	**690**	**920**	**1150**	**320**	**480**	**640**	**800**
P balance	473	710	946	1183	389	583	777	972	270	406	541	676
N balance	365	548	730	913	300	450	600	750	209	313	417	521

P GENERATION (kg/ha/50 years)

# bedrooms		**2**	**3**	**4**	**5**	**2**	**3**	**4**	**5**	**2**	**3**	**4**	**5**
Wastewater ' (l/day)		**560**	**840**	**1120**	**1400**	**460**	**690**	**920**	**1150**	**320**	**480**	**640**	**800**
P conc	**14**	143	215	286	358	118	176	235	294	82	123	164	204

P SORPTION (kg/ha)

Depth (m)	Average P sorption capacity (mg/kg)	Assumed bulk density	P sorption capacity (kg/ha)
0 - 0.15	307	1.4	645
0.15 - 1.0	570	1.4	6783
TOTAL (0 – 1.0 m)			7428

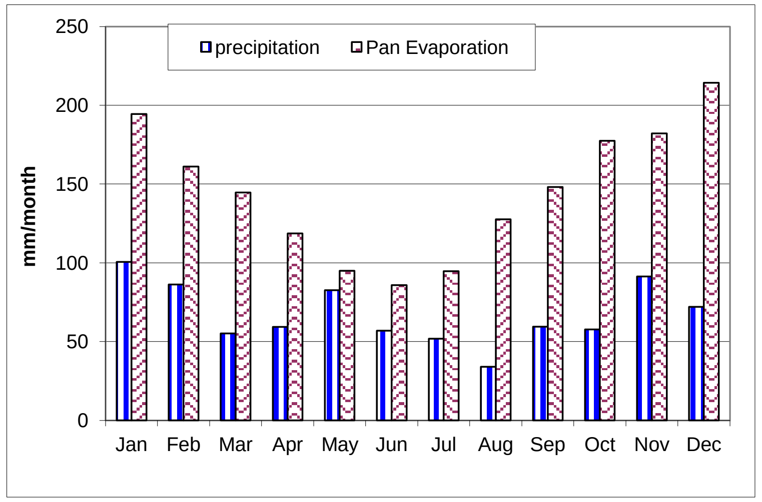
WATER BALANCE

Month	Pan Evaporation (E) (mm)	Crop Factor (C)	Evapo Transpiration (ET) ET=E*C	Precipitation (P) (mm)	Retained Rainfall (r) r=0.75*P	Design Irrigation Rate (DIR) (10 mm/ week) (mm/month)	Disposal rate (mm/month)
Jan	194.4	0.65	126.4	100.6	75.5	44.3	95.2
Feb	161.1	0.65	104.7	86.2	64.7	40.0	80.1
Mar	144.6	0.65	94.0	55.2	41.4	44.3	96.9
Apr	118.7	0.65	77.2	59.3	44.5	42.9	75.5
May	95	0.65	61.8	82.6	62.0	44.3	44.1
Jun	85.8	0.65	55.8	56.9	42.7	42.9	56.0
Jul	94.7	0.65	61.6	51.8	38.9	44.3	67.0
Aug	127.6	0.65	82.9	34	25.5	44.3	101.7
Sep	148.1	0.65	96.3	59.4	44.6	42.9	94.6
Oct	177.4	0.65	115.3	57.7	43.3	44.3	116.3
Nov	182.1	0.65	118.4	91.3	68.5	42.9	92.7
Dec	214.2	0.65	139.2	72	54.0	44.3	129.5

NO water reduction fixtures	2		3		4		5	
	litres/day		litres/day		litres/day		litres/day	
Month	720	Minimum irrigation area	1080	Minimum irrigation area	1440	Minimum irrigation area	1800	Minimum irrigation area
	litres/month	m^2	litres/month	m^2	litres/month	m^2	litres/month	m^2
Jan	22,320	234	33,480	352	44,640	469	55,800	586
Feb	20,160	252	30,240	378	40,320	504	50,400	629
Mar	22,320	230	33,480	346	44,640	461	55,800	576
Apr	21,600	286	32,400	429	43,200	572	54,000	715
May	22,320	506	33,480	759	44,640	1013	55,800	1266
Jun	21,600	386	32,400	579	43,200	772	54,000	965
Jul	22,320	333	33,480	500	44,640	666	55,800	833
Aug	22,320	219	33,480	329	44,640	439	55,800	549
Sep	21,600	228	32,400	343	43,200	457	54,000	571
Oct	22,320	192	33,480	288	44,640	384	55,800	480
Nov	21,600	233	32,400	349	43,200	466	54,000	582
Dec	22,320	172	33,480	259	44,640	345	55,800	431

with STANDARD water reduction fixtures	2		3		4		5	
	litres/day		litres/day		litres/day		litres/day	
Month	580	Minimum irrigation area	870	Minimum irrigation area	1160	Minimum irrigation area	1450	Minimum irrigation area
	litres/month	m^2	litres/month	m^2	litres/month	m^2	litres/month	m^2
Jan	17,980	189	26,970	283	35,960	378	44,950	472
Feb	16,240	203	24,360	304	32,480	406	40,600	507
Mar	17,980	186	26,970	278	35,960	371	44,950	464
Apr	17,400	230	26,100	346	34,800	461	43,500	576
May	17,980	408	26,970	612	35,960	816	44,950	1020
Jun	17,400	311	26,100	466	34,800	622	43,500	777
Jul	17,980	268	26,970	403	35,960	537	44,950	671
Aug	17,980	177	26,970	265	35,960	353	44,950	442
Sep	17,400	184	26,100	276	34,800	368	43,500	460
Oct	17,980	155	26,970	232	35,960	309	44,950	386
Nov	17,400	188	26,100	281	34,800	375	43,500	469
Dec	17,980	139	26,970	208	35,960	278	44,950	347

with FULL water reduction fixtures	2		3		4		5		
	litres/day		litres/day		litres/day		litres/day		
Month	440	Minimum irrigation area	660	Minimum irrigation area	880	Minimum irrigation area	1100	Minimum irrigation area	
	litres/month	m^2	litres/month	m^2	litres/month	m^2	litres/month	m^2	
Jan	13,640	143	20,460	215	27,280	287	34,100	358	31
Feb	12,320	154	18,480	231	24,640	308	30,800	385	28
Mar	13,640	141	20,460	211	27,280	282	34,100	352	31
Apr	13,200	175	19,800	262	26,400	349	33,000	437	30
May	13,640	309	20,460	464	27,280	619	34,100	773	31
Jun	13,200	236	19,800	354	26,400	472	33,000	590	30
Jul	13,640	204	20,460	305	27,280	407	34,100	509	31
Aug	13,640	134	20,460	201	27,280	268	34,100	335	31
Sep	13,200	140	19,800	209	26,400	279	33,000	349	30
Oct	13,640	117	20,460	176	27,280	235	34,100	293	31
Nov	13,200	142	19,800	213	26,400	285	33,000	356	30
Dec	13,640	105	20,460	158	27,280	211	34,100	263	31



Effluent Disposal Area (Nominated Area Method)

Effluent Disposal Area			# bed-rooms	Output		
	Input variables			level of water reduction fixtures nil	standard	full
Water Balance	crop factor	0.65	2	386	311	236
	DIR (mm/wk)	10	3	579	466	354
			4	772	622	472
			5	965	777	590
N Balance	N conc	22	2	469	378	287
	N uptake	27	3	704	567	430
	Denitrification (%)	20	4	939	756	574
			5	1173	945	717
P Balance	P conc	14	2	608	490	372
	P uptake (kg/m2/50yr)	0.055	3	913	735	558
	total P sorp (kg/ha)	7,428	4	1217	980	744
	% soil P sorp capacity	33.3	5	1521	1225	930
Area required (whichever is the largest)			2	608	490	372
			3	913	735	558
			4	1217	980	744
			5	1521	1225	930

N & P Balances

Standard of water reduction fixtures

	Nil				Standard				Full			
# bedrooms	**2**	**3**	**4**	**5**	**2**	**3**	**4**	**5**	**2**	**3**	**4**	**5**
Wastewater \ (l/day)	**720**	**1080**	**1440**	**1800**	**580**	**870**	**1160**	**1450**	**440**	**660**	**880**	**1100**
P balance	608	913	1217	1521	490	735	980	1225	372	558	744	930
N balance	469	704	939	1173	378	567	756	945	287	430	574	717

P GENERATION (kg/ha/50 years)

# bedrooms		**2**	**3**	**4**	**5**	**2**	**3**	**4**	**5**	**2**	**3**	**4**	**5**
Wastewater \ (l/day)		**720**	**1080**	**1440**	**1800**	**580**	**870**	**1160**	**1450**	**440**	**660**	**880**	**1100**
P conc	**14**	184	276	368	460	148	222	296	370	112	169	225	281

P SORPTION (kg/ha)

Depth (m)	Average P sorption capacity (mg/kg)	Assumed bulk density	P sorption capacity (kg/ha)
0 - 0.15	307	1.4	645
0.15 - 1.0	570	1.4	6783
TOTAL (0 – 1.0 m)			7428

48933

Department of Lands

Land Administration & Management
Property & Spatial Information

Soil Conservation Service

PLANNING
21 APR 2006
GROUP

SOIL TEST REPORT

Scone Research Service Centre

REPORT NO:	SCO06/084R1
REPORT TO:	Eric Hollinger Shoalhaven City Council PO Box 42 Nowra 2541
REPORT ON:	Two soil samples Jerberra Estate, Tomerong Ref: 33021 EH
PRELIMINARY RESULTS ISSUED:	Not issued
REPORT STATUS:	Final
DATE REPORTED:	18 April 2006
METHODS:	Information on test procedures can be obtained from Scone Research Service Centre

Shoalhaven City Council
Received
21 APR 2006
File No. 33021
Referred to: E. Hollinger

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

G Holman
(Technical Officer)

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO06/084R1
Client Reference: Eric Hollinger
Shoalhaven City Council
PO Box 42
Nowra 2541

Lab No	Method	C1A/4	C2A/3	C5A/3 CEC & exchangeable cations (me/100g)						C8B/1		P9B/2	
	Sample Id	EC (dS/m)	pH	CEC	Na	K	Ca	Mg	Al	P sorp (mg/kg)	P sorp index	EAT	Texture
1	Jerberra Estate Soil Unit 1 A, 0-20cm	0.03	5.2	7.8	0.3	0.6	2.1	1.4	1.3	321	2.6	8/3(1)	sandy loam
2	Jerberra Estate Soil Unit 2 A, 0-20cm	0.02	5.4	6.6	0.2	0.4	1.3	1.1	1.2	293	2.4	8/3(1)	sandy loam

END OF TEST REPORT

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO12/002R1
REPORT TO:	Ashley Bond Footprint (NSW) Pty Ltd 15 Meehan Drive Kiama Downs NSW 2533
REPORT ON:	Two soil samples
PRELIMINARY RESULTS ISSUED:	Not issued
REPORT STATUS:	Final
DATE REPORTED:	25 January 2012
METHODS:	Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

S R Young

SR Young
(Laboratory Manager)

Scone Research Centre, PO Box 283 Scone 2337, 709 Gundy Road Scone 2337
Ph: 02 6545 1666, Fax: 02 6545 2520

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO12/002R1
Client Reference: Ashley Bond
Footprint (NSW) Pty Ltd
15 Meehan Drive
Kiama Downs NSW 2533

Lab No	Method	P8A/2
	Sample Id	D%
1	A horizon 5cm	50
2	B horizon 300cm	44

SRYoung

END OF TEST REPORT