

PROJECT

**SITE BASED MANAGEMENT
PLAN FOR DISPERSIVE SOILS
PROPOSED FLINDERS
SUBDIVISION, UNDULLAH
QUEENSLAND**

PLANS AND DOCUMENTS
referred to in the PDA
DEVELOPMENT APPROVAL



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CLIENT REFERENCE –

SYNOPSIS This management plan establishes responsibilities and procedures for the management and control of dispersive soils during the construction, on-maintenance and operational phases of the proposed Flinders Subdivision in Undullah, Queensland.

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SUMMARY

Pacific International Development Corporation Pty Ltd (PIDC) commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare a Site Based Management Plan (SBMP) for the management of dispersive soils at the proposed Flinders subdivision in Undullah, Queensland.

Preliminary soil sampling investigations conducted at the Flinders development site in support of the current Development Application indicate that the Flinders site is underlain by dispersive subsoils of varying severity. Dispersive or sodic soils are structurally unstable in water, breaking down into their constituent particles (sand, silt, and clay) and allowing the clay fraction to disperse and cloud the water of receiving environments.

The management of dispersive soils and the occurrence and rehabilitation of tunnel erosion is best achieved through a combination of:

- Identification and avoidance of dispersive soils
- Precise re-compaction.
- Chemical amelioration
- Sand blocks and barriers
- Burial, application of topsoil and revegetation

This report builds on the broad approaches outlined above and provides conceptual management measures to control erosion and sediment transport within dispersive soils during the bulk and civil earthworks and throughout a period of landform stabilisation at the site.

Whilst this conceptual SBMP provides broad strategies to manage dispersive soils, it is anticipated that detailed targeted advice would be necessary for discreet areas of the development, which would be prepared following the identification of dispersive soils, prior to disturbance.

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1 Introduction

Pacific International Development Corporation Pty Ltd (PIDC) commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare a Site Based Management Plan (SBMP) for the management of dispersive soils at the proposed Flinders subdivision in Undullah, Queensland.

Preliminary soil sampling investigations conducted at the Flinders development site in support of the current Development Application indicate that the Flinders site is underlain by dispersive subsoils of varying strength. Dispersive soils exhibit the following properties and associated management challenges:

- Highly erodible and unstable resulting in high levels of turbidity in stormwater runoff,
- Severe rilling of unprotected batter slopes,
- Highly susceptible to tunnel erosion, and
- Tunneling behind rigid (e.g concrete) and semi-rigid surfaces (e.g. gabions).
- Transportation of nutrients and metals bound to clay particles to the receiving environment.

The management of dispersive soils and the occurrence and rehabilitation of tunnel erosion is best achieved through a combination of:

- Identification and avoidance of dispersive soils
- Precise re-compaction.

- Chemical amelioration
- Sand blocks and barriers
- Burial, application of topsoil and revegetation

This report builds on the broad approaches outlined above and provides conceptual management measures to control erosion and sediment transport within dispersive soils during the bulk and civil earthworks and throughout a period of landform stabilisation at the site.

Whilst this conceptual SBMP provides broad strategies to manage dispersive soils, it is anticipated that detailed targeted advice would be necessary for discreet areas of the development, which would be prepared following the identification of dispersive soils, prior to disturbance.

1.1 Guidelines and supporting documentation

The management measures proposed within this SBMP are provided with consideration to the following reference documents:

- International Erosion Control Association (IECA) 2008, Best Practice Erosion and Sediment Control Guidelines¹,
- ULDA 2011 Guideline No.14 – Environment and Natural Sustainability², and
- ULDA 2011 Guideline No.13 – Engineering Standards³.

¹ International Erosion Control Association (IECA) 2008. Best Practice Erosion and Sediment Control. Picton, Australia.

² Urban Land Development Authority (ULDA), 2011. Guideline No.14 – Environment and Natural Resources Sustainability. Brisbane, Australia.

³ Urban Land Development Authority (ULDA), 2011. Guideline No.13 – Engineering Standards. Brisbane, Australia.

2 Site description and proposal

2.1 Site location

PIDC commissioned G&S to prepare an SBMP for the management of dispersive soils at the proposed Flinders subdivision in Undullah, Queensland.

Flinders is located approximately 50km south-west of the Brisbane CBD and approximately 20km north-west of Beaudesert in the south-east Queensland Regional Growth Corridor. It lies within the Logan City Council local government area (LGA). Access to the site is afforded via the existing Undullah Road and Wyatt Road and the unformed Dairy Road.

The entire Flinders site is shown in Drawing No. 10922.1.1. This property is described as:

Lot 79S312955	Lot 20SP133191
Lot 80SL1163	Lot 10SP133192
Lot 2RP896513	Lot 2SP31878
Lot 74S312820	Lot 30SP133190
Lot 42SL5873	Lot 200SP133189
Lot 32S311402	Lot 1RP97710
Lot 19S311970	Lot 3RP46302
Lot 390SP133193	Lot 1RP35158
Lot 2RP46302	Lot 2RP46303
Lot 1RP46806	Lot 3S311896

2.2 Geology

The Queensland Department of Mines – Moreton Geology 1:500,000 Geological Map⁴ describes the site as being part of the Marburg Formation. These early Jurassic formations consist of sandstone, siltstone, shale, conglomerate, coal and oolitic ironstone. The geology is dominated by coarse-grained sedimentary deposits. Site survey indicates that narrow bands of alluvium (silt, sand, and gravel) are present along minor waterways and associated terraces. The rocks of the Marburg formation dip gently at 3° to the east with the strike in a north-south direction.

⁴ Queensland Department of Mines, 1980. 1:500,000 Moreton Geology. Government Printer. Brisbane, Australia.

2.3 Slope and terrain (landform)

The elevation of the site ranges from below 25m Australian Height Datum (AHD) in the eastern floodplain areas adjacent to the main watercourses, to over 300m AHD along the ridge tops to the north. Slopes range up to 15% in the lower eastern portions of the site and are greater than 25% on elevated upper ridge sides. The distribution of slopes on the site is shown in Drawing No 10922.1.2.

The site consists of several large ridges with associated side slopes and broad ridge tops, with aspects ranging from north to east through south to west. Noble (1996) describes the landforms as undulating hills and rises to steep hills and mountains⁵. The important terrain units contained within the first precinct are as follows:

- Hilltop areas that have the roles of initial recharge areas for groundwater movement.
- Sideslopes that are the transmission zones from both surface and groundwater discharge.
- Hillwash zones that form part of the footslope areas and signify secondary seepage and discharge areas for groundwater and surface flows.
- Drainage plains that act as a conveyance for run-off and groundwater that emerges at the surface.
- Floodplains that are prone to flood events.

The distribution of these land units is shown in Drawing No 10922.1.3.

The land is dissected by many drainage plains and only those that present themselves as streams or incised gullies are mapped. The large number of small drainage plains suggests the site generates significant run-off and is prone to erosion.

2.4 Site drainage

This site lies within the lowland freshwater catchment of the Logan River. Two major creeks drain to the western portion of the site:

⁵ Noble K. E (ed), 1996. Understanding and management soils in the Moreton region. DPI and National Landcare program.

- Undullah Creek flows from the north-west to the south-east largely parallel to Undullah Road, fed by several gullies to the north-east. Undullah Creek then joins Woollaman Creek, entering from the west, at its southern end.
- Woollaman Creek drains a more substantial catchment to the west of the site and flows from west to east along the southern site boundary before joining Teviot Brook, approximately 1.4km downstream of the site.

The eastern portion of the site drains via two gullies flowing from the site's north-west to its south-east. These two gullies converge to form one larger waterway, which continues on toward the site's south-eastern boundary. This combined waterway is an unnamed tributary of Teviot Brook.

The confluence of the unnamed tributary and Teviot Brook is approximately 1.3km downstream of the site boundary and approximately 1.4km downstream of the Woollaman Creek and Teviot Brook confluence. Teviot Brook eventually flows to the Logan River some 2.5km further downstream.

2.5 Existing development

The Flinders development, comprising some 3,919ha, is to be divided into precincts and developed progressively. The first precinct is approximately 997ha and lies within the Greater Flagstone Urban Development Area, which is under the control of the Queensland Urban Land Development Authority.

Areas associated with the on-site creeks and streams have been designated as both Agricultural Protection Areas in the Beaudesert

Shire Council Planning Scheme 2007) and possible Strategic Cropping Land by the Department of Environment and Resource Management (DERM), which is now the Department of Environment and Heritage Protection (DEHP).

The areas of agricultural significance within the first precinct are associated with the alluvial plains adjacent to Undullah Creek and the tributaries flowing from the site south into Woollaman Creek.

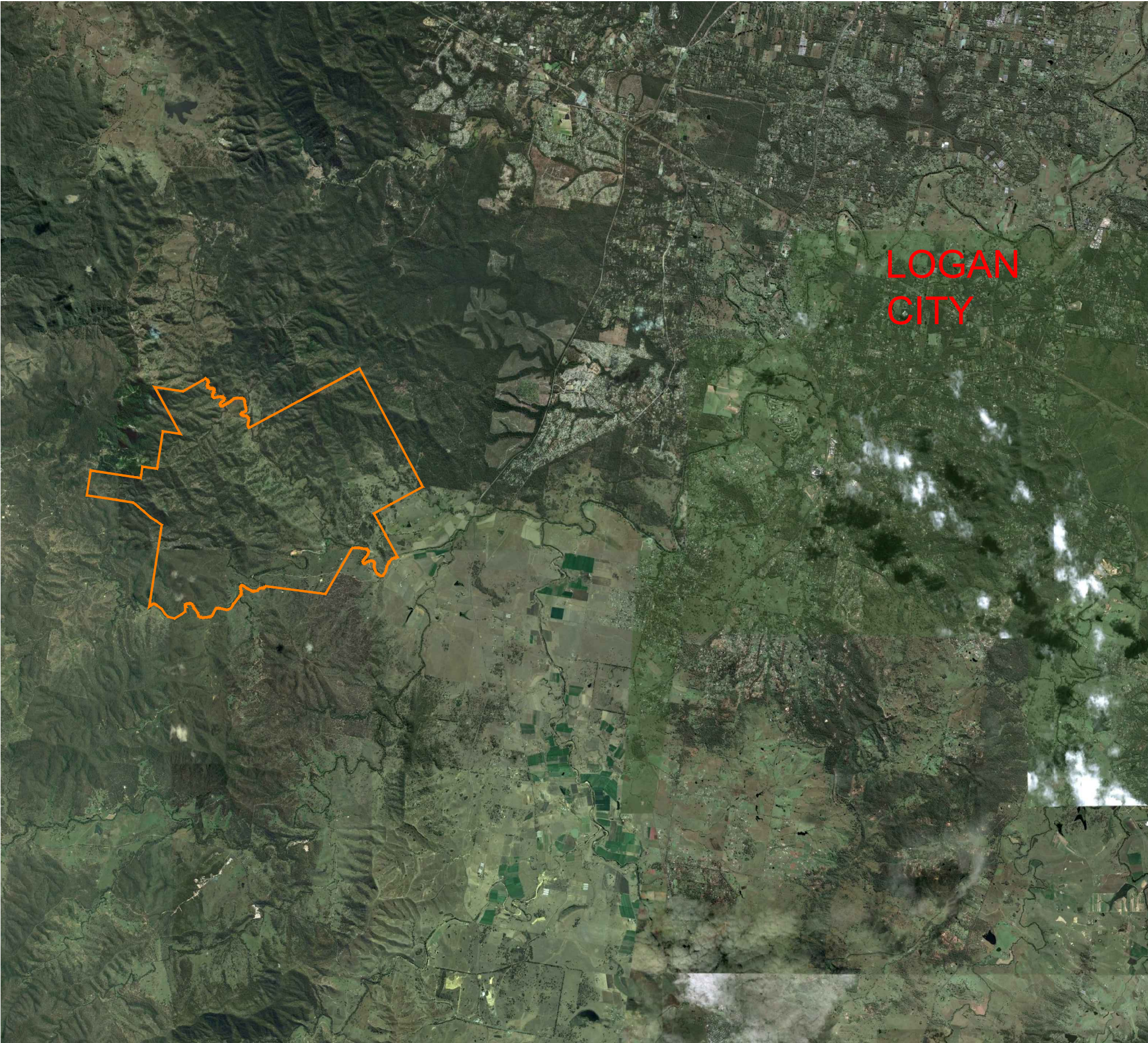
At present the site is used for agricultural purposes accommodating a herd of beef cattle and an infrastructure including stock dams and fenced cattle paddocks and yards.

The site is bounded on all sides by rural land.

2.6 Proposed development

The proposed development is primarily for residential purposes, including the creation of a new master-planned satellite town between Brisbane and Beaudesert. The eastern portion of the site lies within the Greater Flagstone Urban Development Area that is being planned by the Queensland Urban Land Development Authority (ULDA). The western portions of the site provide an opportunity to further extend the proposed town.

The first precinct is approximately 997ha and is shown in Drawing No. 10922.1.4.





SCALE
1:25 000



ORIENTATION
NORTH

LEGEND

- Site boundary
- First precinct boundary
- Extent of Assessment
- Depositional
- Hill Top
- Hill Wash
- Floodplain

Slopes Table			
Number	Minimum Slope	Maximum Slope	Color
1	0.00%	5.00%	
2	5.00%	15.00%	
3	15.00%	25.00%	
4	25.00%	25+%	

SOURCES

Google Earth Pro 2011

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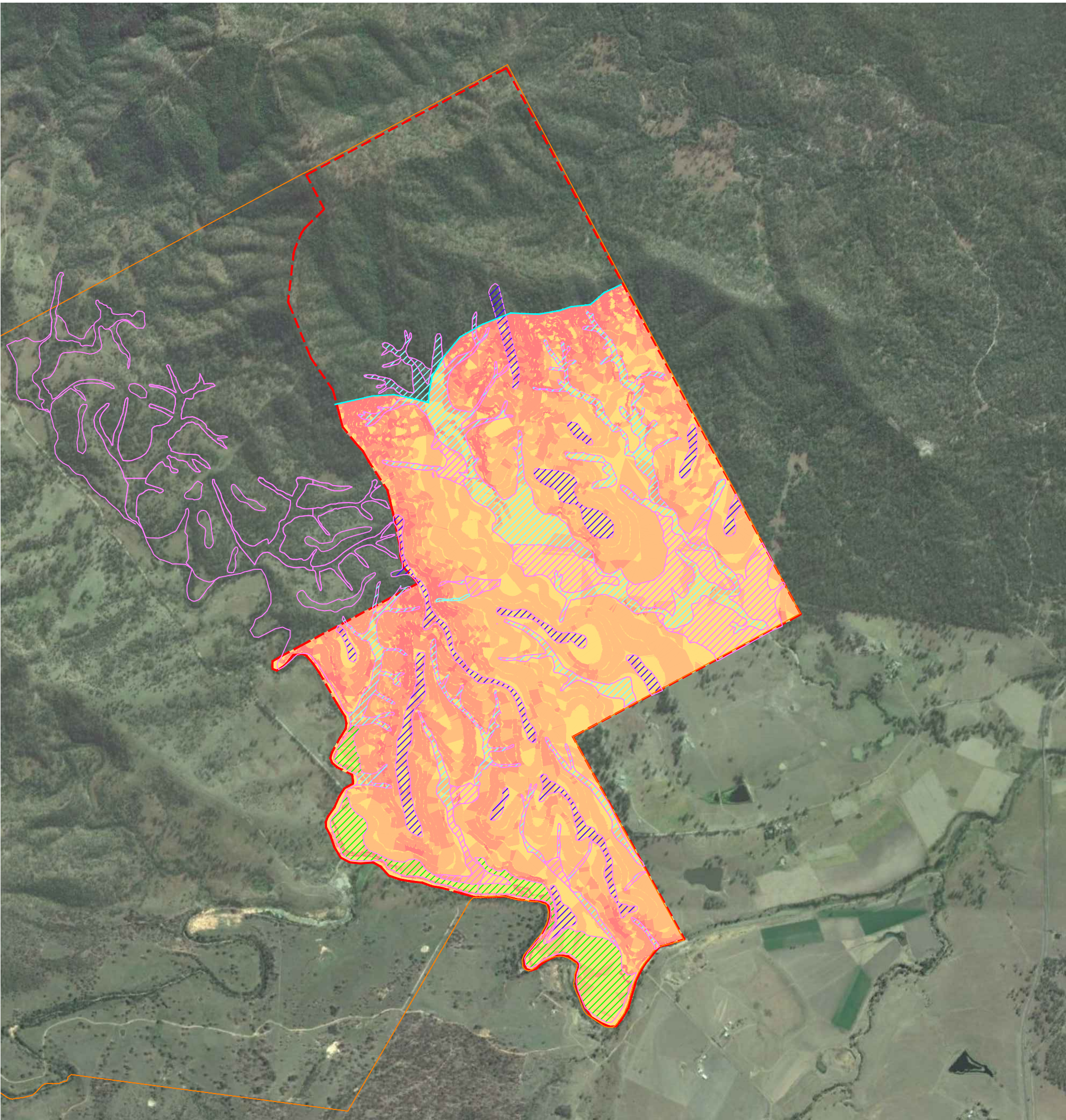
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PROJECT
FLINDERS

CLIENT
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DRAWING
DISTRIBUTION OF SLOPES
WITHIN THE FIRST PRECINCT

DATE
30/11/2011

SCALE
1:25 000

PROJECT NO
10922

DRAWN
AJS

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NZ

DRAWING NO
10922.1.2

REVISION
1



SCALE
1:25 000



ORIENTATION
NORTH

LEGEND

- Site boundary
- First precinct boundary
- Extent of Assessment
- Drainage Plain
- Hill Top
- Hill Wash
- Floodplain
- Sideslope (no hatch)

SOURCES

Google Earth Pro 2011

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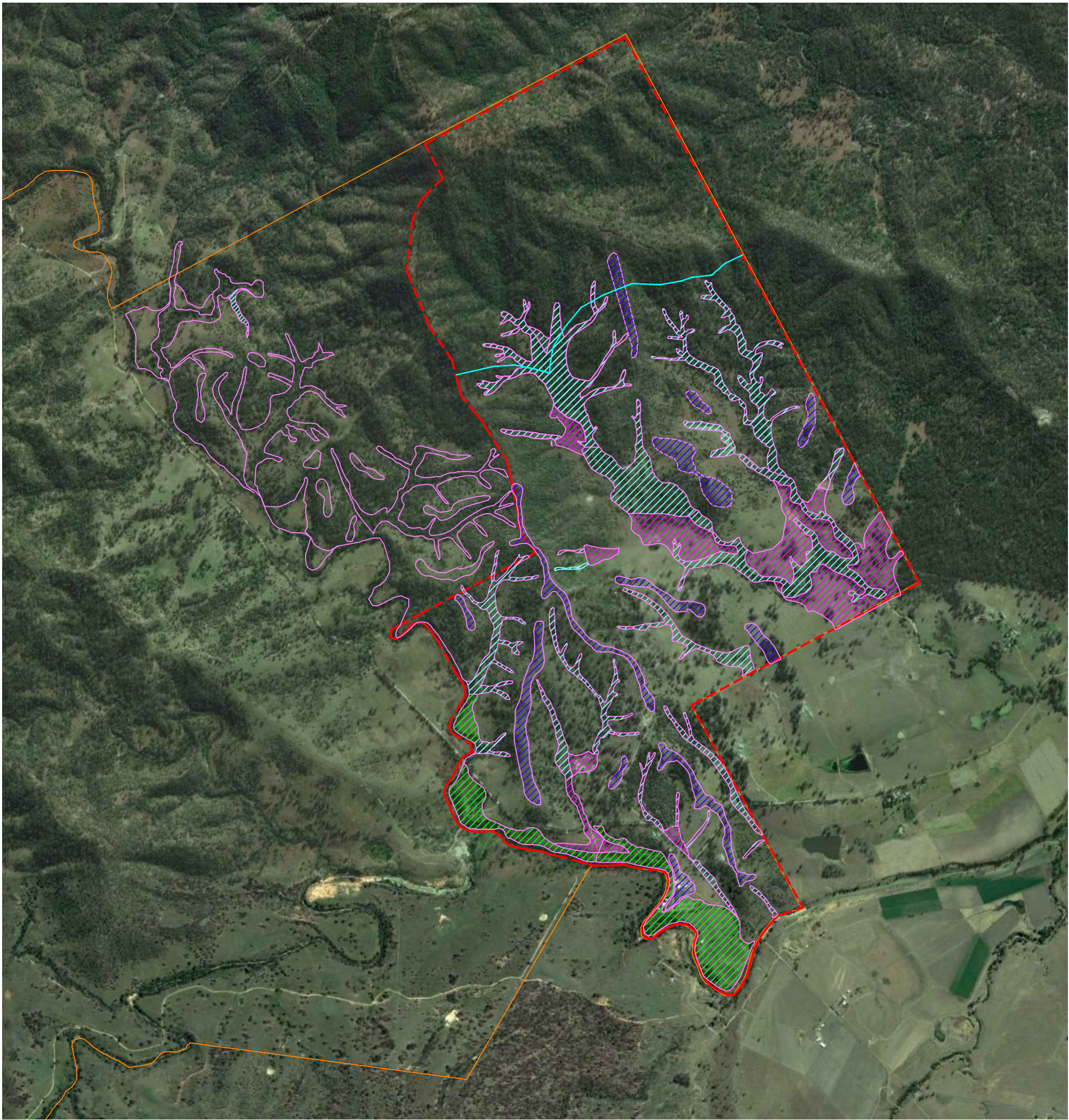
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DRAWING
DISTRIBUTION OF TERRAIN
UNITS OF FIRST PRECINCT

DATE
17/08/2012

SCALE
1:25 000

PROJECT NO
10922

DRAWING NO
10922.1.3

DRAWN
AJS

CHECKED
NZ

REVISION
1



SCALE
1:62 500



ORIENTATION
NORTH

LEGEND

- Site boundary
- First precinct boundary

SOURCES

Google Earth Pro 2011
Mortons Urban Solutions 2011

CAIRNS

KAWANA

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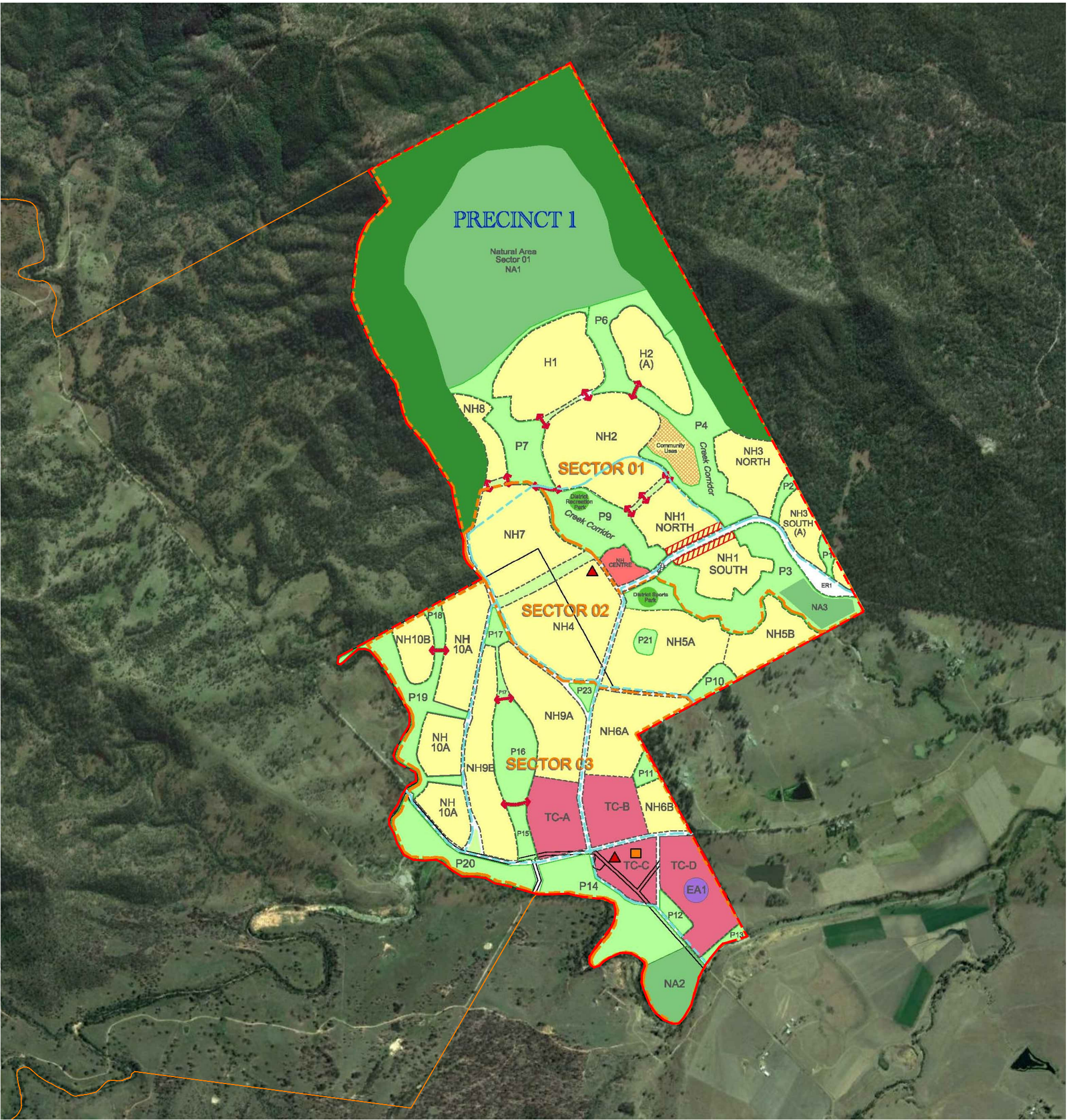
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DRAWING
NEIGHBOURHOOD 1

DATE
17/08/2012

SCALE
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PROJECT NO
10922

DRAWING NO
10922.1.4

DRAWN
AJS

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NZ

REVISION
1

3 Site soils, erodibility and erosion risk

3.1 Soil types

The first precinct site is located within the Marburg forest resource area. The soils associated with the Marburg forest are sandy and loamy solodics, red, yellow and lateritic podzolics, earthy sands and lithosols.

3.2 Soil classification

G&S conducted a preliminary soil assessment of the Flinders subdivision site in 2011⁶. This onsite soils assessment and subsequent laboratory analysis indicated that the site contains the following soil orders:

- Sodosols
- Sodic Dermosols and scattered Natric Kurosols and Sodosols
- Kurosols, Chromosols and Tenosols of lower sodicity
- Mixed Tenosols, Kurosols and Tenosols

Detailed descriptions of each soil classification are provided in the following sub-sections. The distribution of the soils is shown in Drawing No 10922.1.5.

3.2.1 Sodosols

These are soils with a strong texture contrast between A and B horizons in which the upper 0.2m of the B2 horizon is sodic and not strongly acidic. The Sodosols present on the site were further classified as:

- Mottled-Subnatric Eutrophic Yellow and Brown Sodosols.
- Mottled Hypernatric Eutrophic Yellow and Brown Sodosols.

The A horizons (topsoil) were a sandy loam to clay loam (sandy) overlying a B2 horizon of sandy medium to heavy clay or heavy clay with weak to moderate angular blocky structure. Differences between the two Sodosol types were related to:

- the upper part of the B2 horizon is mottled with an ESP between 6 and <15 (i.e. subnatric and the major part of the B2 horizon has a base status of >15cmol/kg clay (see Plate 1)).
- the upper part of the B2 horizon is mottled with an ESP >35 i.e. hypernatric and the major part of the B2 horizon has a base status of >15cmol/kg clay.



Plate 1: Example of a Mottled-Subnatric Brown Sodosol (Note: The topsoil is located in the top left corner of the plate with the deepest part of the profile located in the bottom middle portion of the plate.)

3.2.2 Sodic Dermosols and scattered Natric Kurosols and Sodosols

Dermosols are soils other than Vertosols, Hydrosols, Calcarosols and Ferrosols which:

- have B2 horizons with a structure more developed than weak throughout the major part of the horizon, and
- do not have clear or abrupt textural B horizons.

These soils on this site were further classified into two soil types:

- Acidic-Sodic Eutrophic Brown and Grey Dermosols, and
- Mottled-Sodic Eutrophic Brown Dermosols.

The A horizons (topsoil) were sandy loam to sandy light clay overlying a light to heavy clay B2 horizon with predominantly weak to moderate subangular blocky structure. The differences between the two Dermosol types were:

⁶ G&S, 2011. Preliminary Soil Assessment, Proposed Flinders Subdivision, Undullah, Queensland. Robina, Australia.

- the upper 0.5m of the B2 horizon was brown or grey coloured and the major part of the B2 horizon was acidic and sodic (e.g. Plate 2)
- the upper 0.5m of the B2 horizon was brown and the major part of the B2 horizon was mottled and sodic and has a base status of $>15\text{cmol kg}^{-1}$ clay.



Plate 2: Acidic-Sodic Brown Dermosol – BH20

Kurosols are soils with a strong texture contrast between the A horizon and a strongly acid B horizon. The Kurosols on this site were further classified as predominantly Mottled Natric Eutrophic Yellow and Brown Kurosols.⁷

The A horizons (topsoil) were clayey sand to sandy clay loams overlying a heavy clay to sandy heavy clay B2 horizon with weak to moderate angular blocky to sub-angular blocky structure. The B2 horizon was mottled with a base status of $>15\text{cmol/kg}$ clay. The upper 0.2m of the B2 horizon is brown or yellow coloured and sodic.



Plate 3: Example of Mottled Natric Brown Kurosol – BH1. The soil is arranged from topsoil (located at top left side corner of plate) through to the deepest part of the profile (located at the centre bottom of the plate).

3.2.3 .Kurosols Chromosols and Tenosols of lower sodicity

The Kurosols in this group are similar to the Natric Kurosols, except that they do not exhibit exchangeable sodium percentages of less than 6%. These soils exhibit significantly lower dispersibility and represent a lesser erosion hazard than the Sodic or Natric Kurosols.

Chromosols are soils with a clear texture contrast between A and B horizons. These soils on this site were further classified into Mottled Eutrophic Brown Chromosols.

The A horizons (topsoil) were sandy clay loam overlying a B2 horizon of heavy clay with weak to moderate sub-angular blocky structure. The B2 horizon is mottled with a base status of $>15\text{cmol/kg}$ clay and the upper 0.2m of the B2 horizon is brown coloured.

Tenosols are soils with only weak pedologic organisation apart from the A horizons. These soils on this site were further classified as either Leptic or Orthic Tenosols. Leptic indicates shallow soils with less than 0.5m to surface by rock or partially weathered rock. Orthic indicates soils with a B horizon of 15% clay or less.

On this site the Leptic Tenosols were located in the more elevated sideslope and hilltop areas and were characterised by a sandy loam to sandy clay loam A horizon overlying weathered rock (Plate 4).

⁷ Using field laboratory analysis of soil characteristics.



Plate 4: Example of Leptic Tenosol (The topsoil is located at the top left side corner of plate with the deepest part of the profile located in the bottom middle portion of plate.)

The Orthic Tenosols were predominantly located in the low-lying hillwash and floodplain areas and were characterised in general by a loamy sand to sandy loam A horizon overlying a sand to clayey sand B horizon (Plate 5).



Plate 5: Example of Orthic Tenosol (Again, the soil is arranged from topsoil in the top left to the deepest part of the profile in the bottom right of the plate.)

3.3 Erosion hazard – soil dispersion

Erosion hazard is recognized as the susceptibility of a parcel of land to the prevailing agents of erosion and is dependent on site-specific factors such as climate, landform, soil erodibility, landuse

and land management factors (Houghton and Charman, 1986).⁸

Wind and rain are the two main agents that cause soil erosion. Adequate surface cover (minimizing soil disturbance) or barriers can generally deal with wind erosion. Soil erosion caused by water is significantly more complex.

Truong and Witheridge (1996) identify and define erosion caused by water as one or a combination of six forms:

- Raindrop splash erosion - the impact of raindrops on bare soil surfaces detaches soil particles which can be removed by runoff water. This is a major source of turbidity in stormwater runoff.
- Sheet erosion - this is the uniform removal of soil in thin layers from sloping land.
- Rill erosion - small and shallow channels formed from the concentration of flow on uneven surfaces.
- Gully erosion - these are channels larger and deeper than rills.
- Landslide - this is the mass movement of soil on unstable slopes during high rainfall periods.
- Stream bank erosion - this form of erosion in an urban environment often results from changes in catchment hydrology.

Erodibility is influenced by site-specific factors including soil type, soil chemistry, climate, landform and land use management. To estimate the impact of erosion on this site, G&S conducted a soil dispersion analysis as part of preliminary soil assessment.

This assessment found that the majority of topsoils tested as generally non-dispersive. In contrast, the subsoils tested were predominantly highly dispersive with Emerson Classes 1, 2 and 3 dominating the results.

3.3.1 Dispersive (sodic) soils

Dispersive or sodic soils are structurally unstable in water, breaking down into their constituent particles (sand, silt, and clay) and allowing the

⁸ Houghton, P.D. and Charman, P.E.V. (1986) Glossary of Terms used in Soil Conservation. Soil Conservation Service of NSW.

clay fraction to disperse and cloud receiving waters.

Dispersion is mainly caused by the high levels of exchangeable sodium in the soils and excessive mechanical disturbance which may occur during earthworks, cultivation or grazing activity.

Dispersive soils exhibit the following properties and associated management challenges:

- Highly erodible and unstable soils that can generate high levels of turbidity in stormwater runoff,
- Severe rilling of unprotected batters,
- Highly susceptible to tunnel erosion, and

- Tunneling behind rigid (e.g concrete) and semi-rigid surfaces (e.g. gabions).
- Transportation of nutrients and metals bound to clay particles.

3.4 Erosion risk

To provide further understanding of the potential for erosion at the site, G&S undertook an assessment of the erosion risk across the site. As determined by Logan City Council, the criteria used are from Part 7, Division 3, Chapter 14, Table 1 of the Gold Coast Planning Scheme Erosion Hazard Assessment Form. The criteria developed by Gold Coast City Council are presented in Table 3.4.1. The G&S assessment of erosion risk is presented in Table 3.4.2.

Table 3.4.1 Gold Coast City Council Erosion Hazard Assessment Form

Gold Coast City Planning Scheme – Erosion Hazard Assessment Form	
Factors	Points
Average slope of the whole site, prior to building works: • Slope < 3% • 3% Slope < 5% • 5% Slope < 10% • 10% Slope < 15% • Slope is greater than 15%	0 1 2 4 5
Soil type: • Sandy soil/gravel • Sandy loam • Clay loam • Clay soil	0 1 2 2
Anticipated duration of site disturbance: • Duration < 2 weeks • 2 weeks Duration < 3 months • 3 months Duration < 6 months • Duration > 6 months	0 2 4 5
Month that works are undertaken: • August, September • April, May, June, July, November, October • March, December • January, February	0 1 2 3
Offsite sediment control (i.e. down slope of the soil disturbance): • There is no purpose-built, operational and well-maintained sediment trap (e.g. sediment basin, gross pollutant trap or purpose built wetland) to catch sediment before it enters a waterbody with environmental values (e.g. creek, natural wetland, river or bay).	1
Runoff entering the site: • Stormwater runoff entering the site is not diverted away from the soil disturbance.	1

Extent of site disturbance: - The building work requires reshaping of the ground surface (e.g. 'cut and fill' works); - The area to be disturbed is greater than 600m².	2 5
Works within environmentally sensitive areas: - The disturbance is within the banks of a watercourse; - The disturbance is within 50 metres of the top of bank of a watercourse; - The disturbance is between 50 and 100 metres of the top of bank of a watercourse.	11 5 2

Table 3.4.2 G&S hazard assessment results

Factor	Site Characteristics	Points
Slope	10% to 15%	4
Soil Type	Clay loam to clay soils	2
Duration of site disturbance	Greater than 6 months	5
Timing of works	Works will be undertaken during all months	3
Off-site sediment control	Full sediment controls will be employed with sediment basins employed to ensure no offsite impacts	0
Runoff entering site	Stormwater runoff entering the site from upstream will be diverted away from areas of soil disturbance	0
Extent of site disturbance	Area to be disturbed is greater than 600m ²	5
Works within environmentally sensitive areas	Some works may be within 100m of the top of bank of a watercourse	2
Total Score		21

Based on the above guidelines, the erosion risk for the site can be classified as 'high risk' as the total score is above the critical score of 11 points.

This particular form of erosion hazard assessment does not allow for the adoption of management techniques. With this in mind, an additional assessment was carried out. This assessed the effects of applying management measures and is reported below as SOILOSS modelling.

3.5 SOILOSS modelling

In order to predict the rate of soil loss from the site during development, the National Landcare Program model SOILOSS was used. SOILOSS uses the principles of the Revised Universal Soil Loss Equation (RUSLE) to predict average annual soil losses due to sheet and rill erosion. SOILOSS also provides recommendations to reduce soil loss (including adjustments to land and cover management practices) and facilitates the testing of such alterations and changes.

In the RUSLE, soil erodibility is represented by the K factor and is defined as the annual average soil loss per unit of rainfall erosivity (Houghton and

Charman, 1986, Loch and Rosewell, 1992⁹). Whilst his estimation of soil loss considers key factors influencing the extent of soil loss from a given area, such as rainfall erosivity, slope length, soil cover and soil conservation practices it does not consider the impacts of soil dispersivity and thus should only be considered as an estimate of potential soil loss from the site. True soil loss from the site, particularly in areas where dispersive soils are present, has the potential to be greater than the estimates provided in this section.

For the site slopes, gradients of 5%, 10%, 15% and 20% were used to represent the likely slopes on which development will occur. A slope length of 100m was used to represent non-disturbed and/or construction conditions without controls, with a reduced slope length of 50m selected to represent spacing of controls during the construction phase (for example catch drains or diversion channels). An initial support practice factor (P) of 1.0 was adopted to represent non-disturbed/rehabilitated conditions prior to

⁹ Loch, R.J. and Rosewell, C.J. (1992) Laboratory Methods for Measurement of Soil Erodibilities (K Factors) for the Universal Soil Loss Equation. Australian Journal of Soil Research, 1992, Vol 30 pp233-248.

construction, with a P of 1.3 adopted for the construction case as it represents soil that has been left bare by dozer or grader blade. Cover and crop management factors (C) of 0.1, 0.45 and 0.2 were also assumed to represent the initial non-disturbed/rehabilitated conditions, bare earth prior to controls and mulched cover conditions respectively.

Five different soil types or orders are considered to be present across the site, namely Kurosols, Dermosols, Sodosols, Tenosols and Chromosols.

For SOILOSS modelling purposes, K factors between 0.050 and 0.012¹⁰ were adopted to represent the topsoil and subsoil conditions of each individual soil order. Tables 3.5.1 to 3.5.3 show the results of the SOILOSS modeling for the erosion management scenarios described above. Table 3.5.4 indicates the level of erosion risk associated with the calculated potential soil losses.

¹⁰ Soil erodability factors derived from IECA Best Practice Guideline, 2008. Values represent defined erodibility in loams to clay based soils.

Table 3.5.1 - Estimated soil loss t/ha for pre-development assuming 100m slope length, 0.1 cover factor, P of 1 and a rainfall erosivity factor of 3705¹¹.

Catchment slope	Assumed K factor	Calculated potential soil loss from erosion (t/ha/yr)
Kurosols – clayey sand to sandy clay loam topsoil and a heavy clay to sandy heavy clay subsoil		
5%	0.025	12.5
5%	0.017	8.5
10%	0.025	30.3
10%	0.017	20.6
15%	0.025	60.3
15%	0.017	41.0
20%	0.025	80.4
20%	0.017	54.6
Dermosols – sandy loam to sandy light clay topsoil and a light heavy clay subsoil		
5%	0.030	15.0
5%	0.012	6.0
10%	0.030	36.4
10%	0.012	14.5
15%	0.030	72.4
15%	0.012	28.9
20%	0.030	96.5
20%	0.012	38.6
Sodosols – sandy loam to clay loam topsoil and a sandy medium-heavy clay to heavy clay subsoil		
5%	0.030	15.0
5%	0.017	8.5
10%	0.030	36.4
10%	0.017	20.6
15%	0.030	72.4
15%	0.017	41.0
20%	0.030	96.5
20%	0.017	54.6
Chromosols – sandy clay loam topsoil and a heavy clay subsoil		
5%	0.025	12.5
5%	0.012	6.0
10%	0.025	30.3
10%	0.012	14.5
15%	0.025	60.3
15%	0.012	28.9
20%	0.025	80.4
20%	0.012	38.6
Tenosols – sandy loam to sandy clay loam topsoil and a weathered rock subsoil (<15% clay)		
5%	0.030	15.0
5%	0.050	25.0
10%	0.030	36.4
10%	0.050	60.6
15%	0.030	72.4
15%	0.050	120.6
20%	0.030	96.5
20%	0.050	160.8

¹¹ Rainfall erosivity factor derived from IECA Best Practice Guideline, 2008. Value represents defined erosivity in the wider Brisbane area.

Table 3.5.2 - Estimated soil loss t/ha for development assuming a 100m slope length and no erosion and sediment controls, 0.45 cover factor, P of 1.3 and a rainfall erosivity factor of 3705¹².

Catchment slope	Assumed K factor	Calculated potential soil loss from erosion (t/ha/yr)
Kurosols – clayey sand to sandy clay loam topsoil and a heavy clay to sandy heavy clay subsoil		
5%	0.025	73.1
5%	0.017	49.7
10%	0.025	177.2
10%	0.017	120.5
15%	0.025	352.7
15%	0.017	239.9
20%	0.025	470.3
20%	0.017	319.8
Dermosols – sandy loam to sandy light clay topsoil and a light heavy clay subsoil		
5%	0.030	87.8
5%	0.012	35.1
10%	0.030	212.6
10%	0.012	85.0
15%	0.030	423.3
15%	0.012	169.3
20%	0.030	564.4
20%	0.012	225.8
Sodosols – sandy loam to clay loam topsoil and a sandy medium-heavy clay to heavy clay subsoil		
5%	0.030	87.8
5%	0.017	49.7
10%	0.030	212.6
10%	0.017	120.5
15%	0.030	423.3
15%	0.017	239.9
20%	0.030	564.4
20%	0.017	319.8
Chromosols – sandy clay loam topsoil and a heavy clay subsoil		
5%	0.025	73.1
5%	0.012	35.1
10%	0.025	177.2
10%	0.012	85.0
15%	0.025	352.7
15%	0.012	169.3
20%	0.025	470.3
20%	0.012	225.8
Tenosols – sandy loam to sandy clay loam topsoil and a weathered rock subsoil (<15% clay)		
5%	0.030	87.8
5%	0.050	146.3
10%	0.030	212.6
10%	0.050	354.4
15%	0.030	423.3
15%	0.050	705.5
20%	0.030	564.4
20%	0.050	940.7

¹² Rainfall erosivity factor derived from IECA Best Practice Guideline, 2008. Value represents defined erosivity in the wider Brisbane area.

Table 3.5.3 Estimated soil loss t/ha for development phase assuming 50m slope length, 0.20 cover factor, P of 1.3 and a rainfall erosivity factor of 3705¹³.

Catchment slope	Assumed K factor	Calculated potential soil loss from erosion (t/ha/yr)
Kurosols – clayey sand to sandy clay loam topsoil and a heavy clay to sandy heavy clay subsoil		
5%	0.025	21.9
5%	0.017	14.9
10%	0.025	49.1
10%	0.017	33.4
15%	0.025	93.9
15%	0.017	63.9
20%	0.025	123.3
20%	0.017	83.8
Dermosols – sandy loam to sandy light clay topsoil and a light heavy clay subsoil		
5%	0.030	26.3
5%	0.012	10.5
10%	0.030	58.9
10%	0.012	23.6
15%	0.030	112.7
15%	0.012	45.1
20%	0.030	148.0
20%	0.012	59.2
Sodosols – sandy loam to clay loam topsoil and a sandy medium-heavy clay to heavy clay subsoil		
5%	0.030	26.3
5%	0.017	14.9
10%	0.030	58.9
10%	0.017	33.4
15%	0.030	112.7
15%	0.017	63.9
20%	0.030	148.0
20%	0.017	83.8
Chromosols – sandy clay loam topsoil and a heavy clay subsoil		
5%	0.025	21.9
5%	0.012	10.5
10%	0.025	49.1
10%	0.012	23.6
15%	0.025	93.9
15%	0.012	45.1
20%	0.025	123.3
20%	0.012	59.2
Tenosols – sandy loam to sandy clay loam topsoil and a weathered rock subsoil (<15% clay)		
5%	0.030	26.3
5%	0.050	43.8
10%	0.030	58.9
10%	0.050	98.3
15%	0.030	112.7
15%	0.050	187.8
20%	0.030	148.0
20%	0.050	246.6

¹³ Rainfall erosivity factor derived from IECA Best Practice Guideline, 2008. Value represents defined erosivity in the wider Brisbane area.

Table 3.5.4 Erosion hazard determined by SOILOSS modelling

Soil Loss Class	Calculated soil loss (t/ha/yr)	Erosion Hazard
1	<250	Very Low
2	251 – 300	Low
3	301 – 375	Low to Moderate
4	376 – 500	Moderate
5	501 – 750	High

The qualitative categories of erosion hazard widely used are low, moderate, high, very high and extreme (Houghton and Charman 1986)⁵. The corresponding soil loss quantities for these qualitative categories are presented in the above table; (Rosewell 1993, NSW Department of Housing 1998)¹⁴.

The soil survey and SOILOSS modelling showed that when the site is stripped (prior to placement of controls), all of the five soil orders encountered on the site have moderate erosion hazard at slopes of 15%. The Dermosols, Sodosols and Tenosols have high erosion hazard at slopes $\geq 20\%$.

When soil erosion and sediment management techniques are utilised on site during the construction phase, the erosion hazard is greatly reduced, comparable to pre-disturbance and can be classed as 'very low'.

The following sections detail proposed management measures to minimize erosion and sediment transport during the construction, on-maintenance and operational phases of the proposed development.

¹⁴ Managing Urban Stormwater – Soils and Construction (Blue Book). NSW Department of Housing, (1998).



SCALE
1:25 000



ORIENTATION
NORTH

LEGEND

- Site boundary
- First precinct boundary
- Extent of Data Assessment
- Sodosol
- Sodic Dermosol dispersed Sodosol
- Kurosols and Tenosols of Low Sodicity
- Mixed Tenosol, Kurosol, Sodosol
- Borehole Location

SOURCES

Google Earth Pro 2011

CAIRNS

KAWANA

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5 / 232 Robina Town Centre Dr.
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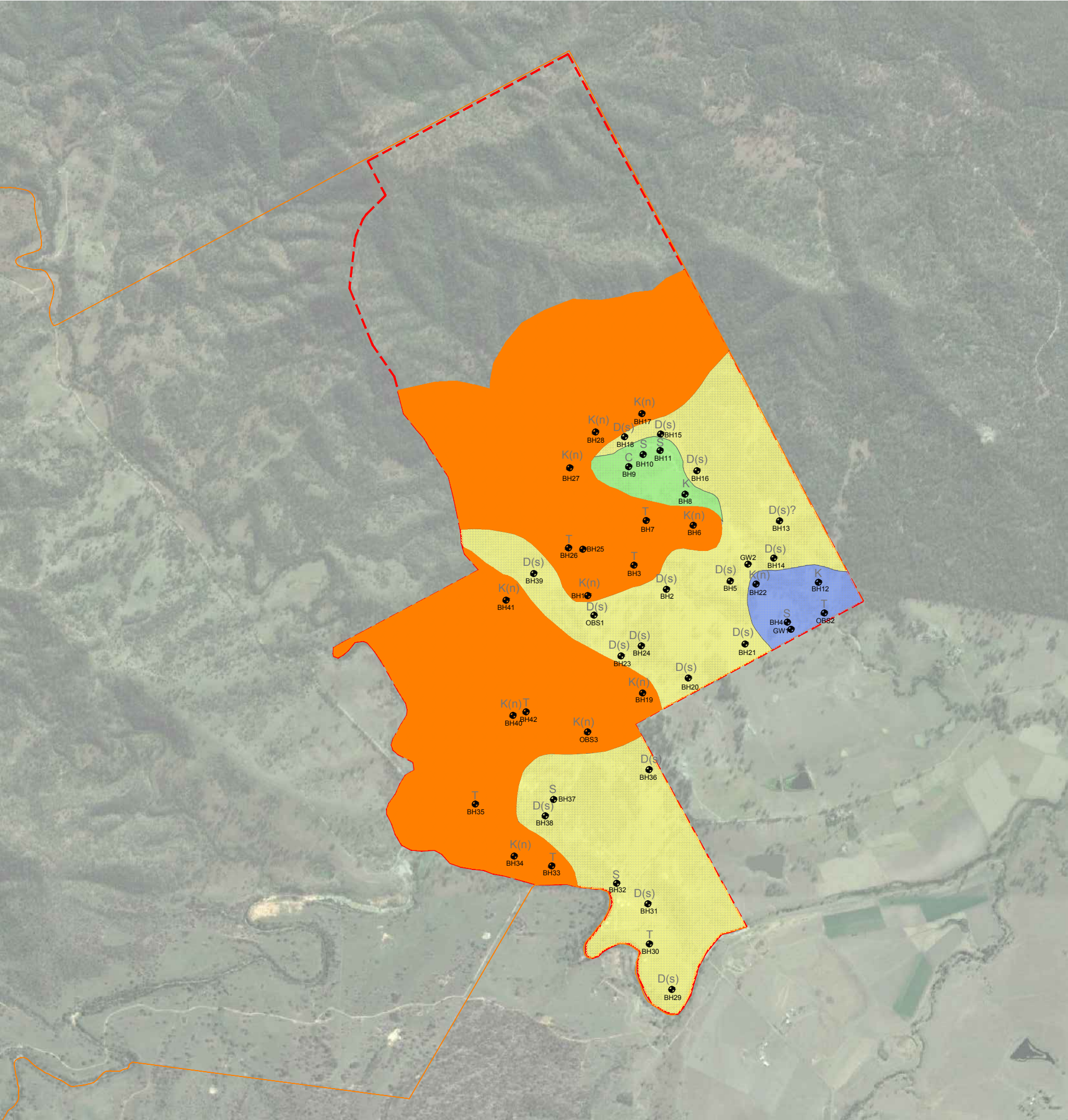
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PROJECT
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CLIENT
PACIFIC INTERNATIONAL
DEVELOPMENT CORPORATION

DRAWING
DISTRIBUTION OF SOIL
ASSOCIATIONS WITHIN FIRST
PRECINCT

DATE
17/08/2012

SCALE
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10922

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REVISION
ORIGIN

4 Dispersive soil management

4.1 Control measures for works within dispersive soils

The management of dispersive soils and the occurrence of tunnel erosion is best achieved through a multi faceted approach. The following sections provide a summary of the recommended approach to dispersive soil management as outlined by the Tasmanian Department of Primary Industries and Water in their Technical Reference Manual for Dispersive Soils Management¹⁵.

4.1.1 Identification and avoidance of dispersive soils

Disturbance of dispersive soils should be avoided wherever possible. Detailed identification of the occurrence of soils throughout the development area should be used to inform the scope of earthworks with disturbance of these subsoils avoided as far as possible.

Soil sampling

The required level of soil sampling is dependent on the depth and area of the proposed land disturbance and the results of preliminary soil testing such as the Emerson Class test.

As noted in Section 3.3, Emerson Class testing at the site indicates that the majority of topsoils tested are non-dispersive. In contrast, the subsoils tested were predominantly highly dispersive with Emerson Classes 1, 2 and 3 dominating the results. In accordance with the IECA Guidelines, 2008 the identified soil properties would necessitate a Level 1 assessment in areas identified as Emerson Class 1 or 2 and a Level 2 Assessment in areas classified as Emerson Class 3. The required borehole intensities based on area of disturbance are provided below.

Table 4.2.1.1 Sample borehole frequencies

Area of site disturbance	Number of boreholes (Level 1 Assessment)	Number of boreholes (Level 2, 3 & 4 Assessments)
<1000m ²	No testing generally required	No testing generally required
Up to 5000m ²	4 holes	2 holes
Up to 1 ha	4 holes	3 holes
1-2 ha	6 holes	4 holes
2-3 ha	8 holes	6 holes
3-4 ha	10 holes	8 holes
>4 ha	5 holes per 2 ha	2 holes per ha

Boreholes should be constructed to a minimum depth of 0.8m, or to 0.5m below the anticipated excavation depth, whichever is deeper.

Borelogs should be recorded at each test site with soil descriptions undertaken in accordance with the Australian Standard AS1726 'Geotechnical site investigations'.

Starting from the existing soil surface, disturbed samples representing the following soil horizons are to be collected from each borehole:

- I. Lower topsoil (i.e. the upper soil layer directly beneath grass root mat – generally the A2 and/or A3 horizon).
- II. Upper and lower subsoils (i.e B-Horizon) if different soil types are identified in the subsoil profile.
- III. Weathered parent rock, if encountered within 1 metre of the expected final surface level (generally the C-Horizon).

¹⁵ Note: Equivalent guidelines have not been developed for Queensland, however the principles of management contained in the Tasmanian guideline are transferable.

The type and number of soil tests required for a detailed analysis of the site's erosion and dispersion potential' and to provide detailed recommendations for soil amelioration, are provided in the following tables:

Table 4.2.1.2 Site assessment test requirements
Level 1 Assessment

Required testing rates	Number of tests
Level 1 Assessment	
Emerson class number (AS1289-3.8.1)	Determined on representative topsoil and subsoil samples – minimum of 1 test from topsoil and subsoil horizon per 2 boreholes (i.e. 8 tests per 8 boreholes)
An accurate visual "soil classification" by a suitably qualified person in accordance with (AS1726)	To be undertaken on each sample
Electrical conductivity & pH (AS1289 – 4.3.1)	To be determined on a representative topsoil sample (i.e. for revegetation assessment) and subsoil sample (minimum of 2 tests for EC and pH per site)
Particle size distribution (AS 1289 – 3.6.1)	To be determined on representative topsoil and subsoil samples (i.e. 1 topsoil and 1 subsoil sample for each different soil profile encountered – minimum 2 tests per site).
Dispersion index (As1289 – 3.8.2) (including PSD (fine) AS1289 – 3.6.3)	To be determined on samples returning Emerson class numbers of 1 or 2 (whichever sample is most dispersive) – minimum of 1 test for each different soil profile encountered per site.

Table 4.2.1.3 Site assessment test requirements
Level 2 Assessment

Required testing rates	Number of tests
Level 2 Assessment	
Emerson class number (AS1289-3.8.1)	Determined on representative topsoil and subsoil samples (minimum of 1 test from topsoil and subsoil horizon for each different soil profile encountered). For consistent profiles, at least 4 tests should be undertaken on soil from 2 different locations (i.e. minimum of 4 per site)
An accurate visual 'soil classification' by a suitably qualified person in accordance with (AS1726)	To be undertaken on each sample.
Electrical conductivity & pH (AS1289 – 4.3.1)	To be determined on a representative upper topsoil sample (i.e. for revegetation assessment) and subsoil sample (minimum 2 tests per site).
Particle size distribution (AS 1289 – 3.6.1)	To be determined on representative topsoil and subsoil samples (i.e. 1 topsoil and 1 subsoil sample for each different soil profile encountered – minimum 2 tests per site).
Dispersion index (AS1289 – 3.8.2) (including PSD (fine) AS1289 – 3.6.3)	To be determined on samples returning Emerson class numbers of 1 or 2 (whichever sample is most dispersive) – minimum of 1 test for each different soil profile encountered per site.

4.1.2 Precise re-compaction.

A high degree of soil compaction reduces soil permeability, thereby restricting the movement of water and dispersed clay through the soil matrix. In this way, soil compaction can reduce the occurrence and severity of dispersion and tunnel erosion.

4.1.3 Chemical amelioration

The application of hydrated lime or gypsum to dispersive soils can be used to reduce the occurrence of dispersion.

Gypsum is the more effective treatment as it increases the electrolyte concentration of the soil as well as displacing sodium with calcium in the soil structure.

Rates of application of hydrated lime or gypsum are likely to vary throughout the site and would be calculated based on the results of soil sampling.

4.1.4 Sand blocks and barriers

Sand filters are used to manage tunnel erosion. They work by trapping entrained sand and silt thereby blocking the exit of the tunnel and preventing continuation of the tunnel. Sand blocks are used to allow water within the profile to rise to the surface and can be used to prevent the re-initiation of existing tunnels.

4.1.5 Burial, application of topsoil and revegetation

Burial of exposed dispersive soil with non-dispersive material such as topsoil minimizes the interaction between water and dispersive clays by providing both a physical and chemical barrier.

This barrier reduces the likelihood of subsoil dispersion and the initiation of tunnel erosion.

In addition to the principles above a range of erosion and sediment controls are recommended by the IECA Guidelines to assist in the management of dispersive soils and the prevention of erosion. Details of ESC measures that are appropriate for use within dispersive soils are provided in the SBMP tables in Section 6. Strategies for the rehabilitation and revegetation of dispersive soils are provided in Section 7.

4.2 Remediation of tunnel erosion

Remediation of existing tunnel erosion is expensive, difficult and can be prone to re-failure. Similarly to the preventative measures outlined in the previous section, existing tunnel erosion is best managed through a combination of mechanical, chemical and vegetative measures. Given the complexity of factors influencing the occurrence of tunnel erosion, rehabilitation works must be considered on a case by case basis in consultation with a suitably qualified soil specialist. General recommendations for the repair of tunnel erosion are provided below;

1. Divert upslope surface water away from the tunnel system using suitably lined catch drains or diversion mounds.
2. Identify the head of the tunnel system to quantify the scale of intervention work required.
3. Tunnel systems should be excavated along their entire flow path using an excavator.
4. If the excavated soils exhibit low to moderate risk of dispersion, then the dispersive soils can be treated using a chemical ameliorant and used to refill the excavated trench.
5. If the soils are highly dispersive, non-dispersive clays will need to be sourced to refill the excavated trench. Chemical ameliorants should be mixed with the non-dispersive materials as an added measure of safety.
6. Repacked materials must be compacted to a minimum of 95% of Proctor maximum ideally using a sheepsfoot roller.
7. Repacked areas should be finished with a convex shape to ensure runoff does not pond on the surface of the rehabilitated area.
8. The upper profile of the repaired work should be treated with gypsum to act as a source of electrolytes for water infiltrating the soil profile.
9. Rehabilitated areas should be topsoiled and revegetated with fast-growing species ensuring adequate fertilizer application for successful establishment.

4.3 Instream works

Without appropriate management, instream works (particularly those within dispersive soils) have the potential to cause widespread disturbance to stream banks and mobilise substantial quantities of bed load sediments into natural waterways. Understanding and managing the geological and ecological processes that occur within natural streams is highly complex and, if poorly managed, can result in additional environmental issues such as weed infestation, alteration of wildlife habitat and increased downstream erosion.

A 'Stream Bank and Bed Erosion Stability Assessment and Conceptual Management Plan' (SBBESA)¹⁶ has been developed for the Flinders, Neighbourhood 1 site. This report includes an assessment of stream characteristics and resultant erosion hazard of the streams located throughout the Neighbourhood 1 development area and conceptual management concepts to optimize the stream stability in this area.

The key management principles when conducting instream works are summarised below:

1. Appropriately plan and organize the work activities.
 - a. Carry out channel maintenance activities only when considered essential.
 - b. Program instream works to minimise harm. Consideration should be given to fish migration periods, aquatic bird nesting and/or migration, and expected weather conditions.
2. Minimise channel disturbance.
 - a. Limit instream disturbance to the minimum area and reach necessary.
 - b. Limit disturbance to existing riparian vegetation. Wherever possible, access the stream channel through a minimum number of narrow access corridors.
- c. Where possible, limit disturbance and access to one side of the stream at any given time.
3. Control the movement of water.
 - a. Divert the overbank inflow of stormwater runoff away from the work area.
 - b. Ensure any overbank flow diversions allow water to enter the channel in a non-erosive manner.
 - c. Divert instream flows around the work area by isolating the disturbance area and/or piping/channeling stream flows around the disturbance.
 - d. Ensure appropriate consideration to fish passage during periods of flow diversion.
4. Minimise soil erosion.
 - a. Avoid unnecessary disturbance.
 - b. Restrict the area of disturbance to as small an area as possible.
 - c. Install appropriate erosion and sediment controls in the vicinity of the works (including upstream and downstream controls).
5. Minimise the release of sediment and sediment-laden water.
 - a. Adopt work practices and procedures that minimise the contamination of water.
 - b. Adopt sediment control techniques that achieve the required treatment standard during the design flow but are also able to produce higher quality discharge during lesser flows.
 - c. Appropriately treat all water contaminated by the work activities.
6. Promptly rehabilitate disturbed areas.
 - a. Actively stabilise and/or rehabilitate stressed and unstable stream banks rather than waiting for natural revegetation.

¹⁶ Gilbert & Sutherland, 2011. 'Stream Bank and Bed Erosion Stability Assessment and Conceptual Management Plan, Proposed Flinders Neighbourhood 1 Development, Undullah Queensland'.

- b. Revegetate with appropriate native plants giving consideration to soil type.
- c. Leave soils in an appropriate condition (i.e. not excessively compacted) that will assist in the quick establishment of vegetation.

Site-specific management options based on the assessment and characterisation of discreet

stream reaches are detailed within the SBBESA report. This Dispersive Soils SBMP and the SBBESA report (and any subsequent amendments) should be viewed concurrently when undertaking any instream works in Precinct 1.

5 SBMP objectives and implementation

5.1 Objectives

The principal objective of this SBMP is to provide mitigation measures to minimise the potential impacts resulting from the disturbance of dispersive (sodic) soils during development of the Flinders site.

The control measures detailed in this SBMP have been developed to minimise impacts on the environment that may result from the disturbance of dispersive soils and to achieve the following objectives:

- Minimise disturbance of dispersive soils
- Track the disturbance of dispersive soils through the implementation of a soil tracking/filing plan
- Prevent the occurrence of tunnel erosion
- Remediate existing tunnel erosion and prevent re-initiation of tunneling
- Minimise transportation of eroded soil in stormwater runoff.

5.2 Implementation

The SBMP requires the Developer to mitigate the potential environmental impacts associated with the construction of the subdivision works.

It is intended that the SBMP will provide a set of performance criteria and guiding principles with which the engineering designs for the development will comply. The plans and specifications forming part of the construction contract for each stage should also include these performance criteria.

This report provides conceptual management measures to control erosion and sediment transport within dispersive soils during the bulk and civil earthworks and throughout a period of landform stabilisation at the site. Whilst this conceptual SBMP provides broad strategies to manage dispersive soils, it is anticipated that a detailed SBMP containing targeted advice for discreet areas of the development would be prepared in support of a future Operational Works application.

This SBMP should be implemented in conjunction with a site specific Erosion and Sediment Control Plan

5.3 SBMP structure

This SBMP acknowledges the environmental impacts associated with the proposed development and details strategies to mitigate them.

Each control strategy is based upon proven environmental management methods in general accordance with the IECA Guidelines, 2008, with each strategy presented as a commitment following the respective management table. The commitments made within this document will form the basis of future assessments, which will be made available to Logan City Council (GCCC) for review.

The SBMP is based on a series of tables supported by reference Drawings included in Appendix 1 for the construction and earthworks phase of the proposed industrial development. The person responsible for the implementation of the measures detailed is written on the table itself. The tables then show the issue, the performance criteria, the implementation strategy, monitoring, auditing, reporting, failure identification and the corrective action. The detachable pages within each section detail the provisions of the SBMP. The format is presented below for reference purposes.

#.# Title

Person responsible	This is the person who has accepted the responsibility of implementing the SBMP provisions detailed on this page.
Issue	The issue with which the table deals.
Operational policy	The operational policy or management objective that applies to the element.
Performance criteria	Performance criteria (outcomes) for each element of the operation.
Implementation strategy	The strategies or tasks (to nominated operational design standards) that will be implemented to achieve the performance criteria.
Monitoring	The monitoring requirements, which will measure actual performance (i.e. specified limits to pre-selected indicators of change).
Auditing	The auditing requirements, which will verify implementation of, agreed construction and operation phase environmental management strategies and compliance with agreed performance criteria.
Reporting	Content, timing and responsibility for reporting and auditing of monitoring results.
Identification of incident or failure	The circumstances under which the agreed performance criteria are unlikely to be met and environmental harm is likely to result.
Corrective action	The action to be implemented in case a performance requirement is not reached and the company(s) responsible for action.

Commitment #

What the management has committed the company to.

An objective of the tabular format is to allow for change and allow the SBMP to be a working document. If items need altering, changes may be made to the individual tables after appropriate consultation with the statutory authorities.

5.4 General commitments

Commitment 1

The Proponent undertakes to comply with the environmental implementation strategy as contained within the approved SBMP on a stage-by-stage basis.

Commitment 2

The Proponent undertakes to fulfil all commitments made in this SBMP and to carry out their activities at the project site in accordance with relevant current statutory requirements and approved amendments.

Compliance with the provisions of this SBMP requires the objectives and management strategies contained herein to be both reasonable and achievable within the context of the approval(s) to which they relate. Incidents and/or failures that involve factors beyond the control of the responsible party(s) and the response and/or corrective actions taken by the responsible party(s) should be considered in assessing compliance with this SBMP.

5.5 Definitions

In this SBMP these terms have the following meanings:

- SBMP means the approved Site Based Management Plan for control of Dispersive Soils and includes any amendments that may be approved from time to time.
- Development means the proposed Flinders subdivision, Undullah, Qld.
- LCC means Logan City Council.
- Proponent means the person undertaking the earthworks and civil works of the proposed development and includes the person nominated by the Proponent as having the responsibility for implementing the provisions of the SBMP.
- DEHP means the Department of Environment and Heritage Protection.

6 Management of dispersive soils – Bulk earthworks and civil construction phase

6.1 Contractor management

Person responsible	Proponent/Site Manager
Issue	Contractor management
Operational policy	To ensure the proponent's Duty of Care is met by ensuring the Contractor is aware of his/her responsibilities under the terms of the SBMP and the <i>Environmental Protection Act (1994)</i> .
Performance criteria	Contractor is fully aware of his/her responsibilities under the terms of the SBMP.
Implementation strategy	- Review of the SBMP and the bulk earthworks and civil construction phase contracts by the Proponent. - Periodic checks to be made by an independent environmental consultant. - Training for construction staff in implementation of SBMP provisions.
Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative. Alternatively, auditing may be carried out by an independent consultant. The audit should include an inspection of site activities, complaints, corrective actions and reporting to assess compliance with the SBMP. Environmental audits shall include a review of training and inductions to ensure that all staff have received adequate guidance and are aware of their responsibilities under the SBMP.
Reporting of monitoring results	A copy of each Audit Report should be provided to LCC upon request. All training records will be recorded, compiled and kept. These documents should be made available to DEHP or other relevant authority upon request.
Corrective action	The Proponent and/or Site Manager has the right to call a halt to any activity being undertaken which is deemed in conflict with the SBMP or has the potential to cause environmental harm. The Site Manager shall ensure that any staff involved with breaches of the SBMP are given further training to ensure the requirements of the SBMP are being met at all times.

Commitment 3

A proactive program of contractor management will be implemented.

6.2 Identification of dispersive soils

Person responsible	Contractor's Site Manager/Environmental Consultant
Issue	Identification of dispersive soils.
Operational policy	To identify the occurrence and distribution of dispersive soils throughout the Precinct 1 area prior to disturbance.
Performance criteria	Dispersive soils are identified and mapped prior to the commencement of works onsite.
Implementation strategy	A 'Level 1' soil sampling program shall be undertaken in areas identified as Emerson Class 1 or 2. As the disturbance area will exceed 4 hectares boreholes shall be constructed at a rate of 5 holes per 2 hectares in accordance with Table 4.2.1.1 A 'Level 2' soil sampling program shall be undertaken in areas classified as Emerson Class 3. As the disturbance area will exceed 4 hectares boreholes shall be constructed at a rate of 2 holes per hectare in accordance with Table 4.2.1.1. Samples shall be collected and analysed for Emerson Class, Electrical Conductivity, pH, Particle Size Distribution and Dispersion index in accordance with the sampling rates specified in Tables 4.2.1.2 and 4.2.1.3. A visual soil classification (by a suitably qualified person) shall be undertaken on each sample. The results of the soil-sampling program shall be used to prepare a detailed map (or maps) of the distribution of dispersive soils throughout the site. This information shall be used by the Site Manager to support a detailed soil-tracking/filling program to ensure the movement of dispersive material around the site is monitored and recorded. Soil amelioration including chemical amendments (e.g addition of lime or gypsum) shall be undertaken following the receipt of laboratory results. These works shall be undertaken in accordance with the recommendations provided by the Environmental Consultant and/or soil laboratory.
Monitoring	Soil sampling shall be undertaken in accordance with the above Implementation Strategy. The Site-Manager shall undertake a detailed soil tracking program throughout the bulk and civil earthworks phases of the development. Records shall be kept in relation to the volumes and location of dispersive soils disturbed during earthworks.
Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative. Alternatively, auditing may be carried out by an independent consultant. The audit should include an inspection of site activities, complaints,

Reporting	corrective actions and reporting to assess compliance with the SBMP.
	A copy of each Audit Report should be provided to LCC upon request.
Identification of incident or failure	Failure to undertake soil sampling at the required frequencies. Failure to adequately map the location of dispersive soils throughout Precinct 1. Failure to prepare or implement an adequate soil tracking program
Corrective action	Undertake soil sampling in accordance with the required frequencies. Prepare/amend dispersive soils map to ensure it is fit for purpose. Prepare/amend the soils tracking program and ensure it is implemented throughout the bulk and civil earthworks phases.

Commitment 4

Soil sampling shall be undertaken prior to the commencement of site disturbance to ensure adequate characterisation of the occurrence of dispersive soils throughout the Precinct 1 area.

6.3 Disturbance of dispersive soils

Person responsible	Contractor's Site Manager
Issue	Disturbance of dispersive soils.
Operational policy	Disturbance of dispersive soils shall be avoided wherever possible.
Performance criteria	Earthworks shall be undertaken with consideration to minimising the disturbance of dispersive soils. For soils identified as 'moderate erosion hazard', land clearing shall be limited to a maximum of 6 weeks' work. For soils identified as 'high erosion hazard', land clearing shall be limited to a maximum of 4 weeks' work.
Implementation strategy	Disturbance of dispersive soils should be avoided wherever possible. Detailed identification of the occurrence of soils throughout the development area should be used to inform the scope of earthworks with disturbance of these subsoils avoided as far as possible. The Site Manager shall track and record the disturbance of dispersive soils throughout the bulk and civil earthworks phases as part of a detailed soil-tracking/filling program. Clearing shall be conducted progressively in a manner that minimises the area of disturbed soil at any time during the works. The area of any disturbance shall be clearly delineated to keep vehicles, building materials and refuse away. Access points onto the site shall be minimised. Vehicle shakedowns shall be utilised to minimise sediment transport onto public roads. All unfinished earthworks should be temporarily stabilised if rainfall is forecast. Topsoil should be stripped only while in a light moisture condition. If the soil is too dry, stripping will pulverize the soil; if too wet, it may lead to clodding or hardsetting. As far as possible, topsoils should not be mixed with subsoils during the stripping and stockpiling procedure. This is especially important in areas of the site containing dispersive soils. Topsoils should be tested for fertility in accordance with the sampling regime outlined in Section 4.1.1 and ameliorated as necessary.

Monitoring	The Site Manager shall track and record the disturbance of dispersive soils throughout the bulk and civil earthworks phases as part of a detailed soil-tracking/filling program. The Contractor's Site Manager shall inspect the perimeter of works on a daily basis to ensure that works do not encroach on 'non-disturbance' areas or the site's perimeters. The Contractor's Site Manager shall monitor all clearing works to ensure that the timeframes listed above (see Performance Criteria) are adhered to.
Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative. Alternatively, auditing may be carried out by an independent consultant. The audit should include an inspection of site activities, complaints, corrective actions and reporting to assess compliance with the SBMP.
Reporting	A copy of each Audit Report should be provided to LCC upon request. Council shall be notified in the event that any clearing or land disturbance occurs in areas outside the site boundary or in areas marked as 'non-disturbance'.
Identification of incident or failure	Failure to track and record the disturbance of dispersive soils as part of a detailed soil tracking/filling program. Failure to separate topsoils from dispersive subsoils. Clearing or disturbance of soils outside of site boundaries or within designated 'non-disturbance' areas.
Corrective action	Commence soil tracking/filling program and ensure adequate records are maintained. Apply chemical ameliorants to topsoil/subsoil stockpile. Reinstate and revegetate over-cleared areas or provide suitable temporary stabilisation if the area is to be used for future development stages.

Commitment 5

Disturbance of dispersive soils shall be minimised wherever possible. Where disturbance is unavoidable, a soil tracking/filling program shall be implemented to track the locations and quantities of disturbed soils.

6.4 Erosion controls for areas containing dispersive soils

Person responsible	Contractor's Site Manager
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Issue	Erosion controls to be implemented in areas containing dispersive soils.
Operational policy	To prevent the occurrence of erosion including tunnel erosion in dispersive soils.
Performance criteria	No visual indication of soil erosion during the bulk and civil earthworks or construction phases of the development. Prevention of the occurrence of tunnel erosion. Remediation of existing areas of tunnel erosion.
Implementation strategy	Where possible, the construction program shall be scheduled to minimise the disturbance of dispersive soils. Erosion and sediment control devices shall be installed prior to commencement of work on site in accordance with the IECA Guidelines, 2008 and an approved site specific Erosion and Sediment Control Plan (ESCP). In areas of the site containing dispersive soils, this plan shall be implemented in conjunction with the approved ESCP. No site disturbance shall commence until the appropriate approvals have been obtained. Upslope 'clean' runoff from undisturbed or off-site areas shall be diverted away from disturbed areas by way of lined clean water diversion channels. Final grade shall be established as soon as practical in disturbed areas to maintain drainage and to minimize ponding and infiltration of stormwater. Clean water diversion channels shall be located upslope of exposed dispersive soils in a way which minimises the upslope catchments, diverts upslope runoff away from dispersive soils and conveys waters to a legal point of discharge. All drainage channels constructed into dispersive soils shall be lined with a minimum of 200mm of non-dispersive soil and lined with an appropriate channel liner. Channel liners shall be determined based on an assessment of catchment size, slope, channel length and the design rainfall event. Check dams must not be used to control erosion within drains formed in dispersive soils. In circumstances where the use of check dams is unavoidable. The drain shall be lined with non-dispersive soil and lined with an appropriate channel liner prior to the placement of check dams. Where disturbance of dispersive soils is unavoidable, disturbed soils should be compacted using a sheepsfoot roller at 1.5 to 2% above optimum moisture content,¹⁷ to minimize the occurrence of tunnel erosion. Water added to the soil (during compaction or for dust suppression) shall be analysed to ensure no additional sodium salts are added to the soil. If the

¹⁷ Bell, F.G., Bryun, I.A. (1997). Sensitive, expansive, dispersive and collapsive soils. Bulletin of the International Association of Engineering Geology 56, 19-38.

water used for soil wetting is identified as 'sodic' additional gypsum must be added to the soils (at a calculated rate), to ensure the calcium load is sufficient to mitigate the sodicity in the soil and water combined.

Compaction and grading of exposed dispersive soils shall be undertaken in a manner that minimizes the potential for ponding of stormwater.

Erosion control measures shall be maintained at operational capacity until disturbed land is effectively rehabilitated.

Temporary erosion measures (e.g. straw bales, sediment fences, parallel to site slopes) are to be employed onsite during construction, where deemed necessary based on an assessment of slope and soil type. Such measures shall be maintained at or above their design capacity. Such measures should be in accordance with the recommendations in the IECA Guidelines, 2008.

If straw bales are to be utilised onsite and are to remain in place for longer than 1 day, bales must be wrapped with filter cloth. Hay or lucerne bales must not be used.

Stockpiling onsite will be minimised where possible. If stockpiles containing dispersive soils are to remain in place for longer than 28 days, these shall be stabilised using mulch, vegetative cover, chemical stabilisers or impervious blankets.

Methods for incorporating gypsum into dispersive soils (either insitu or stockpiled) shall be assessed on a case-by-case basis taking into consideration the dispersivity of the soils, timeframe of exposure and available area for materials handling. Mixing methods shall be chosen in consultation with a suitably qualified soil specialist and may include;

- Incorporation of the calculated quantity of gypsum into stockpiled soils using a loader or similar earth moving equipment. Materials shall be mixed as thoroughly as practicable.
- Application of a layer of gypsum to insitu soils with no or minimal mixing.

The following table provides a matrix of suitable erosion control applications for various slope attributes, from relatively flat ground up to slopes with grades of greater than 1 in 4. Dispersive soils should be covered with a minimum 200mm layer of non-dispersive soil before application of these erosion controls;

Flat land (slopes of less than 1 in 10)	Mild slopes (1 in 10 up to 1 in 4)	Steep slopes (steeper than 1 in 4)
Erosion control blankets	Bonded fibre matrix	Bonded fibre matrix
Gravelling	Compost Blankets	Cellular Confinement Systems
Mulching	Erosion Control Blankets, mats and	Compost Blankets

		Mesh	
	Revegetation	Mulching, well anchored	Erosion Control Blankets, Mats and Mesh
	Rock mulching	Revegetation	Revegetation
	Soil Binders	Rock Mulching	Rock Armouring
	Turfing	Turfing	Turfing
Monitoring	Site Manager to conduct visual inspections weekly and following rainfall events to verify that control measures are in place and properly maintained.		
Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative. Alternatively, auditing may be carried out by an independent consultant. The audit should include an inspection of site activities, complaints, corrective actions and reporting to assess compliance with the SBMP.		
Reporting	A copy of each Audit Report should be provided to LCC upon request.		
Identification of incident or failure	Channels installed directly into dispersive soils. Signs of erosion including tunnel erosion on site. Damaged or failed erosion control devices. Ponding of stormwater on exposed sodic soils. The use of sodic waters for compaction and/or dust suppression without appropriate chemical amelioration of the soils.		
Corrective action	Re-install drainage channels applying a layer of non-dispersive soil and appropriate channel lining. Remediate areas of erosion in accordance with this plan and apply erosion controls to prevent a reoccurrence. Maintain or replace ineffective ESC devices. Immediately drain ponded waters to a sediment basin. Apply chemical ameliorants to the affected soils in consultation with the Environmental Consultant.		

Commitment 6

Dispersive soils and drainage shall be managed to ensure the occurrence of erosion is prevented/minimised wherever possible.

6.5 Sediment controls for areas containing dispersive soils

Person responsible	Contractor's Site Manager
Issue	Sediment Control
Operational policy	To prevent the displacement of sediment across and off site during storm events.
Performance criteria	Offsite discharges are to comply with the specified water quality release criteria. Sediment control structures are to be well maintained and free of excessive accumulated sediment.
Implementation strategy	All sediment control measures and facilities must be installed and stabilised prior to the commencement of site disturbance. No site disturbance shall commence until the appropriate approvals have been obtained. Wherever possible, surface waters from undisturbed lands shall be diverted away from construction areas using appropriately sized and lined clean water diversion channels. Where sediment basins are required and the contributing catchment contains greater than 10% dispersive soils a type D sediment basin should be installed. These basins are required for the treatment of dispersive soils that do not readily settle without the use of flocculating agents. Sediment detention basins and clean-water diversion channels shall be constructed prior to site disturbance in general accordance with the reference drawings included in Appendix 1. Sediment shall be removed from sediment basins when accumulated sediment volumes reach 70%. Removed materials must be disposed of in a manner that does not cause pollution. Sediment basins shall be dosed with gypsum, when required, to ensure that discharge water quality meets required limits. Dosing should be undertaken in general accordance with the following; 1. Place required quantity of gypsum (e.g. 32kg/100m³ of water) in an approximately 50L drum, perforated with 25mm holes spaced at 150mm intervals. 2. Suspend the screened, recirculating pump intake into the drum. 3. Lift the drum into the basin in such a way that basin water can enter and circulate through the drum. 4. Using the pump, spray the gypsum rich solution evenly over the surface of the basin until the gypsum is fully removed from the drum. The pump outlet must spray the mixture over a wide area rather than discharging as a confined jet.

	Level markers shall be installed within all sediment ponds. Temporary sediment control measures (e.g. sediment fences) are to be employed onsite during construction, where deemed necessary from an assessment of slope and soil type. Such measures should be in accordance with the IECA Guidelines, 2008. Sediment fences are to be replaced when damaged or permanently blocked. Sediment controls are required outside the construction site: • Where increased stormwater runoff is likely to accelerate erosion of any downstream watercourse. • To ensure all immediate downstream drainage inlets shall have appropriate controls installed. • In order to maintain existing surface water conditions outside the construction area (wherever possible).
Monitoring	Site Manager to conduct visual inspections on a weekly basis and following significant rainfall events to verify that control measures are in place and properly maintained. Surface water quality to be monitored monthly and during rainfall events (refer to table titled 'Surface Water Quality – Bulk earthworks and civil construction phase' which details monitoring of surface water and stormwater quality including during storm events).
Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative. Alternatively, auditing may be carried out by an independent consultant. The audit should include an inspection of site activities, complaints, corrective actions and reporting to assess compliance with the SBMP.
Reporting	A copy of each Audit Report should be provided to LCC upon request. Results and interpretation of monthly and rainfall event-based water quality monitoring are to be compiled with reports submitted to LCC on a monthly basis (or allowing sufficient time for receipt of laboratory analyses).
Identification of incident or failure	Declining water quality as identified by water quality monitoring. Failure to remove accumulated sediment from control structures. Release of sediment from site into receiving waterways or onto adjacent properties.
Corrective action	Apply remedial measures to improve sediment control measures, for example; • Sediment fences and flocculation of sedimentation ponds. • Maintain or replace ineffective ESC devices. • Add further controls in consultation with environmental consultant or supervising engineer.

Commitment 7

Best management practices will be implemented throughout the construction works to minimise sediment transport offsite.

6.6 Surface water quality management

Person responsible	Contractor's Site Manager, Environmental Consultant																	
Issue	Surface water controls																	
Operational policy	To maintain the water quality conditions of the receiving waters during the bulk earthworks and construction phases of the development.																	
Performance criteria	All controlled water discharges from the site will comply with specified water quality release criteria.																	
Implementation strategy	Sediment basins and clean-water diversion channels will be constructed prior to the commencement of earthworks. Stormwater control will be achieved by directing as much runoff as practicable from disturbed areas to the sediment basins. Wherever possible, surface waters from undisturbed lands shall be diverted away from construction areas using appropriately sized and lined clean water diversion channels. Monitoring of the sediment basins for compliance with the specified release criteria will take place prior to any discharge of stormwater (controlled or uncontrolled) from the site. Where water quality fails to meet the established criteria, corrective measures will be undertaken (e.g. if sediment problems are identified, settling in the sediment ponds shall be aided by dosing with flocculation agents) to achieve compliance with the water quality release criteria. Treated water is to be re-tested prior to release, in order to establish the effectiveness of treatment measures.																	
Monitoring	Surface water monitoring will be conducted monthly and following the first monthly rainfall event (defined as a rainfall of more than 25mm over a 24-hour period) for pH, EC, Turbidity, Suspended Solids, Dissolved Oxygen and Oil or Grease. The release criteria shall be as defined below or shall be set based on background conditions as established by pre-construction water quality monitoring. <table><thead><tr><th>Water Quality Parameter</th><th>Release Criteria</th><th>Criteria Type</th></tr></thead><tbody><tr><td>pH</td><td>6.5 – 9.0</td><td>Range</td></tr><tr><td>Turbidity</td><td>50NTU</td><td>Maximum</td></tr><tr><td>Dissolved Oxygen</td><td>>6mg/L</td><td>Minimum</td></tr><tr><td>Suspended Solids</td><td><50mg/L</td><td>Maximum</td></tr></tbody></table>			Water Quality Parameter	Release Criteria	Criteria Type	pH	6.5 – 9.0	Range	Turbidity	50NTU	Maximum	Dissolved Oxygen	>6mg/L	Minimum	Suspended Solids	<50mg/L	Maximum
Water Quality Parameter	Release Criteria	Criteria Type																
pH	6.5 – 9.0	Range																
Turbidity	50NTU	Maximum																
Dissolved Oxygen	>6mg/L	Minimum																
Suspended Solids	<50mg/L	Maximum																
Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative. Alternatively, auditing may be carried out by an independent consultant. The audit should include an inspection of site activities, complaints,																	

Reporting	corrective actions and reporting to assess compliance with the SBMP.
	A copy of each Audit Report should be provided to LCC upon request. Results and interpretation of monthly and rainfall event-based water quality monitoring are to be compiled with reports submitted to LCC on a monthly basis (or allowing sufficient time for receipt of laboratory analyses).
Identification of incident or failure	Failure to meet the surface water release criteria prior to discharge of contained water.
Corrective action	If the pH of surface water does not comply with the release criteria range, then such waters will be contained and the pH adjusted to within the range prior to release. If the level of total suspended solids exceeds the release criteria for this parameter, then water will be contained on site for a period sufficient to allow suspended solids to settle out or be treated with a flocculant, prior to discharge. Erosion and sediment control devices will be immediately inspected and cleaned if necessary. Additional devices will be installed if necessary to prevent future breaches of the suspended solids criteria. The placement of stockpiles and management of disturbed areas will be reviewed with regard to sediment and erosion control.

Commitment 8

Surface water quality at the discharge points will be maintained during the construction works in accordance with the specified water quality release criteria.

6.7 Remediation of existing tunnel erosion

Person responsible	Contractor's Site Manager, Environmental Consultant
Issue	Remediation of existing tunnel erosion.
Operational policy	Areas of existing tunnel erosion shall be remediated in manner that minimises the risk of re-failure.
Performance criteria	Existing tunnel erosion is remediated
Implementation strategy	Given the complexity of factors influencing the occurrence of tunnel erosion, rehabilitation works must be considered on a case-by-case basis in consultation with a suitably qualified soil specialist. General recommendations for the repair of tunnel erosion are provided below; The head of the tunnel system shall be identified by a suitably qualified soil specialist, to quantify the scale of intervention works required. Upslope runoff shall be diverted away from existing tunnel systems using suitably sized and lined catch drains or diversion mounds. Identified tunnel systems shall be excavated along their entire flow path using an excavator. Excavated soils shall either be retained for amelioration or disposed of offsite. If the excavated soils exhibit low to moderate risk of dispersion, then the dispersive soils shall be treated using a chemical ameliorant and used to refill the excavated trench. Treatment rates shall be determined through soil sampling and laboratory analyses. If the excavated soils are highly dispersive, non-dispersive clays will need to be sourced to refill the excavated trench. Chemical ameliorants should be mixed with the non-dispersive materials as an added measure of safety. Methods for incorporating gypsum into dispersive soils (either insitu or stockpiled) shall be assessed on a case-by-case basis taking into consideration the dispersivity of the soils, timeframe of exposure and available area for materials handling. Mixing methods shall be chosen in consultation with a suitably qualified soil specialist and may include; • Incorporation of the calculated quantity of gypsum into stockpiled soils using a loader or similar earth moving equipment. Materials shall be mixed as thoroughly as practicable. • Application of a layer of gypsum to insitu soils with no or minimal mixing. Sand blocks shall be implemented in designated areas to promote the movement of water out of the soil profile and prevent the re-initiation of existing tunnel erosion. Repacked materials must be compacted to a minimum of 95% of Proctor maximum ideally using a sheepsfoot roller. Repacked areas should be finished with a convex shape to ensure runoff

Auditing	does not pond on the surface of the rehabilitated area. The upper profile of the repaired work shall be treated with gypsum to act as a source of electrolytes for water infiltrating the soil profile. Rehabilitated areas should be topsoiled and revegetated with fast-growing species ensuring adequate fertilizer application for successful establishment. Further guidance on revegetation is provided in Table 6.9.
	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative. Alternatively, auditing may be carried out by an independent consultant. The audit should include an inspection of site activities, complaints, corrective actions and reporting to assess compliance with the SBMP. Environmental audits shall include a review of training and inductions to ensure that all staff have received adequate guidance and are aware of their responsibilities under the SBMP.
	A copy of each Audit Report should be provided to LCC upon request. All training records will be recorded, compiled and kept. These documents should be made available to DEHP or other relevant authority upon request.
	Failure of remediation works and re-initiation of tunnel erosion.
Reporting	
Identification of incident or failure	
Corrective action	Consult a suitably qualified soil specialist for advice on further remediation.

Commitment 9

Existing tunnel erosion shall be remediated in a manner that prevents its reoccurrence.

6.8 Dust management

Person Responsible	Contractor's Site Manager
Issue	Dust movement offsite is to be kept to a minimum.
Operational policy	Acceptable air quality standards will be achieved by minimising the movement of dust offsite from site works.
Performance criteria	The target level for complaints by nearby residents is no more than one in any seven day period. Ambient air quality should not deteriorate by more than 30% over a period of seven consecutive days. Dust deposition at any nearby residence should not exceed 100µg/m ² /day.
Implementation strategy	Soil disturbance and clearing shall be undertaken in a staged and controlled manner to limit the areas exposed at any one time in accordance with Table 6.1. In areas identified as 'moderate erosion hazard' disturbed soil surfaces shall be stabilised with minimum 70% cover within 20 days of completion of works within any area of a work site. In areas identified as 'high erosion hazard' disturbed soil surfaces shall be stabilised with minimum 70% cover within 10 days of completion of works within any area of a work site. In areas identified as 'high erosion hazard' soil stockpiles and unfinished earthworks must be suitably stabilised if disturbance is expected to be suspended for a period exceeding 10 days. Stockpiling onsite will be minimised where possible. If stockpiles containing dispersive soils are to remain in place for longer than 28 days, these shall be stabilised using mulch, vegetative cover, chemical stabilisers or impervious blankets. Ground surfaces will be kept damp (not wet). Surfaces shall be left in a rough cloddy condition to increase roughness and slow surface wind speed. An on-site water cart will be available at all times. All work to cease if wind speed exceeds 10m/sec. Traffic movement on any disturbed areas shall be minimised. Protective ground covers shall be provided, including mulches, vegetation, organic binders or dust retardants with consideration to Table 6.2.1 below;

Table 6.2.1 – Treatment options to aid dust suppression

Site condition	Treatment options							
	Permanent vegetation	Mulching	Watering	Soil binders	Gravel road	Stabilised access pad	Haul truck covers	Minimise site disturbance
Area not subject to traffic	✓	✓	✓	✓				✓
Area subject to traffic			✓	✓	✓	✓		✓
Stockpiles			✓	✓				✓
Clearing/excavations			✓	✓				✓
Unpaved roads			✓	✓	✓	✓	✓	
Earth transport					✓	✓		

Note: Table reproduced from the IECA Guidelines, 2008, Book 1.

Monitoring

Daily inspections will be carried out to verify that dust mitigation measures are being implemented. Dust monitoring will be conducted upon receipt of complaints by residents. If dust monitoring is to take place, the following will occur:

- Temporary dust deposition gauges will monitor the movement of dust offsite at the nearest residences adjacent to the proposed stages and within the predominant wind directions (2008).
- Monitoring will be undertaken in accordance with AS 3580.10.1 (2003).

Auditing

Auditing will be undertaken by the site manager and/or the proponent's nominated representative.

Alternatively, auditing may be carried out by an independent consultant. The audit should include an inspection of site activities, complaints, corrective actions and reporting to assess compliance with the SBMP.

Reporting

Complaints by residents are to be recorded in a Complaints Register.

The Site manager is to examine the Complaints Register weekly and review corrective action taken.

The contractor to notify DEHP of a possible environmental nuisance on receipt of 3 or more dust complaints in any 24 hour period.

Identification of incident or failure

Any dust-related complaints by residents will indicate a failure of the dust control measures.

Corrective action	Locate the source of the dust and implement the following measures: • Cease the dust creating activity until mitigation measures to reduce dust emissions have been applied; • Apply appropriate dust suppression measure with reference to Table 6.2.1 above. • Cease the dust creating activities if dust persists.
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Commitment 10

Dust generated during the construction works will be managed to ensure that dust movement offsite is controlled.

6.9 Rehabilitation and landscaping within dispersive soils

Person responsible	Proponent/Proponent's nominated representative								
Issue	Rehabilitation and landscaping								
Operational policy	Landscaping, stabilisation and revegetation of completed areas to minimise soil erosion and sediment transport.								
Performance criteria	No sediment transport or erosion within completed areas.								
Implementation strategy	Progressive stabilisation and revegetation of completed areas. The landscaping and rehabilitation program shall be timed to ensure that minimal delays occur between final land shaping and permanent rehabilitation. If soil adjustments (e.g. the addition of gypsum or lime) are required (based on soil testing in accordance with Section 4.2.1), these shall be undertaken in accordance with the guidance provided with the soil testing results. All dispersive soils should be buried under a layer of non-dispersive soil before the final surface treatment (e.g. grass seeding, turfing, concrete) is applied. The minimum thickness of the non-dispersive soil layer shall be between 50mm to 300mm depending on the level of ongoing exposure to erosion risks. A minimum cover of 100mm shall be achieved on gentle slopes and 200mm on steep slopes. If sufficient quantities of non-dispersive soils are not available, sufficient quantities of dispersive soil shall be ameliorated through the mixing of gypsum throughout the soil. Dispersive subsoil should not be directly seeded, or covered with Erosion Control Blankets and seeded. A layer of non-dispersive topsoil should be placed over the dispersive soil prior to the commencement of revegetation works. In areas where topsoiling is to be undertaken on moderate to steep slopes, cellular confinement systems may be used to ensure topsoil remains in place and improve the success of seeding and planting works. In areas where slopes are too steep to allow successful placement of topsoil, a compost blanket may be used to assist in stabilisation of the slope and to promote revegetation. The following table should be used to guide the selection of plants for rehabilitation of areas of the site exhibiting erosion or that may be subject to erosive forces following the completion of works. Table 6.9.1 Plant selection for the control of erosion <table><tr><th>Erosion form</th><th>Primary vegetation</th><th>Secondary vegetation</th><th>Comments</th></tr><tr><td>Sheet erosion</td><td>Ground covers, grasses</td><td></td><td>Non clumping, continuous ground cover is required</td></tr></table>	Erosion form	Primary vegetation	Secondary vegetation	Comments	Sheet erosion	Ground covers, grasses		Non clumping, continuous ground cover is required
Erosion form	Primary vegetation	Secondary vegetation	Comments						
Sheet erosion	Ground covers, grasses		Non clumping, continuous ground cover is required						

	Rill erosion	Ground covers, grasses		Non clumping, continuous ground cover is required
	Gully erosion	Ground covers, vetiver grass	Trees, shrubs, woody debris	Vetiver grass can be used to form a vegetative sediment barrier Trees and shrubs may be required for bank stability.
	Tunnel erosion			Stabilisation of soil and control of water pathways are of primary importance. Avoid deep-rooted or short-lived plants on water impoundment embankments.
	All temporary erosion and sediment control works are to be removed once works are complete and revegetation is successfully established in formerly disturbed areas.			
Monitoring	Weekly inspections shall be carried out on completed areas to assess the success of revegetation works.			
Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative. Alternatively, auditing may be carried out by an independent consultant. The audit should include an inspection of site activities, complaints, corrective actions and reporting to assess compliance with the SBMP.			
Reporting of monitoring results	A copy of each Audit Report should be provided to LCC upon request.			
Identification of incident or failure	Plant death or the occurrence of erosion in finalised areas.			
Corrective action	Test topsoil if revegetation works have been unsuccessful, to determine the possible problem. Review procedures in consultation with landscape architect and/or horticulturalist. Remediate any areas of soil erosion.			

Commitment 11

Best management practices will be implemented throughout the landform stabilisation phase to minimise sediment transport offsite and promote rapid stabilisation of disturbed areas.

7 Administration of the SBMP

7.1 Amendment of the SBMP

The Developer may make an application to LCC to amend the provisions of this SBMP. The application shall:

- be in writing; and
- specify the provisions of the SBMP to which the application relates; and
- state how the proposed amendments achieve the objectives of the provisions to which the amendments relate.

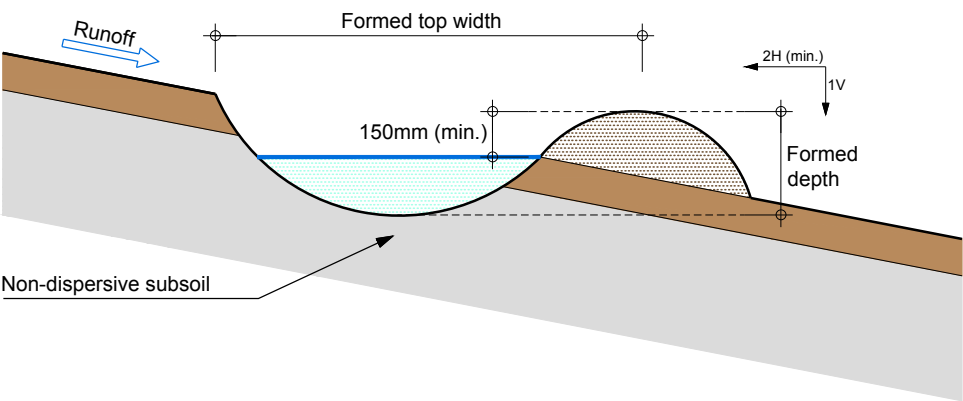
LCC shall approve the amendment where LCC is satisfied acting reasonably that the proposed amendments achieve the objective of the provisions to which the amendment relates.

7.2 Incident management

The Developer and any person appointed by the Developer as having responsibility for a control strategy set out in this SBMP have clearly defined responsibilities under the Qld *Environmental Protection Act* (1994) to report any incidents likely to cause material or serious environmental harm.

8 Appendix 1 – Reference drawings

PARABOLIC CATCH DRAIN WITH DOWN-SLOPE BANK

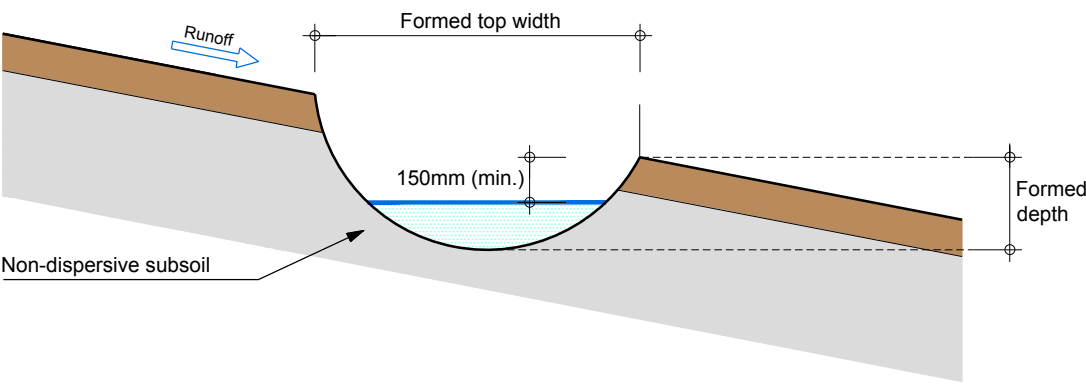


CONSTRUCTED DIMENSIONS OF PARABOLIC CATCH DRAINS		
Drain type	Formed top width with or without bank	Formed depth with or without bank
Type-A	1.60m	0.30m
Type-B	2.40m	0.45m
Type-C	3.60m	0.65m

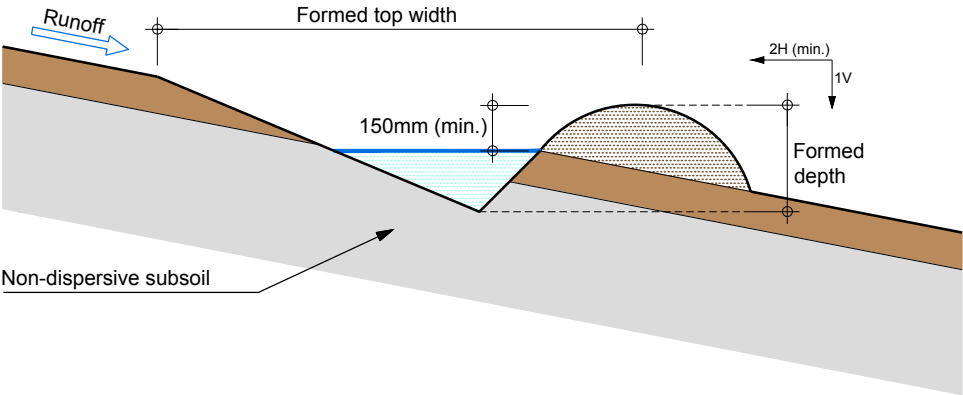


Source:
Base text and schematics reproduced from IECA 2008, Best Practice Erosion and Sediment Control, International Erosion Control Association (Australasia), Piction NSW, Book 6

PARABOLIC CATCH DRAIN WITHOUT BANK



TRIANGULAR V-DRAIN WITH DOWN-SLOPE BANK



CONSTRUCTED DIMENSIONS OF TRIANGULAR V- DRAINS		
Drain type	Formed top width with or without bank	Formed depth with or without bank
Type-AV	2.00m	0.30m
Type-BV	2.70m	0.45m
Type-CV	3.90m	0.65m

CATEGORY
DRAINAGE CONTROL
TECHNIQUES

SUB-CATEGORY
CATCH DRAINS
AND CHUTES

DRAWING
CATCH DRAIN TYPES

SCALE
NTS
DRAWN
SPD
CHECKED
CMA

DRAWING NO
CDC.1

INSTALLATION

1. Refer to approved plans for location, extent, and construction details. If there are questions or problems with the location, extent or method of installation, contact the engineer or responsible on site officer for assistance.
2. Ensure all necessary soil testing (e.g. soil pH, nutrient, levels) and analysis have been completed, and required soil adjustment performed prior to planting
3. Clear the location for the catch drain, clearing only what is needed to provide access for personnel and equipment for installation.
4. Remove roots, stumps and other debris and dispose of them properly. Do not use debris to build the bank.
5. Grade the drain to the specified slope and form the associated embankment with compacted fill. Note that the drain invert must fall 10cm every 10m for each 1% of required channel gradient.
6. Ensure the sides of the cut drain are not steeper than a 1.5:1 (H:V) slope and the embankment fill slope no steeper than 2:1.
7. Ensure the completed drain has sufficient depth (as specified for the type of drain) measured from the drain invert to the top of the embankment. Where necessary, cut the drain slightly deeper than that specified on the plans such that the correct channel dimensions are achieved following placement of the turf.
8. Ensure the drain has a constant fall in the desired direction free of obstructions.
9. Turf should be used within 12 hours of delivery, otherwise ensure the turf is stored in conditions appropriate for the weather conditions (e.g. a shaded area).
10. Moistening the turf after it is unrolled will help maintain its viability.
11. Turf should be laid on a minimum 75mm bed of adequately

fertilised topsoil. Rake soil surface to break the crust just before laying the turf.

12. During the warmer months, lightly irrigate the soil immediately before laying the turf.

13. Ensure the turf is not laid on gravel, heavily compacted soil, or soils that have been recently treated with herbicide.

14. For wide drains and high velocity chutes, lay the first row of turf in a straight line diagonal to the direction of flow. Stagger subsequent rows in a brick-like (stretcher bond) pattern. The turf should not be stretched or overlapped. Use a knife or sharp spade to trim and fit irregularly shaped areas.

15. For narrow drains, lay the turf along the direction of the drain, ensuring, wherever practicable, that a longitudinal joint between two strips of turf is not positioned along the invert of the drain.

16. Ensure the turf extends up the sides of the drain at least 100mm above the elevation of the channel invert, or at least to a sufficient elevation to fully contain expected channel flow.

17. On channel gradients of 3:1 (H:V) or steeper, or in situations where high flow velocities (i.e. velocity > 1.5m/s) are likely within the first 2 weeks following placement, secure the individual turf strips with wooden or plastic pegs.

18. Ensure that intimate contact is achieved and maintained between the turf and the soil such that seepage flow beneath the turf is avoided.

19. Water until the soil is wet 100mm below the turf. Thereafter watering should be sufficient to maintain and promote healthy growth.

20. Ensure the drain discharges to a stable outlet such that down-slope soil erosion will be prevented from occurring. Ensure the drain does not discharge to an unstable fill slope.

REMOVAL

1. When the soil disturbance above the catch drain is finished and the area is stabilised, the temporary drain and any associated banks should be removed, unless it is to remain as a permanent drainage feature.
2. Dispose of any sediment or earth in a manner that will not create an erosion or pollution hazard.
3. Grade the area and smooth it out in preparation for stabilisation.
4. Stabilise the area by grassing or as specified within the approved site rehabilitation plan.

INSTALLATION: drain formation

1. Refer to approved plans for location, extent, and construction details. If there are questions or problems with the location, extent or method of installation, contact the engineer or responsible site officer for assistance.
2. Clear the location for the catch drain, clearing only what is needed to provide access for personnel and equipment for installation.
3. Remove roots, stumps and other debris and dispose of them properly. Do not use debris to build the bank.
4. Grade the drain to the specified slope and form the associated embankment with compacted fill. Note that the drain invert must fall 10cm every 10m for each 1% of required channel gradient.
5. Ensure the sides of the cut drain are not steeper than a 1.5:1 (H:V) slope and the embankment fill slope no steeper than 2:1.
6. Ensure the completed drain has sufficient depth (as specified for the type of drain) measured from the drain invert to the top of the embankment.
7. Ensure the drain has a constant fall in the desired direction free of obstructions.
8. Ensure the drain discharges to a stable outlet such that soil erosion will be prevented from occurring. Ensure the drain does not discharge to an unstable fill slope.

INSTALLATION: mat placement

The method of mat installation varies with the type of mat. Installation procedure should be provided by the manufacturer or distributor of the product. A typical installation procedure is described below, but should be confirmed with the product manufacturer or distributor.

1. Erosion control mats must be stored away from direct sunlight or covered with ultraviolet light protective sheeting until the site is ready for their installation.

2. Vehicles and construction equipment must not be permitted to manoeuvre over the geotextile unless it has been covered with a layer of soil or gravel at least 150mm thick. Fill material shall not be mixed over the geotextile.
3. If the channel is to be grassed prepare a smooth seed bed of approximately 75mm of topsoil, seed, fertilise, water and rake to remove any remaining surface irregularities.
4. Excavate a 300mm deep by 150mm wide anchor trench along the full width of the upstream end of the area to be treated.
5. At least 300mm of the mat must be anchored into the trench with the roll of matting resting on the ground up-slope of the trench.
6. Staple the fabric within the trench at 200 to 250mm spacing using 100mm wide by 150mm penetration length U-shaped, 8 to 11 gauge wire staples. Narrower U-sections may easily tear the matting when placed under stress.
7. When all mats have been anchored within the trench across the full width of the treated area, then the trench is backfilled and compacted. The mats are then unrolled down the slope such that each mat covers and protects the backfilled trench.
8. When spreading the mats, avoid stretching the fabric. The mats should remain in good contact with the soil.
9. If the channel curves, then suitably fold (in a downstream direction) and staple the fabric to maintain the fabric parallel to the direction of channel flow.
10. Staple the surface of the matting at 1m centres. On irregular ground, additional staples will be required wherever the mat does not initially contact the ground surface.
11. At the end of each length of mat, a new trench is formed 300mm up-slope of the end of the mat such that the end of the mat will be able to fully cover the trench. A new roll of matting is then anchored within this trench as per the

first mat. After this new mat has been unrolled down the slope, the up-slope mat can be pinned in place fully covering the new trench and at least 300mm of the down-slope mat. The process is continued down the slope until the desired area is fully covered.

12. In high-velocity channels, intermediate anchor slots are usually required at 10m intervals down the channel.
13. Anchor the outer most edges (top and upper most sides) of the treated area in a 300mm deep trench and staples at 200 to 250mm centres,
14. If the channel was grass seeded prior to placement of the mats, then the mat should be rolled with a suitable roller weighing 60 to 90kg/m², then watered.
15. The installation procedure must ensure that the mat achieves and retain good contact with the soil.
16. Damaged matting must be repaired or replaced.

ADDITIONAL INSTRUCTIONS FOR THE INSTALLATION OF JUTE MESH (NOT JUTE BLANKETS)

1. Ensure the jute mesh is laid on a firm earth surface that has been trimmed, topsoiled, watered, sown with seed and fertilizer.
2. The jute mesh is then either tamped or rolled firmly onto the prepared surface, avoiding stretching, watered to encourage the penetration of the bitumen emulsion, and finally sprayed with a top layer of bitumen at 1 to 3 litres per square metre.
3. The rate of emulsion application should be adjusted such that the emulsion just starts to pond in the mesh square.

REMOVAL

1. When the soil disturbance above the catch drain is finished and the area is stabilised, the temporary drain and any associated banks should be removed, unless it is to remain as a permanent drainage feature.
2. Dispose of any sediment or earth in a manner that will not create an erosion or pollution hazard.
3. Grade the area and smooth it out in preparation for stabilisation
4. Stabilise the area by grassing or as specified within the approved site rehabilitation plan.



Source:

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CATEGORY
DRAINAGE CONTROL
TECHNIQUES

SUB-CATEGORY
CATCH DRAINS
AND CHUTES

DRAWING
CATCH DRAINS
GEOTEXTILE LINED

SCALE
NTS

DRAWING NO
CDC.4

DRAWN
SPD

CHECKED
ELH

MATERIALS

Straw bales:

Straw bales containing minimum seed content. Hay or lucerne bales must not be used.

Support post/stakes:

1500mm² (min.) hardwood, 2500mm² (min.) softwood or 1.5kg/m (min.) steel star pickets.

Aggregate:

15 to 25 mm clean gravel or aggregate.

Filter cloth:

Heavy-duty non-woven, needle punched filter fabric, minimum 'bidim' A34 or equivalent

INSTALLATION

1. Refer to approved plans for location and construction details. If there are questions or problems with the location or method of installation, contact the engineer or responsible on-site officer for assistance

2. Suitably clear and prepare the surface where the bales will be installed.

3. Lay the filter fabric on the ground with the up-slope edge extending at least 200mm up-slope of the intended up-slope edge of the bales.

4. If more than one sheet of fabric is used, then overlap the fabric a minimum of 600mm at all joints.

5. Place the bales end to end (length-wise) on the fabric with the up-slope edge at least 200mm down-slope of the up-slope edge of the fabric.

6. Fold the remainder of the filter cloth over the bales such that the end of the fabric rests firmly on the ground and extends at least 200mm up-slope of the bales.

7. Securely anchor the bales with a minimum of one stake or picket driven through the centre line of each bale. If the bales are not wrapped in filter cloth (not recommended), then use at least two stakes per bale. The first stake being driven towards the adjoining bale at a 45 degree angle to force the bales together

MAINTENANCE

1. Replace the straw bale barrier if full or partial collapse of the bales occurs.

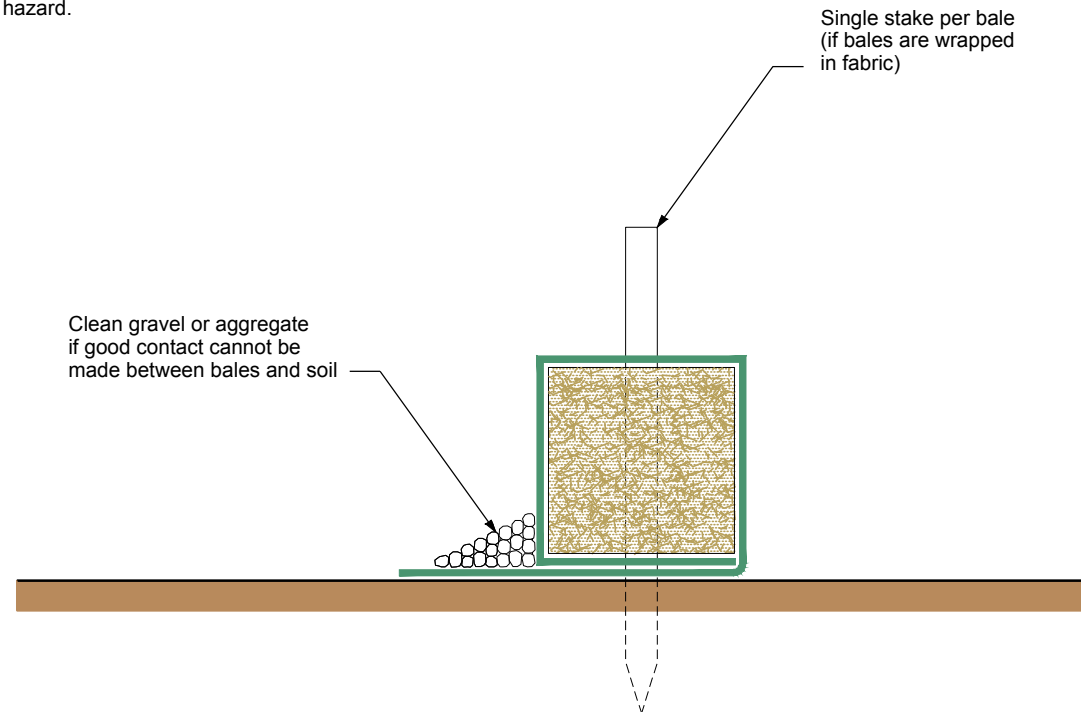
2. Remove and suitably dispose of accumulated sediment prior to replacing the bales.

3. Replace the filter fabric when it becomes blocked with sediment and/or the flow rate through the barrier becomes unacceptable.

REMOVAL

1. When work area up-slope of the straw bale barrier is sufficiently stabilised to restrain erosion, the barrier must be removed.

2. Remove all materials and deposited sediment and dispose of in a manner that will not cause an erosion or pollution hazard.



INSTALLATION OF STRAW BALE BARRIER

CATEGORY
SEDIMENT CONTROL
TECHNIQUES

SUB-CATEGORY
MINOR
CONCENTRATED
FLOW

DRAWING
STRAW BALE
BARRIER

SCALE
NTS

DRAWING NO
MCF.9

DRAWN
SPD

CHECKED
CMA

MATERIALS

Earth fill:

Clean soil with Emerson class 2(1), 3, 4 or 5 and free of roots, woody vegetation, rocks and other unsuitable materials. Soil with Emerson class 4 and 5 may not be suitable depending on particle size distribution and degree of dispersion. Class 2(1) should only be used upon recommendation from a geotechnical specialist. This specification may be replaced by an equivalent standard based on the exchangeable sodium percentage.

Riser pipe:

Minimum 250mm diameter.

Spillway rock:

Hard, angular, durable weather resistant and evenly graded rock with 50% by weight larger than specified nominal (d50) rock size. Large rock should dominate, with sufficient small rock to fill the voids between the larger rock. The diameter of the largest rock size should be no longer than 1.5 times the nominal rock size. The specific gravity should be at least 2.5.

Geotextile fabric:

Needle-punched, non-woven filter cloth, minimum 'Bidim' A24 or equivalent.

CONSTRUCTION:

1. Notwithstanding any description contained within the approved plans or specifications, the contractor shall be responsible for satisfying themselves as to the nature and extent of the specified works and the physical and legal conditions under which the works will be carried out.

This shall include:

- Means of access
- Extent of clearing
- Nature of materials to be excavated
- Type and size of mechanical plants required
- Location and suitability of water supply for construction and testing

purposes

- Any other like matter affecting the construction of the works.

2. Refer to approved plans for location, dimensions and construction details. If there are questions or problems with the location, dimensions or method of installation, contact the engineer or responsible on-site officer for assistance.

3. Before starting any clearing or construction, ensure all the necessary materials and components are on the site to avoid delays in completing the pond once works begin.

4. Install required short-term sediment control measures downstream of the proposed earthwork to control sediment runoff during construction of the basin.

5. The area to be covered by the embankment, borrow pits and incidental works, together with an area extending beyond the limits of each for a distance not exceeding 5 metres all around must be cleared of all trees, scrub, stumps, roots, dead timber and rubbish and disposed of in a suitable manner. Delay clearing the main pond area until the embankment is complete.

6. Ensure all holes made by grubbing within the embankment footprint are filled with sound material, adequately compacted and finished flush with the cut-off trench.

7. Before construction of cut-off trench or any ancillary works within the embankment footprint, all grass growth and topsoil must be removed from the area to be occupied by the embankment and must be deposited clear of this area and reserved for topdressing the completed embankment.

8. Excavate a cut-off trench along the central line of the earth fill embankment. Cut the trench to stable soil material, but in no cases make it less than 600mm deep. The cut-off trench must extend into both abutments to at least the elevation of the riser pipe crest. Make the minimum

bottom width wide enough to permit operation of excavation and compaction equipment, but in no case less than 600mm. Make the slopes of the trench no steeper than 1:1 (H:V).

9. Ensure all water, loose soil and rock are removed from the trench before backfilling commences. The cut-off trench must be backfilled with selected earth-fill of the type specified for the embankment and this soil must have moisture content and degree of compaction the same as that specified for the selected core zone.

10. Material excavated from the cut-off trench may be used in construction of the embankment provided it is suitable and it is placed in the correct zone according to its classification.

EMBANKMENT:

11. Scarify areas on which fill is to be placed before placing the fill.

12. Ensure all fill material used to form the embankment meets the specifications certified by a soil scientist or geotechnical specialist.

13. The fill material must contain sufficient moisture so it can be formed by hand into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction. Place fill material in 150 to 250mm continuous layers over the entire length of the fill area and then compact before placement of further fill.

14. Place riser pipe outlet system, if specified, in appropriate sequence with the embankment filling. Refer to separate installation specifications.

15. Unless otherwise specified on the approved plans, compact the soil at about 1 to 2% wet of optimum and to 95% modified or 100% standard compaction.

16. Where both dispersive and non-dispersive classified earth fill materials are available, non-dispersive earth-fill must be used in the core zone. The remaining

classified earth-fill materials must only be used as directed.

17. Where specified, construct the embankment to an elevation 10% higher than the design height to allow for settling; or otherwise finished dimensions of the embankment after spreading of topsoil must conform to the drawing with a tolerance of 75mm from the specified dimensions.

18. Ensure debris and other unsuitable building waste is not placed within the earth embankment.

19. After completion of the embankment all loose uncompacted earth-fill material on the upstream and downstream batter must be removed prior to spreading of topsoil.

20. Topsoil and revegetate/stabilise all exposed earth as directed within the approved plans.

SPILLWAY CONSTRUCTION

21. The spillway must be excavated as shown on the plans and the excavated material, if classified as suitable, must be used in the embankment, and if not suitable it must be disposed of into spoil heaps.

22. Ensure excavated dimensions allow adequate boxing-out such that the specified elevations, grades, chute width and entrance and exit slopes for the emergency spillway will be achieved after placement of the rock or other scour protection measures as specified in the plans.

23. Place specified scour protection measures on the emergency spillway. Ensure the finished grade blends with the surrounding area to allow a smooth flow transition from spillway to downstream channel.

(continued on drawing No. TC.2.2)

24. If a synthetic filter fabric underlay is specified, place the filter fabric directly on the prepared foundation. If more than 1 sheet of filter fabric is required, overlap the edges by at least 300mm and place anchor pins at minimum 1m spacing along the overlap. Bury the upstream end of the fabric a minimum of 300mm below ground and, where necessary, bury the lower end of the fabric or overlap a minimum of 300mm over the next downstream section as required. Ensure the filter fabric extends at least 1m upstream of the spillway crest.

25. Take care not to damage the fabric during or after placement. If damage occurs, remove the rock and repair the sheet by adding another layer of fabric with a minimum overlap of 300mm around the damaged area. If extensive damage is suspected, remove and replace the entire sheet.

26. Where large rock is used, or machine placement is difficult, a minimum 100mm layer of fine gravel, aggregate or sand may be needed to protect the fabric.

27. Placement of rock should follow immediately after placement of the filter fabric. Place rock so that it forms a dense, well-graded mass of rock with a minimum of voids. The desired distribution of rock throughout the mass may be obtained by selective loading at the quarry and controlled dumping during final placement.

28. The finished slope should be free of pockets of small rock or clusters of large rocks. Hand placing may be necessary to achieve the proper distribution of rock size to produce a relatively smooth, uniform surface. The finished grade of the rock should blend with the surrounding area. No overfall or protrusion should be apparent.

29. Ensure that the final arrangement of the spillway crest will not promote excessive flow through the rock such that the water can be retained within the settling basin an elevation no less than 50mm above or below the nominated spillway crest elevation.

ESTABLISHMENT OF THE SETTLING POND:

30. The area to be covered by the stored water outside the limits of the borrow pits must be cleared of all scrub and rubbish. Trees must be cut down stump high and removed from the immediate vicinity of the work.

31. Establish all required inflow chutes and inlet baffles, if specified, to enable water to discharge into the basin in a manner that will not cause soil erosion or the re-suspension of settled sediment.

32. Install a sediment storage level marker post with a cross member set just below the top of the sediment storage zone (as specified on the approved plans). Use at least 75mm wide post firmly set into the basin floor.

33. If specified, install internal settling pond baffles. Ensure the crest of these baffles is set level with, or just below, the elevation of the emergency spillway crest

34. Install all appropriate measures to minimise safety risk to on-site personnel and the public caused by the presence of the settling pond. Avoid steep, smooth internal slopes. Appropriately fence the settling pond and post warning signs if unsupervised public access is likely or there is considered to be unacceptable risk to the public.

MAINTENANCE:

1. Inspect the sediment basin during the following periods:

- During construction to determine whether machinery, falling trees or construction activity has damaged any components of the sediment basin. If damage has occurred, repair it

- After each runoff event inspect the erosion damage at flow entry and exit points. If damage has occurred, make the necessary repairs.

- At least weekly during the nominated wet season (if any) otherwise at least fortnightly.

- Prior to, and immediately after, periods of 'stop work' or site shutdown.

2. Clean out accumulated sediment when it reaches the marker board/post, and restore the original storage volume. Place sediment in a disposal area or, if appropriate, mix with dry soil on the site.

3. Do not dispose of sediment in a manner that will create an erosion or pollution hazard.

4. Check all visible pipe connections for leaks and repair as necessary

5. Check all embankments for excessive settlement, slumping of the slopes or piping between the conduit and the embankment; make all necessary repairs.

6. Remove all trash and other debris from the basin and riser.

7. Submerged inflow pipes must be inspected and de-silted (as required) after each inflow event.

REMOVAL:

1. When grading and construction in the drainage area above a temporary sedimentation basin is completed and the disturbed areas are adequately stabilised, the basin must be removed or otherwise incorporated into the permanent stormwater drainage system. In either case sediment should be cleared and properly disposed of and the basin area stabilised.

2. Before starting any maintenance work on the basin or spillway, install all necessary short-term sediment control measures downstream of the sediment basin.

3. All water and sediment must be removed from the basin prior to the dam's removal. Dispose of sediment and water in a manner that will not create an erosion or pollution hazard.

4. Bring the disturbed area to a proper grade, then smooth, compact and stabilise and/or revegetate as required to establish a stable land surface

CATEGORY SEDIMENT CONTROL TECHNIQUES

SUB-CATEGORY TYPE 1 & 2 CONTROLS

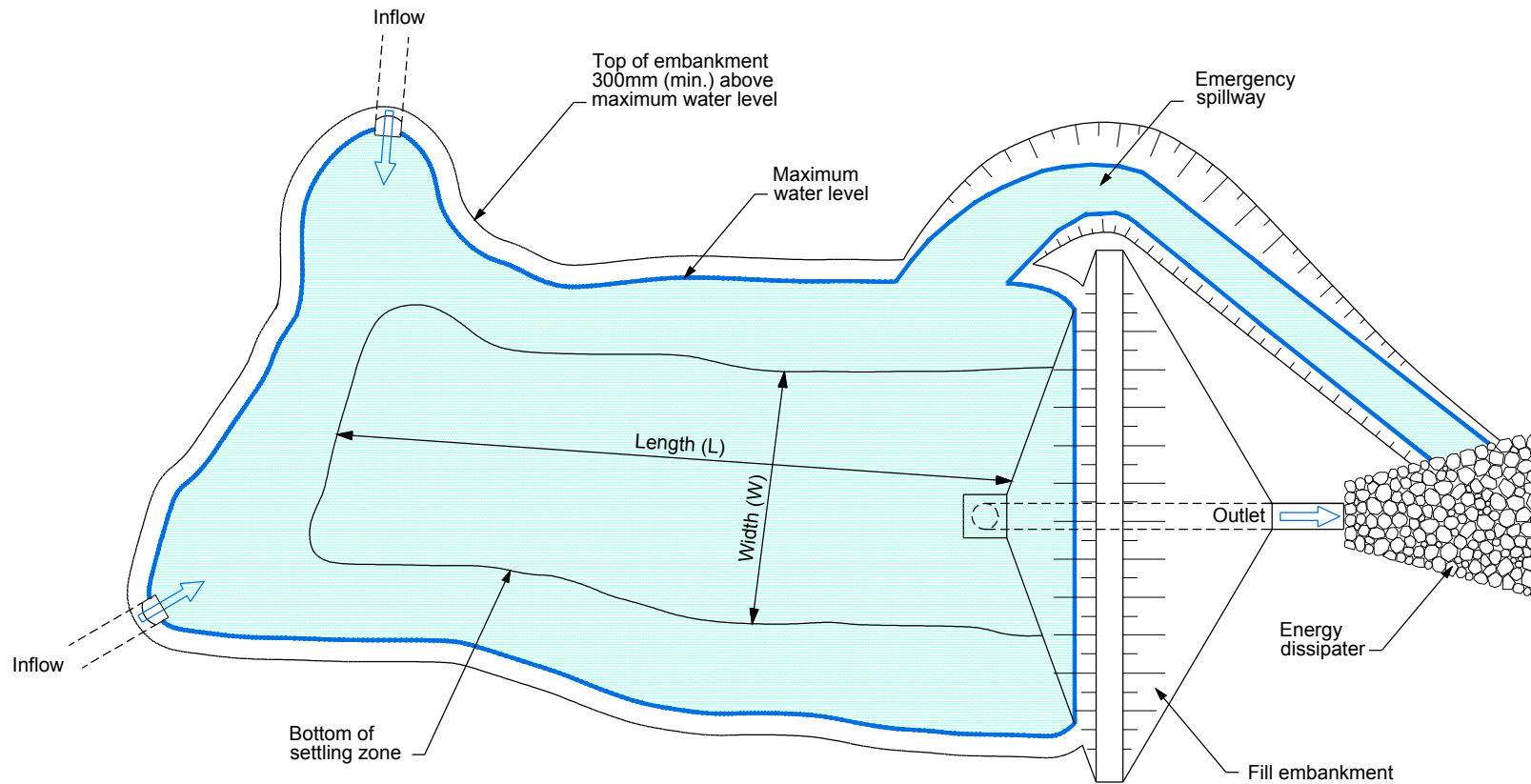
DRAWING SEDIMENT BASINS

SCALE
NTS

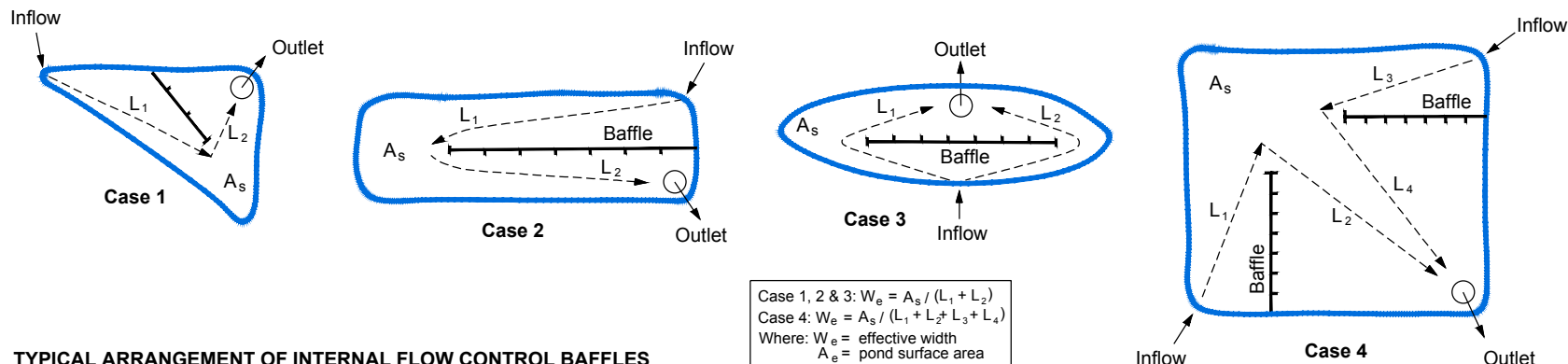
DRAWING NO
TC.2.2

DRAWN
SPD

CHECKED
CMA



TYPICAL PLAN OF A TYPE C (DRY) BASIN WITH RISER PIPE OUTLET SYSTEM



TYPICAL ARRANGEMENT OF INTERNAL FLOW CONTROL BAFFLES

CATEGORY
SEDIMENT CONTROL
TECHNIQUES

SUB-CATEGORY
TYPE 1 & 2
CONTROLS

DRAWING
SEDIMENT BASINS

SCALE
NTS

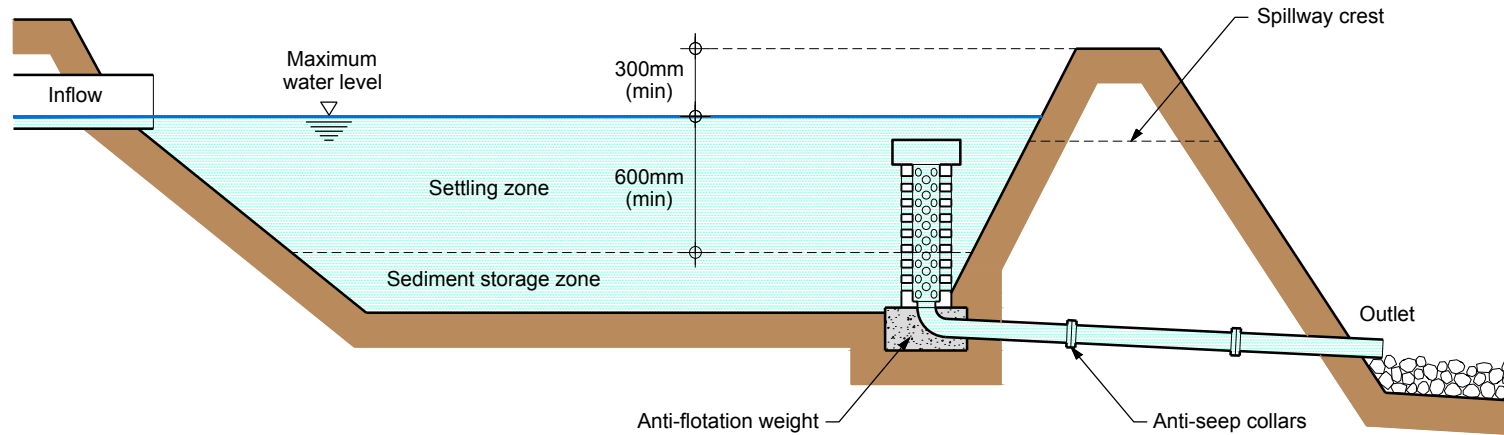
DRAWN
SPD

DRAWING NO
TC.2.3

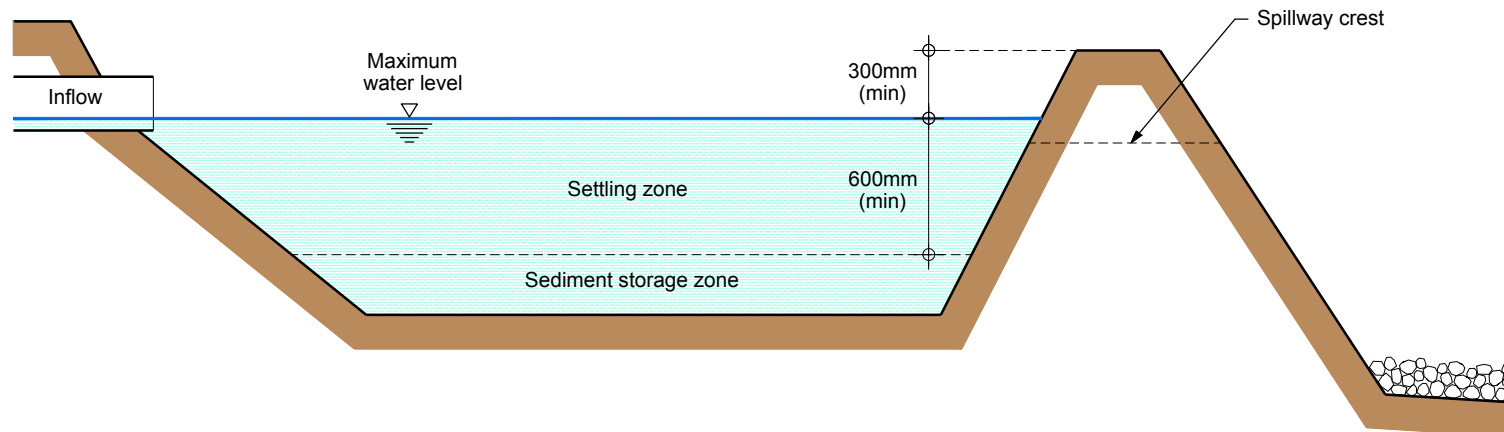
CHECKED
CMA

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TYPICAL SECTION THROUGH TYPE C (DRY) BASIN WITH RISER PIPE OUTLET SYSTEM



TYPICAL SECTION THROUGH TYPE F/D (WET) BASIN

CATEGORY
SEDIMENT CONTROL
TECHNIQUES

SUB-CATEGORY
TYPE 1 & 2
CONTROLS

DRAWING
SEDIMENT BASINS

SCALE
NTS

DRAWN
SPD

DRAWING NO
TC.2.4

CHECKED
CMA