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Report on
Land Capability, Salinity & Contamination Investigation
Volume 2 – Geotechnical and Salinity Assessment

Riverstone East Precinct
North West Growth Centre

Prepared for
Mott MacDonald Pty Ltd

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Integrated Practical Solutions

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Report on Geotechnical and Salinity Assessment and Management Plans
Land Capability, Salinity and Contamination Investigation
Riverstone East Precinct – North West Growth Centre

1. Introduction

This report comprises Volume 2 of the overall Land Capability, Salinity and Contamination Investigation for the Riverstone East Precinct of the North West Growth centre. The report presents results of the geotechnical and salinity portion of the assessment of the project. This volume should be read in conjunction with the entire report.

Volume 1 presents and outlines the detailed background for the overall project and includes the following Sections;

- Study Area
- Proposed Development
- Scope of Works
- Previous Assessments
- Site Description
- Regional Topography, Geology, Soils and Water
- Methodology
- Limitations

Volume 3 provides the results of the Preliminary Contamination Investigation and Volumes 4 to 6 provide the Appendices.

2. Field Work Results

2.1 Site Observations

The observations made during the various inspections of the site undertaken during and following the field investigation programme (April 2014) are summarised below:

- The landform is predominantly gently sloping undulating terrain of gradual relief within the site. Crests and gullies are mostly broad, although some deeper and more incised gullies are present along creek lines (towards First Ponds Creek), and along some of the drainage lines from the more elevated ridge area of the site.
- Several small and relatively isolated areas of minor soil erosion (gully, rill and sheet erosion) were noted along the lower creek bank (First Ponds Creek and the upper reaches of Killarney Chain of

Ponds) and adjoining areas. Erosion was generally limited to about 1.5 m depth for gully erosion and 0.15 m for the area of sheet erosion. .

- Rock outcrops were identified at several locations across the site, predominantly within road cuttings and other man made excavations.
- Other than minor soil erosion, further signs of significant slope instability were not identified within the site. At a number of locations, however, there were section of creek banks potentially at risk of minor collapse. Such instability is likely to be present at several locations throughout the side slopes of the incised gullies.
- The soil profile across the site is mostly of residual original although alluvial sediments are present associated with the First Ponds Creek and some minor drainage lines. The profiles typically comprise silty clay and clay overlying shale and silty and sandy clay overlying siltstone and minor areas of sandstone bedrock. The residual soil is mottled and contains some ironstone gravel in places.
- Several salt tolerant vegetation species are evident at some locations on the site, including paspalum, couch grasses and bulrushes/reeds. Although indicative of saline soil conditions, there were no significant signs of salt scalding, efflorescence, iron-staining, or extensive bare areas of soil. Vegetation appeared to be relatively healthy across the site although some tree die-back noted.
- Some areas of abruptly changing vegetation (mostly grasses) were noted across the site, suggesting a possible progressive change from native to more salt tolerant species, although all vegetation appeared relatively healthy. Abrupt changes in grasses can also be a sign of different underlying soil conditions.

2.2 Subsurface Conditions

The subsurface conditions observed in the test locations drilled and excavated at site were logged by DP's geotechnical engineering staff. The results of the boreholes, test pits and DCP tests (incorporated onto bore logs) are presented on the borehole and test pit logs included in Appendix B, together with explanation sheets describing classification methods and

The conditions encountered were generally consistent with and confirmed the geology and soil maps.

The boreholes, drilled using a geotechnical drilling rig for the installation of groundwater monitoring wells (Bores 41 to 45), generally on the lower creek line parts of the Precinct, typically encountered clays with some ironstone gravel to the full depth of investigation (5 m to 6 m). The exceptions were Bores 42 and 44, which were located on a minor creek line and the upper end of Killarney Chain of Ponds, respectively and encountered shale below 2.2 m depth.

The remaining bores and test pits typically encountered stiff to hard residual clays and silty clays (away from the creek lines) grading into weathered bedrock of shale and siltstone at depths ranging from 0.5 m to about 1.5 m. The soil depths were greater towards the creek lines where alluvial sediments were present and in some mid-slope areas, particularly overlying the Ashfield Shale.

2.3 Groundwater

Groundwater was not generally observed in any of the test pits excavated at site, (except Pit 72A where seepage was encountered at 1.6 m). Although test pits and push tube bores were immediately backfilled, preventing long term monitoring of groundwater levels, the moisture contents of the subsurface soils did not indicate free groundwater to be likely within the depth of the investigation.

Given the elevation of the site above the adjoining creek lines, groundwater levels are generally expected to lie well below the ground surface. The exceptions are likely to be within flood areas of the creek lines which could be affected by periodic storm and flood events. Ongoing/future monitoring of the installed monitoring wells will provide information on ground water fluctuation levels across lower parts of the site.

Groundwater was encountered in the deeper bores (Bores 41, 43 and 45) at 3.5 m to 5.9 m depth, whilst Bores 42 and 44 did not encounter groundwater during the drilling and installation of monitoring wells. Subsequent monitoring indicated water levels between 0.44 m and 1.5 m below surface level (on 10/4/2014) with the recorded data presented in Table 2.1 below.

Table 2.1: Summary of Groundwater Levels/Depth Measurements (undertaken 10/04/2014)

Borehole	Surface Level	Groundwater Level 10/04/2014	
	m AHD	m bgl	m AHD
41	24.6	Well destroyed prior to sampling	
42	31.8	0.44	31.36
43	29.7	0.8	28.9
44	47.3	1.74	45.56
45	36.3	0.55	35.75

3. Laboratory Testing

3.1 Geotechnical

Soil and weathered rock samples were collected from the test locations during the field investigation. Representative samples were selected to undergo the following suite of Geotechnical and Salinity tests:

- Field moisture content tests (FMC) – 6 samples;
- Atterberg limits tests (Plastic Limit & Liquid Limit – PL & LL) and Linear Shrinkage (LS) – 6 samples;
- Shrink-swell index tests (SSI) – 6 samples;
- Emerson Class Number tests (ECN) – 6 samples;
- California bearing ratio (CBR and field moisture content) – 3 samples.

The detailed results of these tests are presented in Appendix F and are summarised in Table 2.2.

Table 2.2: Laboratory Test Results (Geotechnical)

Test Location No.	Depth (m)	FMC (%)	SSI (Iss %)	LL (%)	PL (%)	PI (%)	LS (%)	ECN	CBR (%)
TP53	0.4 – 0.8	23.1	3.2	-	-	-	-	-	-
TP54	0.4 – 0.8	14.4	3.0	-	-	-	-	-	-
TP58	0.4 – 0.8	10.0	3.0	-	-	-	-	-	-
TP58	0.5 – 1.0	9.9		30	17	13	8	2	7
TP58	1.0	8.6		30	16	14	8	2	-
TP69	0.4 – 0.8	11.7	1.8	-	-	-	-	-	-
TP69	0.5 – 1.0	20.1		45	18	27	13.5	6	5
TP69	1.0	17.5		51	20	31	15	6	-
TP72	0.4 – 0.8	16.5	1.4	-	-	-	-	-	-
TP72	0.5 – 1.0	19.0		44	16	28	14	2	4
TP72	1.0	17.9		31	23	8	3.5	2	-
TP73	0.4 – 0.6	15.2	3.2	-	-	-	-	-	-

Where: FMC = Field Moisture Content; SSI = Shrink-swell Index; - = Not Tested
LL = Liquid Limit; PL = Plastic Limit
PI = Plasticity Index; LS = Linear Shrinkage
ECN = Emerson Class Number; CBR = California bearing ratio

The laboratory test results indicate

- moderate to high reactivity (SSI range 1.4%. to 3.2%),
- medium to high plasticity (Plasticity Index range 8% to 31%),
- linear shrinkage test results for the six samples subjected to Atterberg limits testing ranged from 3.5% and 15%,
- some predisposition to dispersion and slaking (ECN generally 2, two values of 6); and
- CBR value ranging from 4% to 7%.

The laboratory test results confirm the generally clayey nature of the residual soils at the site and indicate soil classifications, in accordance with the Unified Soil Classification system, corresponding to inorganic clays of medium to high plasticity (CH) and inorganic silts or fine sandy or silty soils (MH).

The Emerson Class Number (ECN) for a soil relates to the potential for the soil to slake and disperse. Higher Emerson Class Numbers correspond to soils with a lower tendency to disperse. Emerson Class Numbers of 5 and 6 indicates a tendency for the soil to slake with a low susceptibility to dispersion. Emerson Class Numbers of 2 and 3 indicates a tendency for the soil to slake with some dispersion, possibly more when remoulded.

The CBR values are considered typical of the materials tested.

3.2 Salinity - General

The detailed results of salinity tests on samples collected from Bores and Pits 43, 44, 45, 46, 48, 54, 72 and 74 are presented in Appendix F.

The Summary Table (in Appendix E) presents the results of the laboratory tests on each sample, together with assessments of aggressivity to concrete and steel, sodicity classes, textural classifications, calculated salinities ECe and salinity classes inferred from ECe values using the method of Richards (1954).

Bulk pH and Bulk ECe values were also calculated to enable spatial mapping of aggressivities and salinities throughout the investigation area, within defined “foundation” and “piling” depth zones (refer Drawings S1 to S4).

Vertical soil salinity profiles and vertical soil aggressivity profiles were constructed from the test results from an initial batch of analysis in order to determine if a particular depth zone or zones presented a more significant salinity-related risk to proposed land use or structures. Elevated salinities and aggressivities were indicated in the 1.0 m to 1.5 m depth zone, resulting in testing of a second batch of samples taken predominantly from this zone.

3.2.1 Aggressivity

Figure 2.1 (below) presents variations of aggressivity with depth, based on pH profiles at test locations, together with the aggressivity class ranges indicated in Australian Standard AS2159 (2009). The absence of free groundwater from most test pits and the impermeability of the sampled clay-rich soils indicate that soils at all test pits are in Condition “B” as defined by AS2159.

The pH profiles of Figure 2.1 indicate that the materials throughout the Site are predominantly non-aggressive to concrete and steel. However, some individual samples at depths less than 1.5 m were mildly aggressive to concrete (pH<5.5) and mildly aggressive to steel (pH<5).

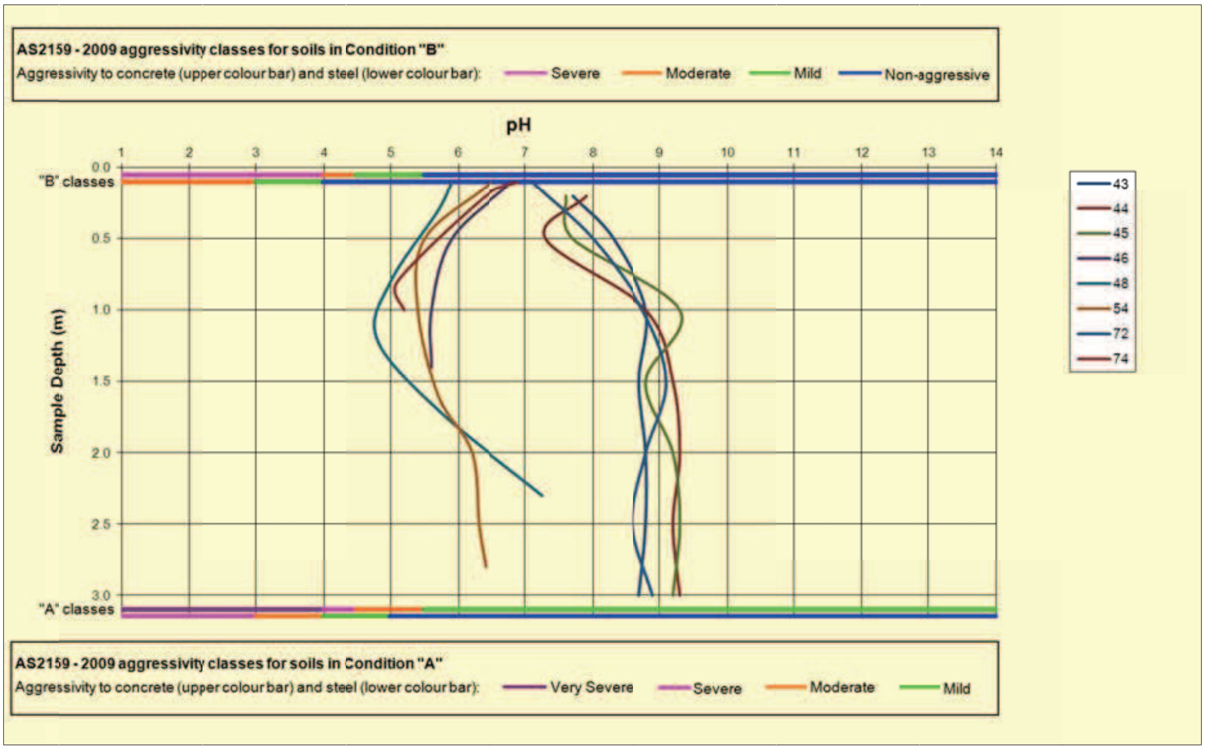

Figure 2.1: Vertical pH Profiles and Aggressivity Classes

Bulk pH values calculated from the individual sample results, over depth zones of 0 – 1 m and 0 – 3 m, were used to better define the aggressivity classes over the investigation area, leading to definition of some areas of mild aggressivity to concrete only. These areas are shown on Drawings S1 and S2 (Appendix A).

3.2.2 Electrical Conductivity and Salinity

Figure 2.2 (below) presents the variations of salinity with depth, based on salinity (ECe) profiles at test locations, together with the salinity classifications of Richards (1954).

Individual samples tested from non-saline to very saline as indicated in Figure 2.2 and Bulk ECe values when interpolated and contoured defined non-saline to very saline areas of the site in each depth zone (see Drawings S3 and S4, Appendix A).

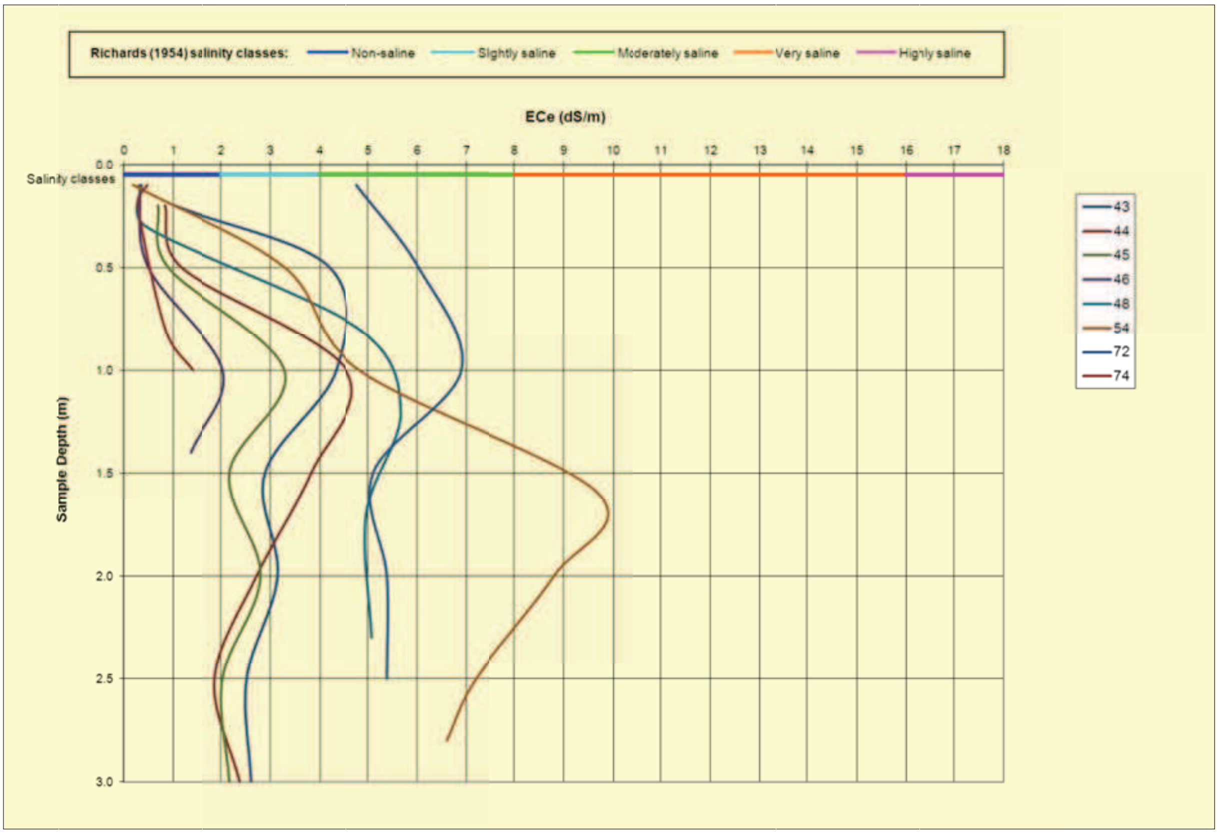

Figure 2.2: Vertical Salinity Profiles and Salinity Classes

3.2.3 Sodicity

The sodicity tests reported in the Summary Table (refer to Appendix E) shows sodic to highly sodic soils, indicating some potential for erodability of soils left exposed.

4. Comments

4.1 Slope Instability

No evidence of significant slope instability (i.e. landslip, etc.) was observed within the site. This is consistent with the generally gently sloping landforms that typically provide hillside slopes with falls of 10 degrees or less across most of the site.

Minor, very localised areas of potential creek bank collapse and erosion were noted at a number of locations along the edges of the alignment of First Ponds Creek. It is considered, however, that such instability does not impose significant constraints on the proposed site development under the current Masterplan.

It is therefore considered that hillside instability does not impose significant constraints on the proposed site development. A stability hazard map has not been prepared, as no significant stability hazards were identified within the site.

4.2 Erosion Potential

Soils of the Blacktown (bt), Berkshire Park (bp) and South Creek (sc) soil landscape groups are typically of moderate to high erodibility.

The more sodic or saline soils of the Blacktown soil landscape can have a high to very high erodibility for concentrated flows and the erosion hazard for this landscape is estimated as moderate to high (Penrith Soil Landscapes). The soils of the South Creek group are typically of high erodibility and may have a very high to extreme erosion hazard with stream bank and gully erosion common.

Given the presence of isolated, shallow soil erosion and some minor stream bank collapse/erosion, development should avoid the construction of landforms that create concentrated overland flow of surface waters. As this is not always possible, the following measures could be adopted to reduce the risk of soil erosion:

- Placement of filling within overland flow paths using select materials (i.e. non–dispersive or least erodible) placed under controlled conditions;
- Provision of a temporary surface cover within overland flow paths (e.g. biodegradable matting that is pegged in place) during the period of gully floor revegetation;
- Construction of channel lining in sections of rapid change in gully floor grade;
- Collection and discharge of water flows through a piped network, where appropriate; and
- The re-establishment of an appropriate vegetated zones to protect the ground surface over the long-term.

It is considered that the erosion hazard within the areas proposed for urban development would be within usually accepted limits, and can be managed by good engineering and land management practices.

4.3 Salinity - General

The generally mild aggressivity to concrete, the presence of moderately to very saline materials and the sodic to highly sodic soils are naturally occurring features of the local landscape and are not considered significant impediments to the proposed development, provided appropriate remediation or management techniques are employed during bulk earthworks and construction. These classifications will require refinement by further sampling and testing to cover areas presently untested due to access restrictions or restrictions due to underground services and when cut/fill designs are available to confirm the likely depths of impact of the development.

4.3.1 Aggressiveness to Concrete

As indicated above in Section 3.2.1, the site materials have been classified as non-aggressive to mildly aggressive to concrete, using the criteria within AS2159 (2009).

Concrete classifications under AS2159 allow for a 40 – 60 year lifetime, provided a minimum concrete strength of 25 MPa is applied in non-aggressive conditions and 32 MPa in mildly aggressive conditions. Where concrete of lower than recommended strength is employed, then a shorter lifetime may be expected, however no estimates are given in the Standard of this reduced lifetime.

4.3.2 Soil Salinity

Moderately saline to very saline conditions were found within the investigated depth zones, flagging the potential for salt-induced damage to susceptible services, slabs and shallow footings and demonstrating the need for appropriate salinity management.

4.3.3 Sodicity

The results indicate that soils tested within depths of 1.5 m below the current ground surface are often sodic to highly sodic and it is considered that there is potential for such soils (either in situ, transported or imported as filling) to occur at the proposed ground surface levels. Sodic soils have low permeability due to infilling of interstices with fine clay particles during the weathering process, restricting infiltration of surface water and potentially creating perched water tables, seepage in cut faces or ponding of water in flat open areas. In addition, sodic soils tend to erode when exposed.

Management of sodic soils is therefore required to prevent these adverse effects. As detailed in Section 6, management of sodic soils, particularly following the completion of bulk earthworks, is focussed on prevention of exposure.

4.4 Geotechnical and Salinity Considerations

4.4.1 Site Classification

Classification of individual lots or residential building areas within the site should comply with the requirements of AS 2870 – 2011 *"Residential Slabs and Footings"*. Based on the limited work for the current investigation, the undisturbed subsurface profiles at most locations are typical of Class M (moderately reactive) and Class H (highly reactive) sites. Further delineation between Class H1 and Class H2 sites may be required prior to linen release of the subdivision arrangements and would be required prior to future construction certificate issue for individual allotments.

Laboratory shrink swell index tests have returned low and moderate to high values, indicating potential high variations in the shrink-swell potential across the site. The current results of Atterberg limits testing are considered potentially more representative of the soils observed at the test locations. Prior to development construction, lot classification ranges should be clarified and specific classifications should be made for each new residential site.

The exception to the above would be where existing filling, such as that within the existing dam walls and other areas of major filling is present, and therefore warrants an alternative classification of Class P (Problem site).

However, the construction of residences is unlikely to occur close to dams, and they will probably be removed during subdivision construction. Similarly, the placement of filling during subdivisional earthworks is likely to alter the classification of site areas. Such areas affected by the placement of controlled filling are likely to require additional consideration and testing during design, however subject to appropriate testing may be able to be maintained as Class M or Class H sites.

4.4.2 Footings

All residential footing systems should be designed and constructed in accordance with AS2870-2011 for the appropriate site classification, providing they conform with the layout and loading requirements of the Standard. High level footing systems founding on stiff to very stiff clay soil would be appropriate for Class M and Class H sites (most new lots). Further delineation between Class H1 and Class H2 sites may be required prior to linen release and would need to be made for any subsequent construction certificate issue.

In addition, foundation systems may be required for Class S or Class A sites, depending upon the depth to rock and the depth/extent of excavation which may be undertaken during individual residence construction, particularly in higher areas of the site where rock depths are shallower. It is pointed out that Class S and Class A sites are difficult to achieve, when dealing with clay soils.

Whilst conventional high level footing systems would be appropriate for Class M or Class H sites, suitable foundation systems for Class P lots could include (depending on the depth of suitable founding stratum and the presence of groundwater) backhoe excavated mass concrete footings, pier and beam, screw piles or possibly driven timber piles and also mini piles founding on the underlying stiff clays or weathered rock.

For hillside construction, reference should be made to the Australian Geomechanics Society (AGS) publication Practice Note on Landslide Risk Management and relevant Australian Geoguides LR1 to LR9 which are included in Appendix G.

Footings for all other structures should be based on the results of specific Geotechnical and Salinity investigations. As a guide, preliminary design could be based on maximum allowable bearing pressures of 150 kPa for stiff to very stiff clays and 800 kPa for highly weathered rock of at least very low strength.

4.4.3 Site Preparation and Earthworks

Site preparation for the construction of structures and pavements should include the removal (and stockpiling for subsequent re-use) of topsoils and removal of other deleterious materials from the proposed building areas.

In areas that require filling, the stripped surfaces should be proof rolled in the presence of a geotechnical engineer. Any areas exhibiting significant deflections under proof rolling should be appropriately treated, typically by over-excavation and replacement with low plasticity filling placed in near horizontal layers no thicker than 250 mm compacted thickness. Each layer should be compacted to a minimum dry density ratio of 98%, (relative to Standard compaction) with placement moisture contents maintained within 2% of standard optimum moisture content (OMC). The upper 0.5 m in areas of pavement construction should achieve a minimum dry density ratio of 100% (relative to Standard compaction) with placement moisture contents similarly maintained.

All batters should be constructed no steeper than 3H:1V and appropriately vegetated to reduce the effects of erosion.

To confirm site classifications, sufficient field inspections and in situ testing of future earthworks should be undertaken in order to satisfy the requirements of a Level 1 inspection and testing service as defined in AS3798-2007 *"Guidelines on Earthworks for Commercial and Residential Developments"*.

Earthworks required for pavement construction will need to be based on batters formed no steeper than 3H:1V in the residual clays. All batters should be suitably protected against erosion with toe and spoon drains constructed as a means of controlling surface flows on the batters.

Within hillside lots (i.e. those on steeper ground surface slopes), excavation and filling should generally be limited to a maximum vertical height of 1 m respectively below or above the existing ground surface, unless appropriately supported by retaining structures (designed by a structural engineer) or where specific investigation provide alternate design options.

Proposed earthworks that exceed the above requirements should be subject to review by a geotechnical engineer during the design phase of the individual project.

If embankments are proposed for use as water quality control ponds, then the results of testing completed to date indicates that the site soils may be suitable for re-use as embankment materials, subject to further consideration of sodicity, dispersion and erosion. Subject to the detailed design, detention basins (i.e. short term, temporary storage only) could be dimensioned with maximum batter slopes of 4H:1V, with allowance made for accommodating the results of erosion (such as topsoiling and turfing) if soils with an ECN of less than 4 are used. Subject to design permeability requirements, the use of liners on both the embankments and within parts of the reservoir area may also be necessary.

Site observations have indicated the presence of silty topsoils and silty clays which could be adversely affected by inclement weather. Whilst these soils are typically of a stiff to very stiff consistency when dry, they can rapidly lose strength during rainfall and subsequent partial saturation, and result in difficult trafficability conditions. As a result, surface drainage that directs runoff away from work areas should be installed prior to construction, possibly in conjunction with the designation of construction equipment haul routes to minimise trafficking of stripped areas.

Conventional sediment and erosion control measures should be implemented during the construction phase, with exposed surfaces to be topsoiled and vegetated as soon as practicable following the completion of earthworks.

4.4.4 Site Maintenance and Drainage

The developed lots should be maintained in accordance with the CSIRO publication *"Guide to Home Owners on Foundation Maintenance and Footing Performance"*, a copy of which is included in Appendix G. Whilst it must be accepted that minor cracking in most structures is inevitable, the guide describes suggested site maintenance practices aimed at minimising foundation movement to keep cracking within acceptable limits.

Adequate surface drainage should be installed and maintained at the site. All collected stormwater, groundwater and roof runoff should be discharged into the stormwater disposal system. Similarly, effluent flows should be directed to the sewerage system.

4.4.5 Pavements

Whilst detailed design of pavements will be undertaken at the development application stage, a range of pavement thickness designs (excluding asphalt thicknesses) is shown in Table 2.3. These designs are based on the procedures given in AUSTROADS Guide to Pavement Technology Part 2: Pavement Structural Design, Figure 8.4, for a range of traffic loadings and subgrade CBR values and are provided to give an indication of the range of pavement thickness that can be expected. Wollondilly Shire Council may require slightly thicker pavements, where the following thicknesses are less than Council's minimum pavement construction thickness.

Table 2.3: Preliminary Pavement Thickness Designs

Traffic Loading (ESA)	Total Pavement Thickness Excluding Asphalt (mm)			
	CBR 3%	CBR 4%	CBR 5%	CBR 7%
1×10^5	380	330	290	240
3×10^5	440	380	340	280
1×10^6	520	440	390	320

The pavements should be placed and compacted in layers no thicker than 200 mm with control exercised over placement moisture contents. If layer thicknesses greater than 200 mm are proposed, then it may be necessary to test the top and bottom of the layer to ensure that the minimum level of compaction has been achieved through the layer. Suggested material quality and compaction requirements are given in Table 2.4.

Whilst the use of lesser quality pavement materials than that detailed in Table 2.4 may be feasible, some compromise in either performance and/or pavement life must be anticipated and accepted. It is also suggested that advice be sought from Council if lesser quality pavement materials are proposed.

Surface and subsoil drainage should be installed and maintained to protect the pavement and subgrade. The subsoil drains should be located at a minimum of 0.6 m depth below the pavement subgrade with drains placed on the high sides of all pavements, as a minimum. Guidelines on the arrangement of subsoil drains are given on Page 20 of ARRB-SR41.

Table 2.4: Suggested Materials and Compaction Requirements

Layer	Material Quality	Minimum Compaction
Wearing Course	To conform to Council requirements Generally AC10/AC14 asphalt	To conform to Council requirements
Base Course	To conform to RTA3051 for DGB20 Soaked CBR ≥ 80%, PI ≤ 6% or Council requirements	Minimum dry density ratio of 98% Modified (AS1289.5.2.1)
Sub-base Course	To conform to RTA3051 for DGS20 Soaked CBR ≥ 30%, PI ≤ 12% or Council requirements	Minimum dry density ratio of 98% Modified (AS1289.5.2.1)
Subgrade		Minimum dry density ratio of 100% Standard (AS1289.5.1.1)

Note: PI = Plasticity Index

Where weak, water-logged soils are encountered (for example, in the vicinity of gullies or downstream of existing dams), the inclusion of a 500 mm thick granular bridging layer (possibly in conjunction with geotextiles) may be required.

5. Preliminary Soil and Water Management Plan

Based on the results of the current site assessment, the implementation of a soil and water management plan (SWMP) for this development is not essential, as assessment results indicate non-saline and generally non-aggressive to mildly aggressive soil conditions. However, it may be prudent to develop a SWMP to ensure appropriate site design given that the sodicity and erosion potential is moderate to very high. A common sense approach to the control of ground surfaces, by maintaining constant vegetation or limiting the time of exposure for stripped ground, should be sufficient to maintain the integrity of the site.

Further testing is recommended for soil and surface water salinity prior to development application approval. Hence, a SWMP can be developed and implemented then, if the results of these works show a plan is necessary. If adopted, the scope of the plan could also be expanded to cater for controls on minimising soil erosion and maximising the re-use of existing site materials, together with providing guidance for implementation controls, land disturbance, pollution control and construction inspections and maintenance during development.

The following provides a conceptual SWMP with the objectives of controlling site works:

General Instructions: These conditions include methods to ensure compliance with the SWMP, specifically:

- The SWMP will be read with the engineering plans and site specific instructions issued in relation to the development;
- Contractors will ensure that all soil and water management works are undertaken as instructed in the specification and constructed in accordance with AS 3798 - 2007);

- All subcontractors will be informed by the Superintendent of their responsibilities in minimising the potential for soil erosion and pollution of downslope areas.

Land Disturbance: These conditions provide methods to minimise soil erosion, the exposure of potentially or known saline subsoils and direction of overland drainage into areas of potential slope instability, specifically:

- The erosion hazard will be kept as low as possible by limiting of construction area size at any one time and clearly defining the area by barrier fencing upslope and sediment fencing downslope (to be installed before the commencement of construction activities);
- Access areas will be clearly defined and limited in size while being considerate of the needs of efficient work areas. All site workers will clearly recognise these boundaries;
- The prohibition of entry into areas outside physical works except for essential management works;
- Restriction of work in creek lines during periods of rainfall, with programming of works in these areas to be within periods of anticipated lower rainfall;
- The programming of development road works and major excavations to minimise the time of soil exposure and to coincide with periods of anticipated lower rainfall;
- Placement of topsoils and subsoils in separate stockpiles (where required) with appropriate sediment fencing and dimensions selected to minimise the surface area of soils exposed to rainfall and hence erosion and leaching of saline materials;
- The creation of larger lots on steeper slope sections to permit the more sensitive development of the individual site;
- Orientation of access roads and services to minimise the requirements of excavation and possible retaining structures;
- Where excavation or filling of batters is required, the construction of these at as low as practical gradient with a maximum 3:1 (H:V) in the clay soil profiles;
- The placement of excavated soils in filled areas in the sequence of excavation (i.e. to place potentially saline or sodic subsoils below a capping of non-saline material);
- During windy conditions, large, unprotected areas will be kept moist by sprinkling with water to keep dust under control. In the event that water is not available in sufficient quantities, soil binders and/or retardants will be used or the surface will be left in a cloddy state that resists removal by wind;
- The inclusion of techniques, such as spray coating or a secured protective turf overlay on cut and fill batters to minimise erosion;
- The maximisation and/or replacement of native tree cover and deep-rooted plants, particularly in areas of known or potential slope instability;
- Where vegetation cover is not adequate to control erosion, the improvement of soil resistance to erosion by the addition of lime and gypsum (the proportion to be determined by site specific testing);
- Maintenance including watering of lands established with grass cover until an effective cover has been established. Where there has been inadequate vegetation establishment, further

application of seed should be carried out. During establishment, trafficking of the treated areas should be minimised;

- The design of stormwater drainage, including lined catch drains at the crest of cut slopes, stormwater pipes and dissipators as required to minimise concentrated runoff and to provide controlled discharge of the collected runoff;
- The sampling and analysis of groundwater samples from monitoring bores installed prior to construction in order to assess impacts on groundwater quality.

Pollution Control: These conditions provide measures to protect downstream areas for water-borne pollution, specifically:

- The installation of sediment fences to contain the coarser sediment fraction as near as possible to their source;
- Ensuring that stockpiles are not located within hazard areas, including areas of likely high velocity flow, such as waterways, paved areas and driveways;
- The installation of sediment basins downslope of areas to be disturbed, with the design based upon a design storm event;
- The inclusion of one or more pegs in the floor of the sediment basins to indicate the level at which design capacity occurs and when collected sediment will be removed;
- Disposal of trapped materials from sediment basins to locations where further erosion and consequent pollution to downslope lands and waterways will not occur;
- Sampling and laboratory analysis of collected waters to ensure compliance with benchmark parameters prior to discharge;
- The treatment of collected waters by gypsum and settling of flocculated particles before any discharge occurs (unless the design storm event is exceeded);
- The removal of sediment basins (where not required as part of the on-going site management) only after the lands they are protecting are stabilised.

Site Inspection and Maintenance: These conditions provide for self and external auditing of the performance of construction and pollution protection measures, together with appropriate maintenance of erosion and sedimentation structures, specifically:

- A self-auditing program against an established checklist to be completed by the site manager at least weekly, immediately before site closure and immediately following rainfall events in excess of 5 mm in any one 24 hour period. The audit should include the recording of the condition of temporary sediment and water control devices, any maintenance requirements for these structures, volumes and disposal sites of material removed from sediment retention systems. A copy of the audit should be provided to the project Superintendent;
- Provision for periodic inspection of records and site conditions by an external, suitably qualified person, for oversight of soil and water management works. The person will be responsible for ensuring that the SWMP is being implemented correctly, repairs are being undertaken as required and modifications to the SWMP are made if and when necessary. A short written report will be provided at appropriate intervals and will confirm that the works have been carried out according to the approved plans.

Additional information and methods can be obtained from the "The Blue Book", Managing Urban Stormwater; Soils and Construction

6. Preliminary Salinity Management Plan

The following general management strategies are recommended for the management of those salinity factors with a potential to impact on future development. This preliminary salinity management plan is based on the current, broad scale data which indicates that the soil and weathered rock at the Site range from non-saline to very saline. Testing of other parameters associated with salinity, indicates that the soils are typically non-aggressive to mildly aggressive to concrete (by the pH criteria of AS2159) and non-aggressive to steel. In addition, shallow soils were sodic to highly sodic.

It should be noted that the data obtained to date may not cover localised conditions in various areas of the Precinct. Additional investigation may be appropriate in development areas which are to be excavated deeper than 3 m and elsewhere where direct sampling and testing of salinity has not been carried out. Salinity management strategies outlined below may need to be modified or extended following any additional investigations by deep test pitting and/or drilling, sampling and testing for soil and water pH, electrical conductivity, TDS, sodicity, sulphates and chlorides, such as may be carried out at future dates for specific developments.

It is considered that the general management strategies described herein, when incorporated into the design and construction works are appropriate to mitigate the levels of salinity, aggressivity and sodicity identified at the site

A. Management should focus on capping of the upper surface of the sodic soils, both exposed by excavation and placed as filling, with a more permeable material to prevent ponding, to reduce capillary rise, to act as a drainage layer and to reduce the potential for erosion.

B. When possible, place excavated materials in fill areas with similar salinity characteristics (ie: place material onto in-situ soils with a similar or higher aggressivity or salinity classification). With respect to imported fill material, testing should be undertaken prior to importation, to determine the salinity characteristics of the material, which should be non-aggressive and non-saline to slightly saline where possible but in any case not more aggressive or more saline than the material on which it is to be placed.

C. Sodic soils can also be managed by maintaining vegetation where possible and planting new salt tolerant species. The addition of organic matter, gypsum and lime can also be considered where appropriate. After gypsum addition, reduction of sodicity levels may require some time for sufficient infiltration and leaching of sodium into the subsoils, however capping of exposed sodic material should remain the primary management method. Topsoil added at the completion of bulk earthworks is, in effect, also adding organic matter which may help infiltration and leaching of sodium.

D. Avoid water collecting in low lying areas, in depressions, or behind fill. This can lead to water logging of the soils, evaporative concentration of salts, and eventual breakdown in soil structure resulting in accelerated erosion.

E. Any pavements should be designed to be well drained of surface water. There should not be excessive concentrations of runoff or ponding that would lead to waterlogging of the pavement or additional recharge to the groundwater through any more permeable zones in the underlying filling material.

F. Surface drains should generally be provided along the top of batter slopes to reduce the potential for concentrated flows of water down slopes possibly causing scour.

G. Salt tolerant grasses and trees should be considered for landscaping, to reduce soil erosion as in Strategy A above and to maintain the existing evapo-transpiration and groundwater levels. Reference should be made to an experienced landscape planner or agronomist.

The following additional strategies are recommended for completion of service installation and for building construction. These strategies should be complementary to standard good building practices, including cover to reinforcement within concrete and correct installation of a brick damp course (where used), so that it cannot be bridged to allow moisture to move into brick work and up the wall.

H. Where soils are classified as non-aggressive to concrete (refer Drawing S2), concrete piles should nevertheless have a minimum strength of 32 MPa and a minimum cover to reinforcement of 45 mm (as per AS2159).

I. Where soils are classified as mildly aggressive to concrete (refer Drawing S2), concrete piles should have a minimum strength of 32 MPa and a minimum cover to reinforcement of 60 mm (as per AS2159) to limit the corrosive effects of the surrounding materials (in accordance with AS2159).

J. With regard to concrete structures for non-saline and slightly saline soils (salinities less than 4 dS/m) refer to Drawing S3 and S4:

  - Where soils are classified as non-aggressive to concrete (refer to Drawing S1), slabs and foundations should have a minimum strength of 20 MPa, and should be allowed to cure for a minimum of three days (as per AS3600) to limit the corrosive effects of the surrounding soils; and
  - Where soils are classified as mildly aggressive to concrete (refer to Drawing S1), slabs and foundations should have a minimum strength of 25 MPa, and should be allowed to cure for a minimum of three days (as per AS3600) to limit the corrosive effects of the surrounding soils;

K. With regard to concrete structures for moderately saline soils (salinities of 4 – 8 dS/m) refer to Drawings S3 and S4;

  - Where soils are classified as non-aggressive to concrete (refer to Drawing S1), slabs and foundations should have a minimum strength of 25 MPa, a minimum cover to reinforcement of 45 mm from unprotected ground and should be allowed to cure for a minimum of three days (as per AS3600) to limit the corrosive effects of the surrounding soils; and
  - Where soils are classified as mildly aggressive to concrete (refer to Drawing S1), slabs and foundations should have a minimum strength of 25 MPa, a minimum cover to reinforcement of 45 mm from unprotected ground and should be allowed to cure for a minimum of three days (as per AS3600) to limit the corrosive effects of the surrounding soils;

L. With regard to concrete structures, for very saline materials (salinities of 8 – 16 dS/m) refer to Drawings S3 and S4:

- Where materials are classified as non-aggressive to concrete (refer to Drawing S1), slabs and foundations should have a minimum strength of 32 MPa, a minimum cover to reinforcement of 50 mm from unprotected ground and should be allowed to cure for a minimum of seven days (as per AS3600) to limit the corrosive effects of the surrounding materials; and
- Where materials are classified as mildly aggressive to concrete (refer to Drawing S1), slabs and foundations should have a minimum strength of 32 MPa, a minimum cover to reinforcement of 50 mm from unprotected ground and should be allowed to cure for a minimum of seven days (as per AS3600) to limit the corrosive effects of the surrounding materials;

M. Any future installation of concrete pipes up to a maximum diameter of 750 mm, within the Site, should employ fibre reinforced cement. Alternatively, concrete pipes in these areas should be encased in outer PVC conduits or should have a minimum equivalent strength as defined in J, K and L above.

N. Concrete pipes with a larger diameter than 750 mm should utilise sulphate resistant cement.

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