

**PLANS AND DOCUMENTS
referred to in the PDA
DEVELOPMENT APPROVAL**

Approval no: DEV2017/844

Date: 25 October 2017



Precinct 1

In association with:



**WATERWAY CORRIDOR RESTORATION STRATEGY
(REVISION 3)**

Address: Dairy, Undullah & Wyatt Roads, Undullah

Lot & RP Description: Lot 3 on S311896, Lot 200 on SP133189, and Lot 1 on RP97710.

Parish / County: Undullah / Stanley

Assessment Manager: Economic Development Queensland (DSDIP)

Prepared for:



DATE: APRIL 2017



CIVIL ENGINEERING

TOWN PLANNING

PROJECT COORDINATION

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ACKNOWLEDGEMENTS

The Flinders team is proud of the collaborative approach taken by all consultants involved with this project and we would like to acknowledge and thank all those involved. This report has been specifically prepared in conjunction with Gilbert & Sutherland, BMT WBM, Morrison Geotechnic, Wholistic Environment, Place Design, James Warren & Associates, Saunders Havill Group and Gassman Development Perspectives.



*Stephen Hosking
Surveys Pty Ltd*



BOZ Technical Services





1.0 LIST OF REFERENCES

- Reference 1 **Preliminary Soils Assessment**
Prepared by Gilbert and Sutherland Pty Ltd, Revision 3 dated 2.12.2011
(Submitted with previous NH1 South MCU/ROL Application)
- Reference 2 **Broad Geotechnical Assessment – Precinct 1**
Prepared by Morrison Geotechnic, dated 09.02.2012
(Submitted with previous Precinct 1 'Whole of Site' MCU Application)
- Reference 3 **Stream Bank & Bed Erosion Assessment & Conceptual Management Plan**
Prepared by Gilbert and Sutherland, Revision 2, dated December 2012
(Submitted with previous NH1 South MCU/ROL Application)
- Reference 4 **Stability Assessment of Creek Banks - Neighbourhood 1**
Prepared by Morrison Geotechnic, dated 01.09.2011
(Submitted with previous NH1 South MCU/ROL Application)
- Reference 5 **Stability Assessment of Creek Banks – Phase 2**
Prepared by Morrison Geotechnic, dated 06.12.2011
(Submitted with previous NH1 South MCU/ROL Application)
- Reference 6 **Flood Impact Assessment**
Prepared by BMTWBM, dated April 2017
(Submitted with new Precinct 1 MCU Application)
- Reference 7 **Significant Biodiversity Assessment**
Prepared by Saunders Havill Group, dated April 2017
(Submitted with new Precinct 1 MCU Application)
- Reference 8 **Bushfire Management Strategies – Precinct 1**
Prepared by The Consultancy Bureau, dated February 2012
(Submitted with previous Precinct 1 'Whole of Site' MCU Application)
- Reference 9 **Cultural Heritage Assessment - Overall**
Prepared by Converge, Revision 2, dated 05.12.2011
(Submitted with previous Precinct 1 'Whole of Site' MCU Application)
- Reference 10 **Site Based Management Plan for Dispersive Soils**
Prepared by Gilbert and Sutherland, Revision 3, dated September 2012
(Submitted with previous Precinct 1 'Whole of Site' MCU Application)
- Reference 11 **Dispersive Soil Management Plan:
Addendum for Lake Development (Planning)**
Prepared by Wholistic Environment, dated 16th February 2017
(Submitted with new Precinct 1 MCU Application)
- Reference 12 **Flinders Precinct 1: Stormwater Quality Management Plan**
Prepared by BMT WBM, dated April 2017
(Submitted with new Precinct 1 MCU Application)
- Reference 13 **Flinders Precinct 1: Concept Lake Management Plan**
Prepared by BMT WBM, dated April 2017
(Submitted with new Precinct 1 MCU Application)

Please note, the documents included in the reference list are not provided as part of this Waterway Corridor Restoration Strategy. They are documents that have previously been provided to EDQ for assessment as part of the originating application; or the request to amend approval DEV2012/247 Application.

2.0 INTRODUCTION AND PURPOSE

This Waterway Corridor Restoration Strategy was prepared on behalf of *Pacific International Development Corporation Pty Ltd ATF The PIDC Trust* and was prepared to support the 'Whole of Site' Material Change of Use Development Application for Flinders (Precinct 1).

Through the integration of specialist consultant disciplines, this report provides a framework for the re-establishment of the proposed waterway corridors throughout Flinders (Precinct 1). It discusses the assessments performed on the existing waterways, details the proposed restoration strategies and proposes mitigation measures for the potential impacts. It outlines the proposed treatments to address the waterway instability evident on-site and the different rehabilitation categories along the waterways. This document also considers the proposed lakes which have been located in some of the most eroded and degraded area of Flinders (Precinct 1).

Where necessary re-profiling of the waterway banks is proposed to improve public safety and increase stability. These re-profiling works will require clearing of existing vegetation most of which is Category X. Future vegetation clearing applications will be submitted to EDQ for approval in accordance with the project's future Natural Environment OSS. Following the re-profiling works, rehabilitation and revegetation of the disturbed areas will be required with landscaping augmenting the riparian vegetation. In some cases the existing waterway banks have little to no vegetation and will therefore require weed management and a greater degree of revegetation. A Rehabilitation Management Plan will be prepared that addresses the revegetation of the banks and riparian zone in the re-profiled areas upstream of the lakes prior to works commencing onsite.

Beyond the riparian zone will be a landscape zone that varies in width and will include bike and pedestrian paths, stormwater treatment basins, bushfire management strategies and general landscaped open space areas.

This document has been prepared as a framework for future operational works to occur within the waterways of Flinders (Precinct 1). The framework discusses the proposed works, staging and sequencing of these works and the dedication of public parkland associated with future staged ROL Applications. The future detailed design of the waterway rehabilitation works will take into account this framework and will also consider the integration of natural channel design techniques where suitable.

The WCRS provides concepts and strategies that have been developed collaboratively and are the result of a combined approach to the stabilisation works based on investigations performed at that point in time. Areas of the waterway that may not have works proposed within the WCRS document may still require some stabilising works which will be assessed on a case by case basis at the appropriate time in consultation with EDQ. Further to this, once WCRS works commence, on-site alternative details may be considered more appropriate and these will be incorporated into the project to ensure the most appropriate treatments are implemented.

2.1 Flow of Documents

To assist with the understanding of the WCRS information that will be submitted to EDQ in support of the various applications over time, we provide the following outline:

- ***Waterway Corridor Restoration Strategy (WCRS) (this document)***
What: Over-Arching Site Strategy that summarises previous assessments and outlines the proposed strategies to restore the waterway corridors.
When: Submitted in support of the Precinct 1 MCU Application. The WCRS may be updated from time to time.
- ***Detailed Operational Works Drawings***
What: Detailed drawings outlining the proposed treatment works in the waterways generally in accordance with the concepts outlined in the WCRS.
When: To be provided as part of each OPW submission to EDQ that proposes works within a waterway.

2.2 Applicable Legislation & Required Approvals

This revised strategy is submitted to EDQ for approval in support of the Flinders (Precinct 1) MCU application and will also provide supporting documentation for any future environmental applications to DEHP.

The existing assessments, concepts and proposed strategies outlined in this report are generally the same as those previously submitted to and approved by EDQ as part of the WCRS dated 2nd November 2012.

It is understood that other future environmental applications may include the following:

- Quarry Material Allocation Notice / Resource Entitlement (DNRM);
- Riverine Protection Permit for Interfering with a Waterway (DNRM);
- Tree Clearing Permit (EDQ – may require referral depending on vegetation significance); and
- Self-certification of the detailed engineering & landscape designs (Consultant).

3.0 SITE DESCRIPTION

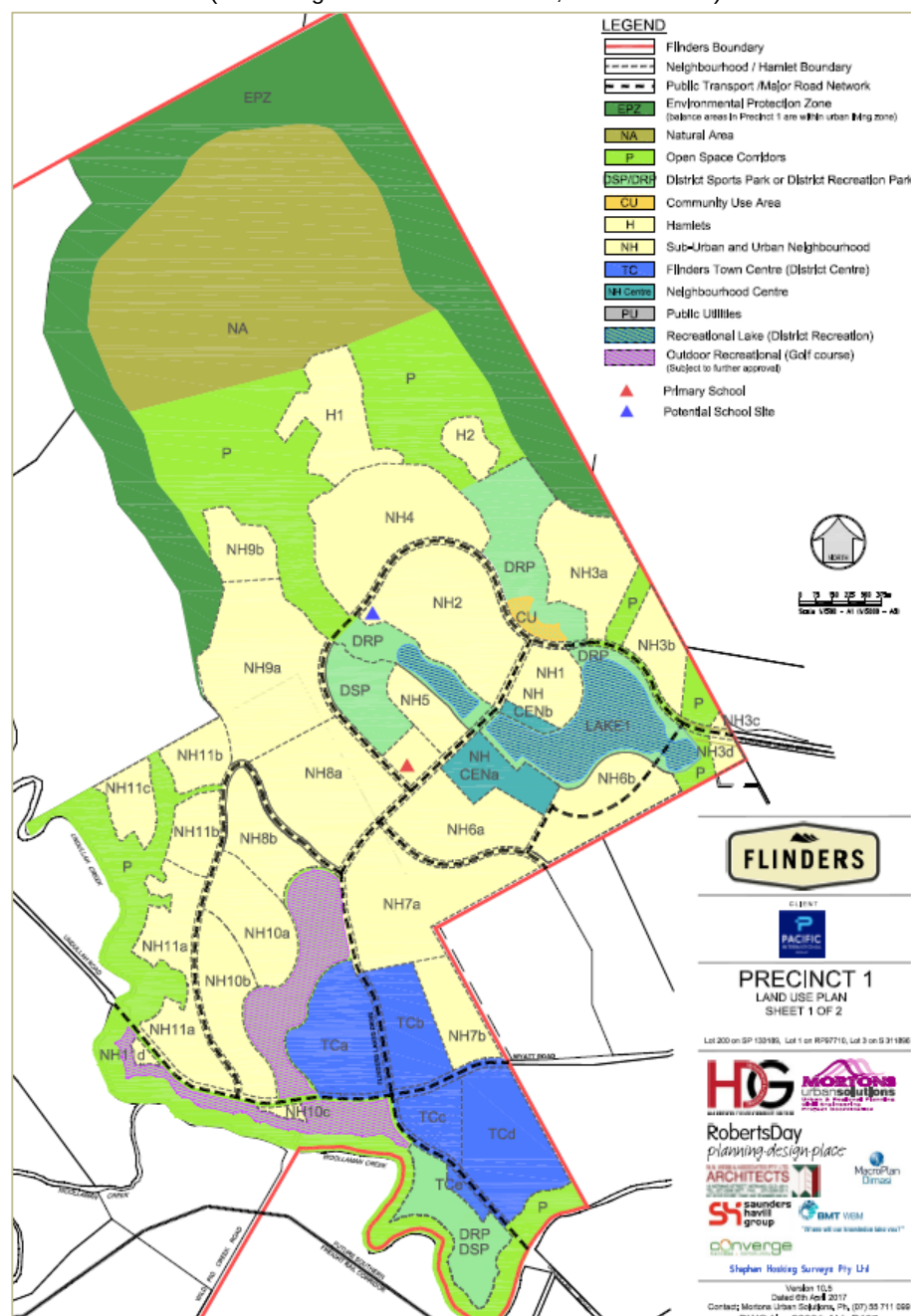
Flinders is a large master-planned development which spans several Local Authorities. This report only relates to Flinders (Precinct 1) which is located within the Greater Flagstone Priority Development Area. As such Development Applications are assessed and administered by EDQ.

The real property descriptions of Flinders (Precinct 1) include:

- Lot 3 on S311896 (approx. 678.152Ha);
- Lot 200 on SP133189 (approx. 322.684 Ha); and
- Lot 1 on RP97710 (approx. 0.3794Ha).

This provides a total precinct area of approximately 1,001.22 Ha.

Figure 1: Flinders Land Use Plan (MUS Dwg No: 23301-ALL-P137, Revision 10.5)



3.1 Ownership and Control

Ownership and control of the Flinders development is outlined in the following table:

Table 1: Ownership and Management

Property Ownership & Management entities	
Owner	Flinders Land Holdings Pty Ltd; and Darwin & Michelle King
Rural Management Company	Pacific Agricom Pty Ltd
Applicant (Developer)	Pacific International Development Corporation (PIDC) as Trustee for The PIDC Trust

3.2 Waterways within Flinders (Precinct 1)

The two main waterways within the Flinders (Precinct 1) are currently heavily degraded. There is significant erosion along parts of these waterways for several reasons; but in particular, the soil types and lack of vegetation.

The next few pages contain photos taken of the onsite waterways showing the typical conditions.







4.0 EXISTING WATERWAY CORRIDOR ASSESSMENT

The waterways within Flinders (Precinct 1) are ephemeral as they only flow during periods of rainfall, although they do contain ponded water at numerous locations. Undullah and Woollaman Creeks flow along the western and southern boundaries of Flinders (Precinct 1).

The waterways particularly surrounding NH1, contain areas of significant erosion as a result of poor soil characteristics and historic clearing for grazing. The worst areas are the outer bends of the creeks where the water is at its highest velocity and therefore causes higher levels of erosion. Given the amount of erosion these areas are considered unsafe and require treatment to rectify instability.

The following sections of the report outline the findings of the investigations performed to date addressing the Waterway Corridors within Flinders (Precinct 1).

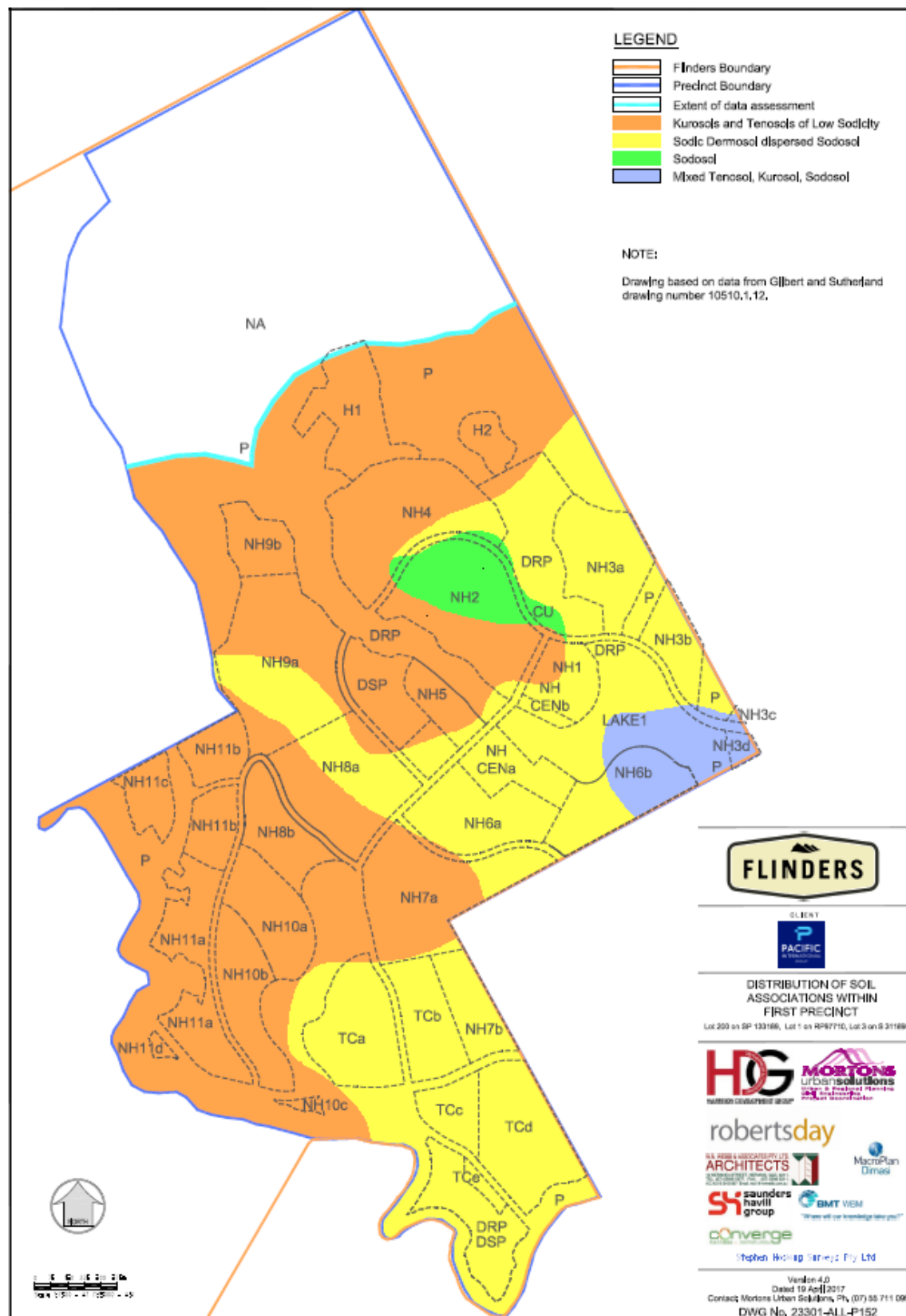
4.1 Preliminary Soils Assessment

Gilbert & Sutherland (G&S) were engaged to prepare a *Preliminary Soils Assessment* for the entire Precinct 1 area of the *Flinders* development (**Reference 1**). The aim of this assessment was to “undertake a pilot study of the land associated with the initial development (i.e. Neighbourhood 1) to identify the critical landscape factors that impact on the development potential of the remainder of the first precinct”.

Following a desktop review, a total of 44 boreholes were drilled across the subject site “to a maximum depth of 1.2m below natural surface level (NSL) or to a depth of auger refusal”. From this assessment G&S have identified the various soil types encountered within Precinct 1 of the Flinders development and provided observations regarding potential constraints to development.

The field assessment and subsequent laboratory testing revealed a total of five (5) soil orders present across the site being *Kurosols*, *Dermosols*, *Sodosols*, *Chromosols* and *Tenosols*. The approximate locations of these soil orders are depicted in **Figure 2** overleaf.

Figure 2: Distribution of Soil Orders (G&S soil mapping results)





A summary of each of these soil orders is provided as follows:

Kurosols:

- Strong texture contrast between A and B horizons;
- A horizon comprises primarily clayey sand to sandy clay loam;
- B horizon heavy clay to sandy heavy clay;
- Weak to moderate angular blocky structure;
- Associated with boreholes drilled on side slope and hilltop areas.

Dermosols:

- No clear textural horizon change;
- A horizon consists of sandy loam to sandy light clay;
- B horizon consists of light to heavy clay;
- Weak to moderate sub-angular blocky structure;
- Associated with boreholes drilled on lower elevation hill wash, depositional and floodplain areas.

Sodosols:

- Exhibit a strong textural change between A and B horizons;
- A horizon comprises sandy loam to clay loam (sandy);
- B horizon comprises sandy, medium to heavy or heavy clay;
- Weak to moderate angular blocky structure;
- Associated with boreholes drilled in Hill wash, Side slope and Hilltop areas.

Chromosols:

- Clear textural contrast between A and B horizons;
- A horizon comprises primarily sandy clay loam;
- B horizon comprises heavy clay;
- Weak to moderate sub-angular blocky structure;
- Only located within boreholes drilled in Hilltop areas (BH9 and BH32).

Tenosols:

- Classified into two (2) subtypes – Leptic or Orthic;
- Leptic soils are shallow with less than 0.5m to surface by rock or partially weathered rock;
- Orthic soils have a B horizon with less than 15% clay content;
- Leptic Tenosols characterised by sandy loam to sandy clay loam A horizon over Weathered Rock;
- Leptic Tenosols associated with boreholes drilled in elevated side slope and hilltop areas;
- Orthic Tenosols characterised by loamy sand to sandy loam A horizon overlaying a sand to clayey sand B horizon;
- Orthic Tenosols associated with boreholes drilled in low lying hill wash and floodplain areas.

The Laboratory analysis conducted on the soils indicates that the topsoil (ie. A horizon) has pH levels generally between 4.5 to 5.7, with the majority less than 5.5 indicating strong acidity. The subsoil profile (B horizon) exhibited pH levels in the range of 4.4 and 7.3 with the majority above a level of 5.5 indicating moderate acidity.

Whilst the topsoil is predominantly non-sodic (i.e. relatively low levels of sodium), the subsoils encountered on the site are sodic to highly sodic.

The investigation concluded that given the sodicity levels encountered, combined with relatively high levels of magnesium, conditions may lead to potential issues including soil dispersion and breakdown, impeded permeability, tunnel erosion, increased run-off, erosion and high turbidity in run-off.

Photo: Example of soil profile in eroded waterway with stable sand layer overlying an abrupt change to a dispersive subsoil



4.2 Broad Geotechnical Assessment

Morrison Geotechnic (MG) undertook initial borehole drilling to provide broad geotechnical assessments of the various landforms occurring across the subject site and provided their findings within their *Flinders (Precinct 1) Broad Geotechnical Assessment (Reference 2)* report. This report provided subsurface profiles and an assessment of slope stability for each identified landform.

Further investigations have supplemented this report with site-specific geotechnical investigations that provided detailed recommendations for the design of each Neighbourhood.

Generally the drainage features are considered a very high hazard risk.

MG state that “*most of the site displays no evidence of recent past slope instability involving small scale or large scale movements...there are however localised areas within the flatter, lower portions of the site where slope instability is evident*”. The localised areas observed by MG are located within the drainage features and alluvial terrace landforms units and take the form of slips, slumps, erosion and hummocky ground with some groundwater evident.

MG has made a number of recommendations within their reports in relation to ensuring the ongoing stability of the site, particularly in relation to drainage, filling and excavation. MG’s recommendations for drainage to reduce the risk of slope instability include the following:



- Following the removal of all wet and unstable materials the exposed soil should be benched and battered to appropriate angles and subsurface drains installed where groundwater is evident.
- Lined surface contour drains must be constructed upslope to intercept surface water flows.
- Subsurface drains should be installed above all modified drainage features.
- Drainage filter rock to be provided behind retaining walls.
- Drainage filters are to be separated from insitu soils or fill using appropriate geofabric.

4.3 Waterways Analysis

Gilbert & Sutherland (G&S) have prepared a document entitled, *Stream Bank and Bed Erosion Stability Assessment and Conceptual Management Plan* dated December 2011 (**Reference 3**) which addresses the quality of waterways in Neighbourhood 1 of Flinders (Precinct 1). Considerable instability was found during assessments of the beds and banks of the unnamed waterways bordering Neighbourhood 1 and this was found to result from the inherent characteristics of the sodic soils identified on the site. G&S advise that the historical removal of vegetation from these waterways and the disturbance of riparian vegetation and soils through grazing has further exacerbated the instability of these areas.

For the purpose of their report G&S have used a Uniform Stream Reaches (USR) method which groups stream reaches based on sharing similar characteristics and management requirements. Consequently twenty-three (23) reaches were identified. Descriptions of each reach and its subsequent management requirements are detailed in Section 6 of the *Stream Bank and Bed Erosion Stability Assessment and Conceptual Management Plan* (**Reference 3**).

The investigation concluded with five treatment options, including a mixture of the following:

- Extending buffers to be consistent with stream order.
- Rehabilitation and planting of vegetation to stabilise area.
- Enhancing existing vegetation.
- Chemical amendment of soil surface depending on soil pH.
- Installation of surface and sub-surface interceptor drains to intercept and prevent lateral flows to creek.
- Waterway bank erosion control (eg reshaping and grading of creek bank batter).
- Stream bank toe stabilisation.
- Bed erosion control.
- Stabilisation works (e.g. rock weirs, log weirs and bank-lining).

Figure 3: Excerpt from G&S Report – Reach Assessment & Observation Locations.



4.4 Waterway Stability

Morrison Geotechnic (MG) was engaged to prepare two reports in relation to the existing stability of stream banks within the Eastern Catchment Waterway Corridors (**References 4 & 5**).

The aim of these reports was to identify the *'prevalent geomorphical processes occurring along the assessed creek bank sections adjacent to the proposed development and any adverse subsurface conditions that may be critical to the stability of banks'*. The assessment also identifies areas of the banks which are considered to be unstable or which may impact on the proposed development.

For the purpose of the assessment, the assessed waterway banks have been divided into several distinct sections based on observed features such as the bank conditions, the extent of instability evident, the form of the creek, the presence of vegetation and subsurface conditions.

Morrison Geotechnic observed several geomorphical processes occurring within the waterway banks with the most prominent being erosion. The *'predominant geomorphical process that is continually occurring along the assessment area is undercutting or incised meandering during significant rainfall events'*. This type of erosion presents itself through the vertical to near vertical banks observed on the outer bends of the creeks which is caused by high flow velocities within the waterways (refer **Section 3.2** above for indicative photos).

Significant volumes of material transportation and deposition via colluvial processes were also observed.

In assessing the subsurface conditions of the waterways, a total of sixteen (16) boreholes were drilled adjacent to the banks of the creeks. The depth of drilling was between 2.0m and 4.5m dependent upon

location and subsurface conditions encountered. Samples from boreholes where existing erosion had already occurred were collected for Particle Size Distribution, Atterberg Limit and Emerson Class Dispersion tests to assess the composition and erodibility of the soil within the waterways.

Morrison Geotechnic's report concluded with seven treatment options that include a mixture of the following depending on the location, severity and likelihood of continued erosion:

- Buffers to development based on Vegetation Management Act (VMA) stream order basis.
- Planting of vegetation within areas where the soils are exposed.
- Removal of localised areas of bank instability such as undercut or slumped areas.
- Re-profiling these areas of the creek bank to a slope angle of no steeper than 2(H):1(V). Alternatively, maintain the near vertical bank sections by supporting and protecting the banks with gabion structures that incorporate a thick filter zone behind the walls to minimise internal erosion.
- The re-profiled banks should comprise surface protection such as ecocell matting, geomats, geocells, biomats or similar with the toe of the batter protected using rock mattresses or similar keyed in at least 1.0m below the toe of the batter to minimise the impact of undercutting or possible groundwater effects. The surface protection should include the planting of vegetation where appropriate.
- Surface drains should be constructed behind the crest of all batters to intercept upslope surface water and redirect the water into dedicated drainage easements.
- Remove all soft/weak soils, trees, grass and surface irregularities from the base of the drainage inlets to expose a competent base for the placement of fill. If groundwater is encountered or likely, appropriate drainage provisions must be installed at the base of the fills to maintain positive drainage. Where the ground surface slopes at 7° or more, the foundation must be benched prior to filling.

Wholistic Environment in their Reporting recommend appropriate chemical and re-compaction treatment of surface and top layer (nom 300mm depth) of Dispersive Soil slopes and beds.

4.5 Flooding – Pre-Development

BMTWBM prepared a base case flood model that analyses the pre-development flood extents on the subject site. The report summarises that under the existing conditions, generally the Q_{100} flood remains within the existing waterways and flooding beyond the banks is not experienced. BMTWBM's report is titled '*Flood Impact Assessment*' report (**Reference 6**).

4.6 Ecological Assessment

Saunders Havill Group (SHG) completed a '*Significant Biodiversity Assessment*' (**Reference 7**) of the Flinders (Precinct 1) development in 2017 which included an assessment of the waterway corridors. The assessment used a combination of desktop studies and field flora and fauna surveys. The resulting report comprises a detailed description of the site, the methodology of the above-mentioned studies and a discussion of the constraining ecological and legislative factors and the impact amelioration strategies and recommendations. In particular it responds to EDQ's Guidelines 14 & 17.

Saunders Havill investigations confirmed that the site is a relatively disturbed rural landscape with extensive historical clearing on the lower slopes and gullies. The result is a patchwork of open clearing and regrowth and remnant vegetation along drainage lines that have undergone extensive erosion and shedding of dispersive soils.

Habitat is generally confined to the northern area of remnant vegetation and regrowth koala habitat adjacent to the Flinders Karawatha Bio-regional Corridor. The central gully lines provide no effective connectivity value with Undullah and Woolaman Creek corridors providing the greatest opportunity for ongoing connectivity value.

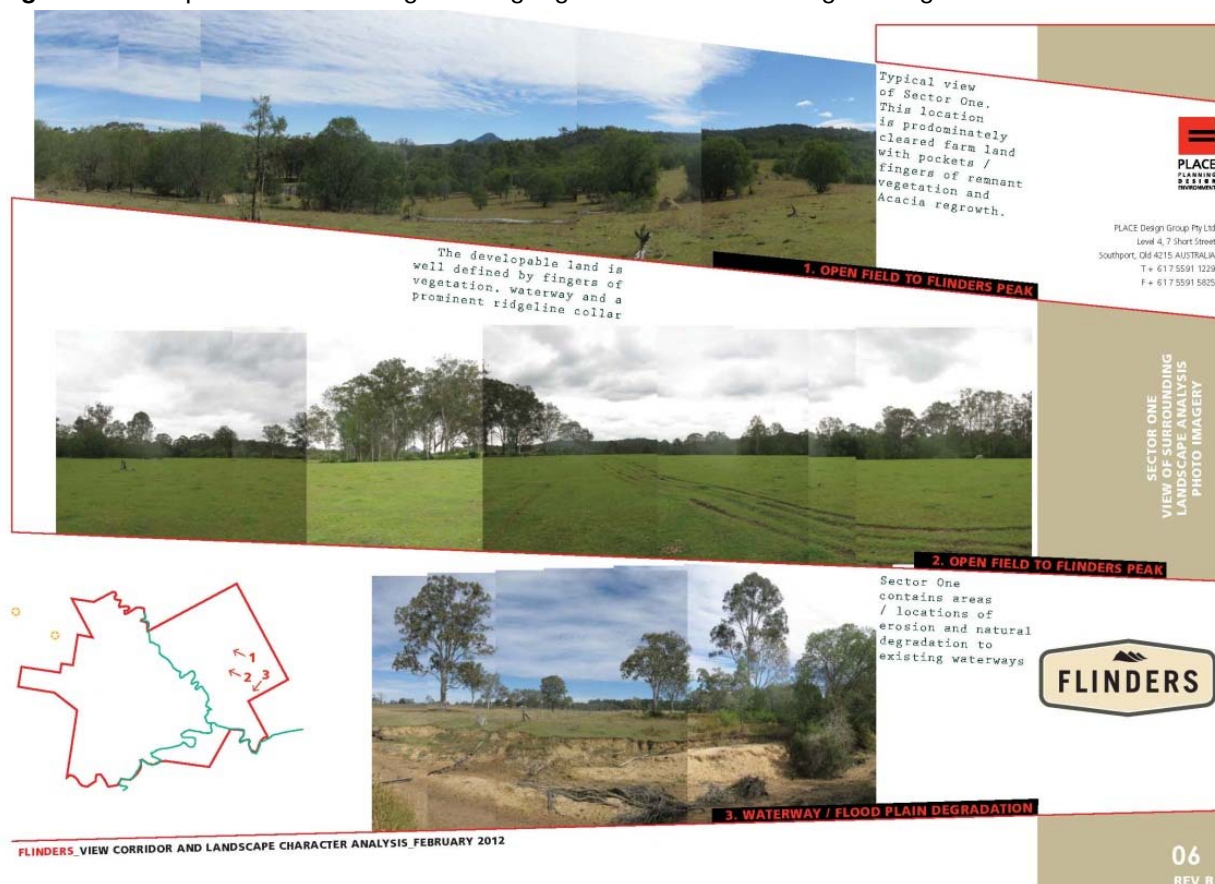
Notwithstanding the presence of some vegetation along waterways, Saunders Havill acknowledge the need for extensive stability works on the waterways, particularly the central drainage features. They did not identify any specific conflict between these works and the ecological values of the waterways but they will contribute to the drafting of a future rehabilitation management plan.

4.7 Landscape Character and Design

Place Design Group (PDG) have summarised the existing waterway corridors as containing remnant Dry Sclerophyll vegetation confined to the embankments of the waterway which are generally characterized by a degraded channel.

A history of land clearing for agricultural uses has generally confined the extent of remnant vegetation to the upper waterway corridors with significant *Eucalyptus* and *Corymbia* species punctuating the corridor landform and providing a strong visual reference within the rural landscape.

Figure 5: Excerpt from Place Design's 'Language of the Land' showing existing character.



4.8 Bushfire Hazard Risk Assessment

The Consultancy Bureau (TCB) undertook a detailed site investigation of the subject site with respect to bushfire in August 2011 and prepared a document entitled 'Bushfire Management Strategies'

(**Reference 8**). The site was found to have a low bushfire risk under the current rural management classifications; however the potential bushfire hazard risk ranged from low to high.

The report concludes that generally, a 20m separation around the edge of development is recommended and ideally includes a road as a divider between development and open space, however a cleared zone is also acceptable (ie. low grasses, stormwater basins etc.) with no vegetation 'up to' development. Where an external road is not possible, a 6m wide cleared zone with a fire trail is also acceptable. Where the bushfire hazard risk is identified as 'medium' the minimum separation distance may reduce to 10m if low risk strategies are in place (eg. retained strips and small areas of vegetation).

It is proposed that some waterway corridors will be revegetated to their original ecosystems and as such these may carry a low intensity fire in dry times. TCB concluded that these fires will be of nuisance value and overall the risk from vegetation internal to Precinct 1 (ie the waterway corridors) is low to moderate.

4.9 Indigenous & Non Indigenous Cultural Heritage

A Cultural Heritage Report has been prepared by Converge (refer **Reference 9**) and has assessed cultural heritage with respect to both indigenous cultural heritage and non-indigenous cultural heritage.

With respect to Indigenous Cultural Heritage, owing to the pastoral history of parts of the study area, Category 4 of the Cultural Heritage Duty of Care Guidelines would adequately describe the status of these sections of the study area. However, the permanent waterways and the sections of the study area which contain areas that haven't been subject to historic modification and clearing, would fall under Category 5 and part 6 of the ACH Duty of Care Guidelines. Therefore any ground disturbing activities other than those which have been previously carried out (eg. grazing and tree removal) will be carried out in accordance with a Cultural Heritage Management Plan.

A Cultural Heritage Management Plan (CHMP) has been signed by the Developer and Jagera Daran Pty Ltd (whom are registered with DEHP as an Aboriginal Cultural Heritage Body) and Cultural Heritage Surveys will be conducted under that Management Plan for various sections of Precinct 1.

Non-indigenous Cultural Heritage value was also assessed and three locations were identified within Flinders (Precinct 1). These locations are outside the waterways and will be maintained in accordance with the approved CHMP.

5.0 PROPOSED STRATEGY

The following section of this report details the integration of the specialist disciplines to provide a framework for the stabilisation and re-establishment of the proposed Waterway Corridors.

5.1 Lake

A lake is proposed near to the eastern boundary of Flinders (Precinct 1). This lake is proposed to be 'online' and will involve earthworks to stabilise existing waterways and the treatment of dispersive soils.

The lake has been located in the most eroded section of Precinct 1 and as a result, in an area where most of the existing vegetation was required to be removed in order to stabilise the waterways and dispersive soils. The upstream waterways will require stabilising to minimise sediment transfer into the lake, as well as ensuring the structural integrity of the waterway corridors.

5.2 Waterway Corridor Re-Profiling

In the unstable areas upstream and downstream of the lake an integrated solution is proposed that includes reshaping of the stream cross-sections and subsequent revegetation and landscaping. Whilst soft treatments are preferred, consideration will be given to the installation of rock mattresses, gabion structures, rock vanes and cut-off/interceptor drains.

The treatment proposed for each area will take into account its current condition, likelihood of erosion in the future and the proposed adjacent development.

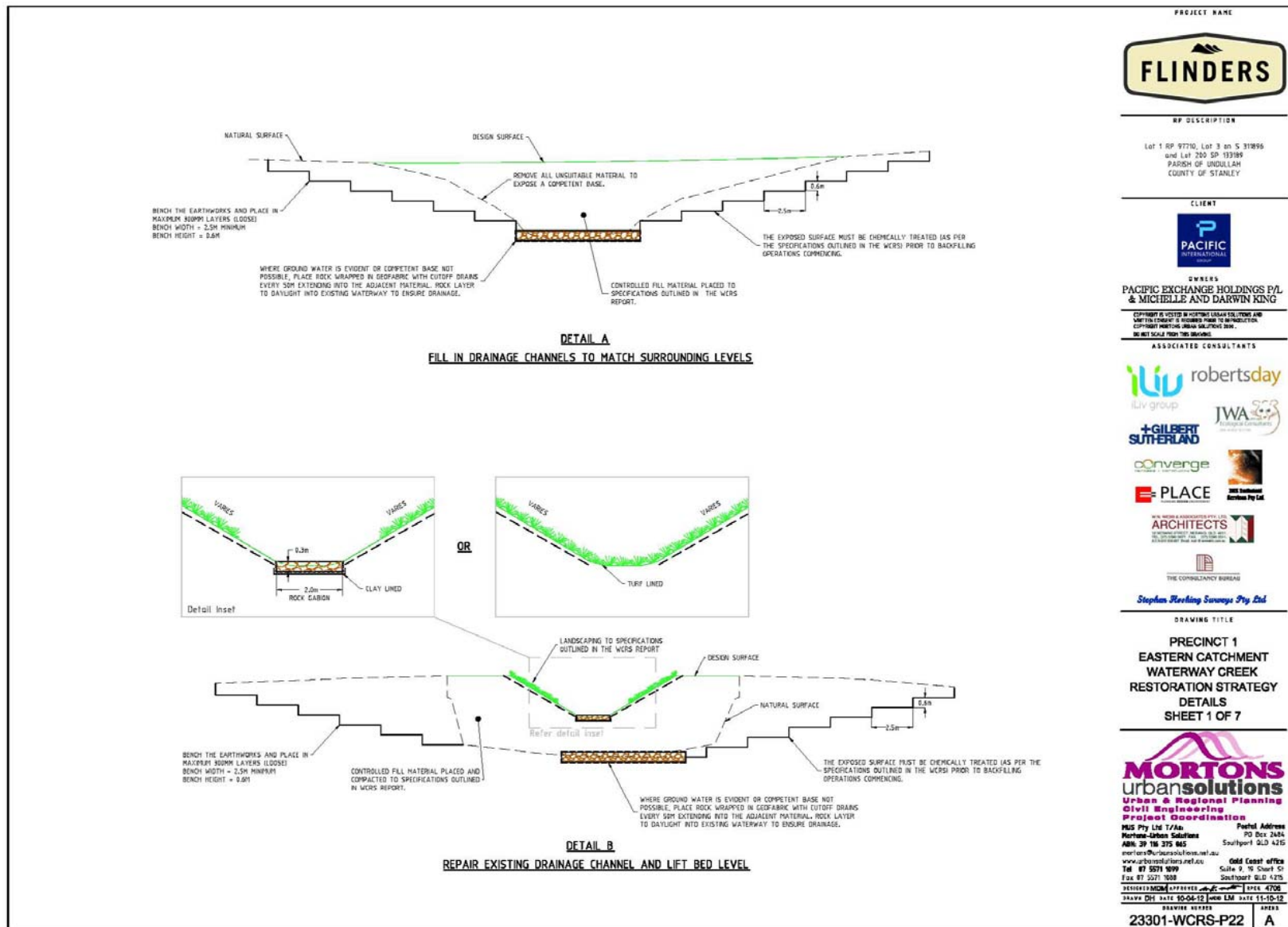
The re-profiling methods proposed for rehabilitation include a combination of the strategies outlined by Gilbert & Sutherland (refer Section 4.3) and Morrison Geotechnic's (refer Section 4.4) reports and can be described as follows (refer plans within **Figure 6**):

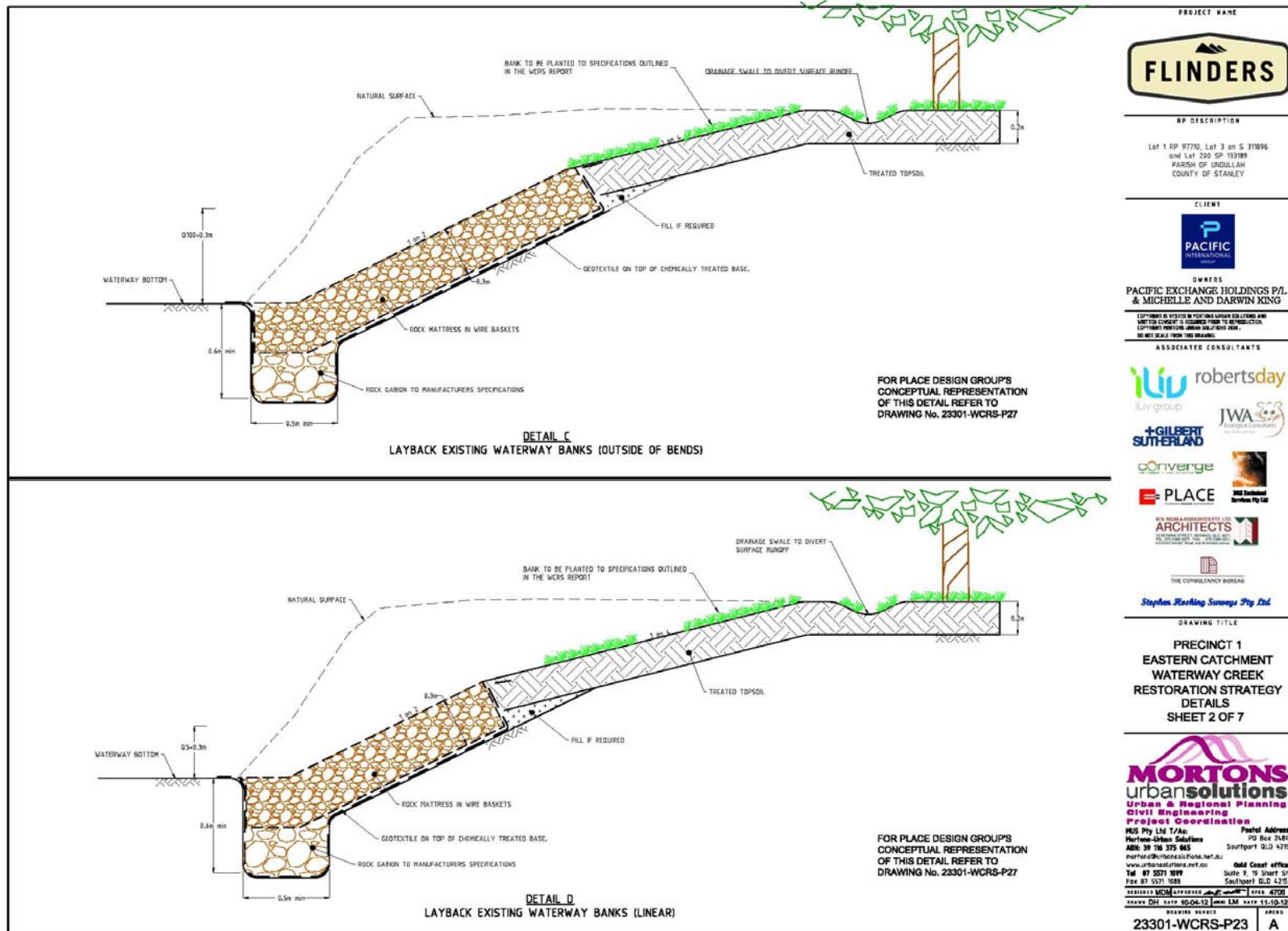
- Rehabilitation of drainage channels to match surrounding levels (Detail A)
 - Removal of base materials to competent base
 - Treatment of ground water if evident (eg wrapped rock layer)
 - Chemical treatment of exposed surface
 - Fill drainage channel with suitable material from site (chemically treated if required)
 - Application of topsoil and landscaping
- Repair of existing drainage channels (lift bed level) (Detail B)
 - Treatment as per Detail A above although existing drainage path is maintained
- Layback of existing waterway banks (outside of bends) (Detail C)
 - Removal of existing material
 - Chemical treatment of exposed surface
 - Rock protection to toe and batter to a minimum of $Q_{100}+300\text{mm}$ at a 1:2 slope. Beyond the rock protection is a landscaped batter at a 1:4 slope.
 - Drainage swale to divert surface runoff on top of bank
 - Application of topsoil and landscaping
- Layback of existing waterway banks (linear) (Detail D)
 - Treatment as per Detail C above although rock protection to a minimum height of $Q_5+300\text{mm}$.
- Layback of existing banks adjacent to retained vegetation (retaining wall) (Detail E)
 - Removal of existing material

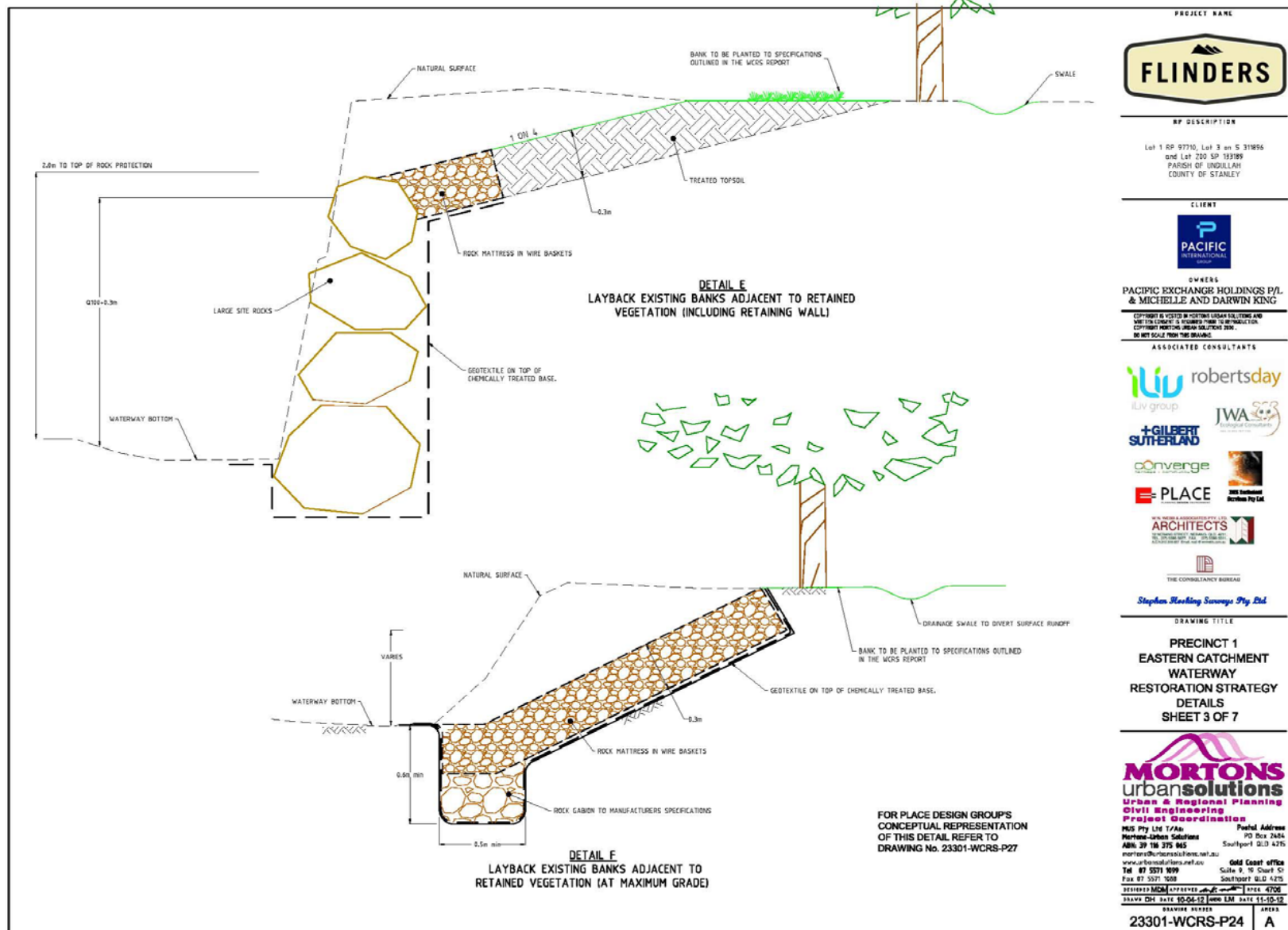


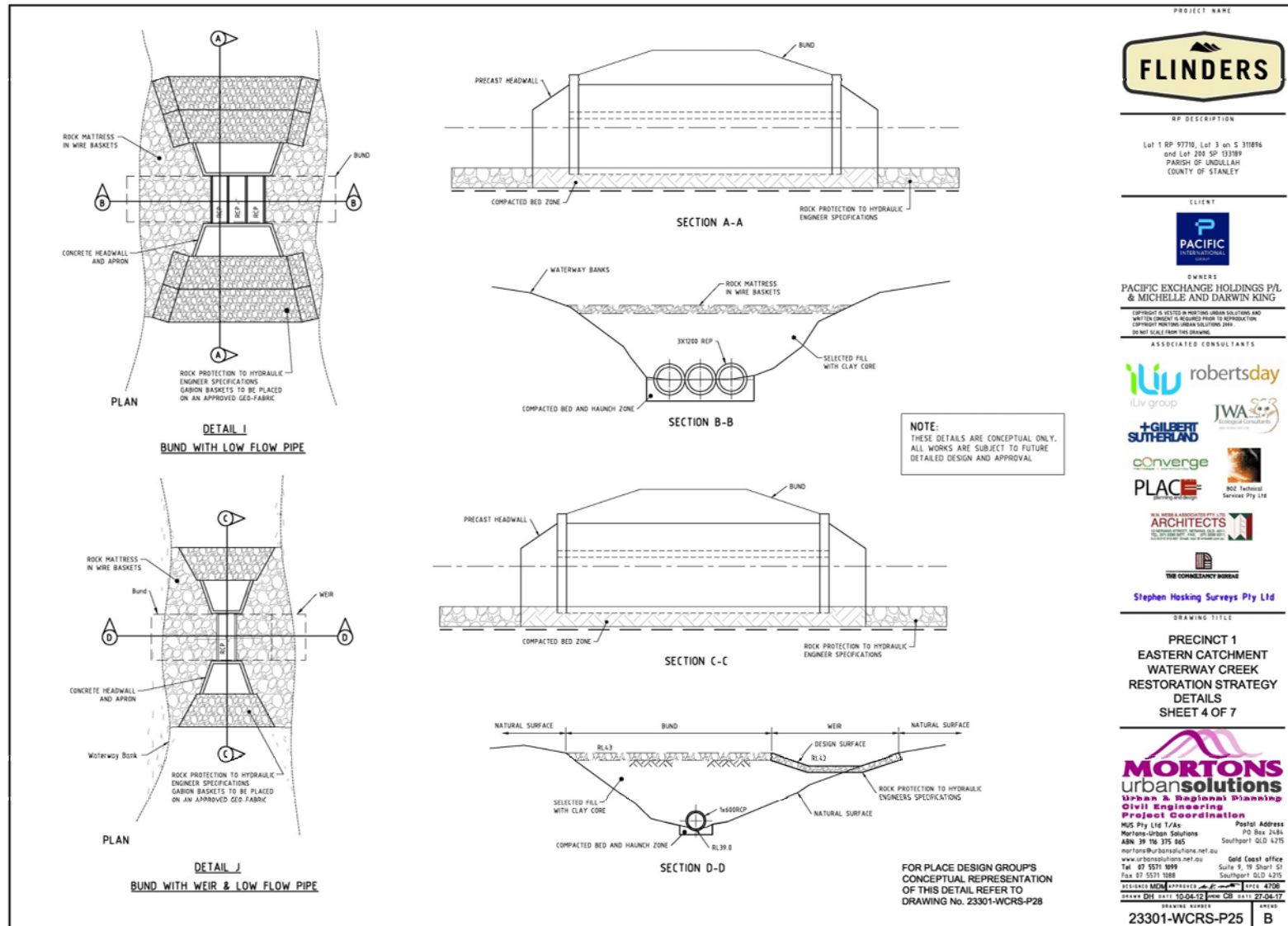
- Chemical treatment of exposed surface
- Rock wall (or similar) to a minimum height of $Q_{100} + 300\text{mm}$
- Drainage swale to divert surface runoff on top of bank
- Application of topsoil and landscaping
- Layback of existing banks adjacent to retained vegetation (maximum grade) (Detail F)
 - Treatment as per Detail C above although rock protection extends to natural ground at a slope of 1:2 to retain the existing vegetation.

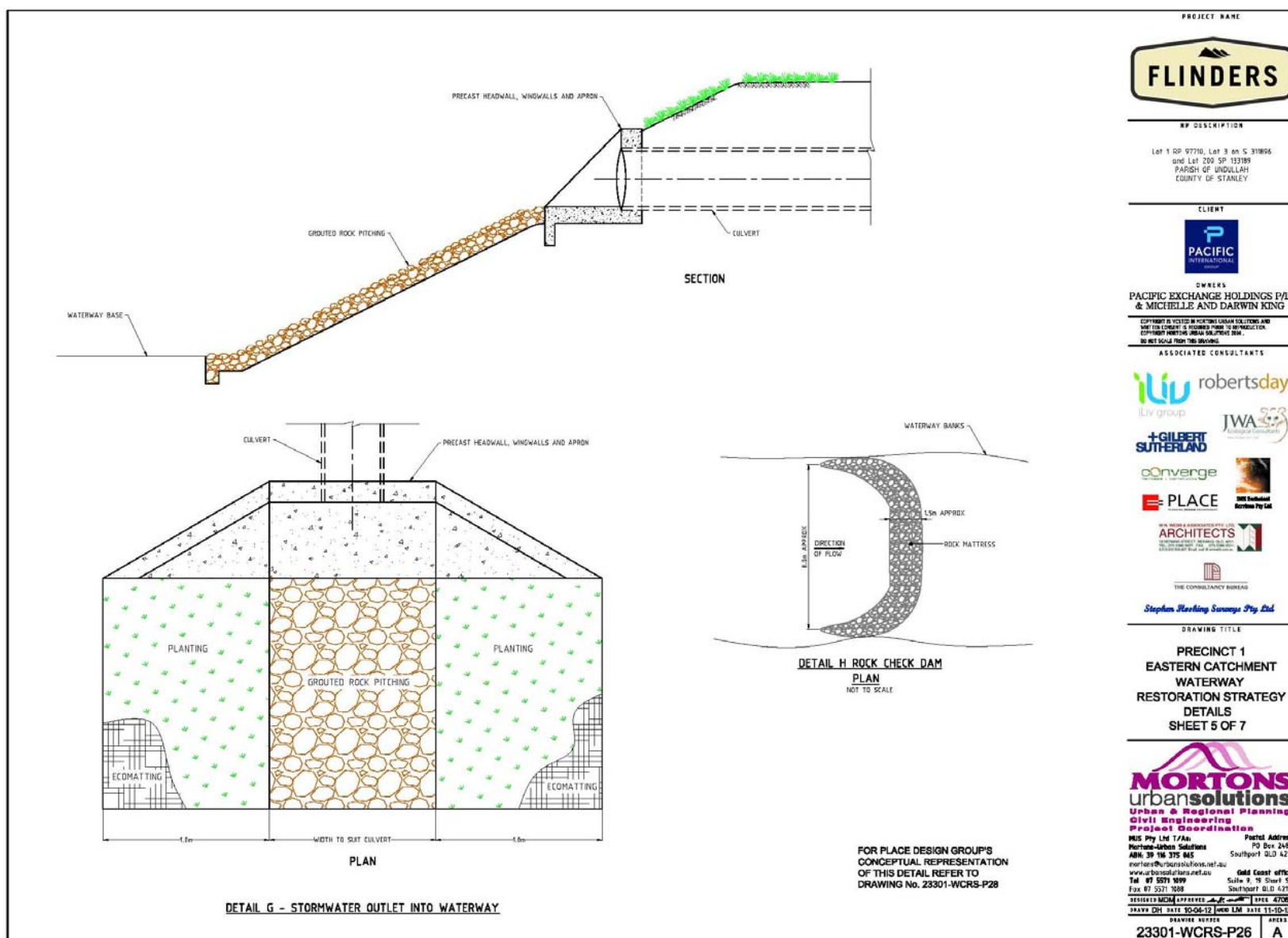
Figure 6 over the next seven pages shows typical concept details for the re-profiling of the unstable waterway banks within Precinct. These details are conceptual only and are subject to future detailed design and approval.

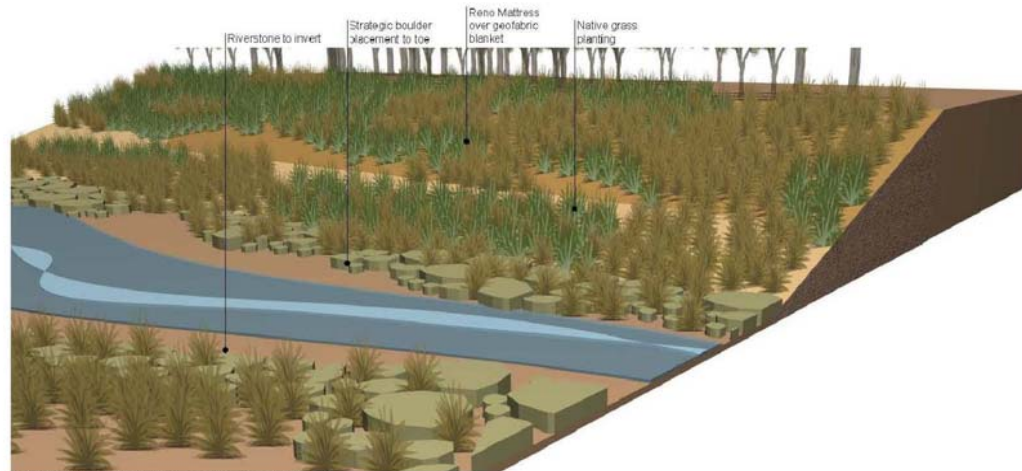




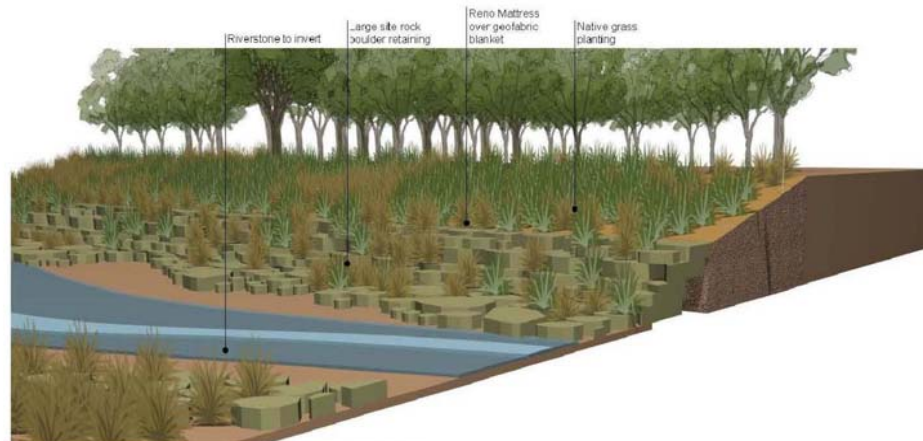








TYPICAL LAYBACK EXISTING WATERWAY



TYPICAL RETAINING LAYBACK EXISTING WATERWAY
ADJACENT TO RETAINED SIGNIFICANT VEGETATION

NOTE:
GRAPHICS PROVIDED BY
PLACE DESIGN GROUP

PROJECT NAME



RP DESCRIPTION

Lot 1 RP 97710, Lot 3 on S 31896
and Lot 200 SP 133189
PARISH OF UNDULLAH
COUNTY OF STANLEY

CLIENT



OWNERS

PACIFIC EXCHANGE HOLDINGS PTY LTD
& MICHELLE AND DARWIN KING

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ASSOCIATED CONSULTANTS



DRAWING TITLE

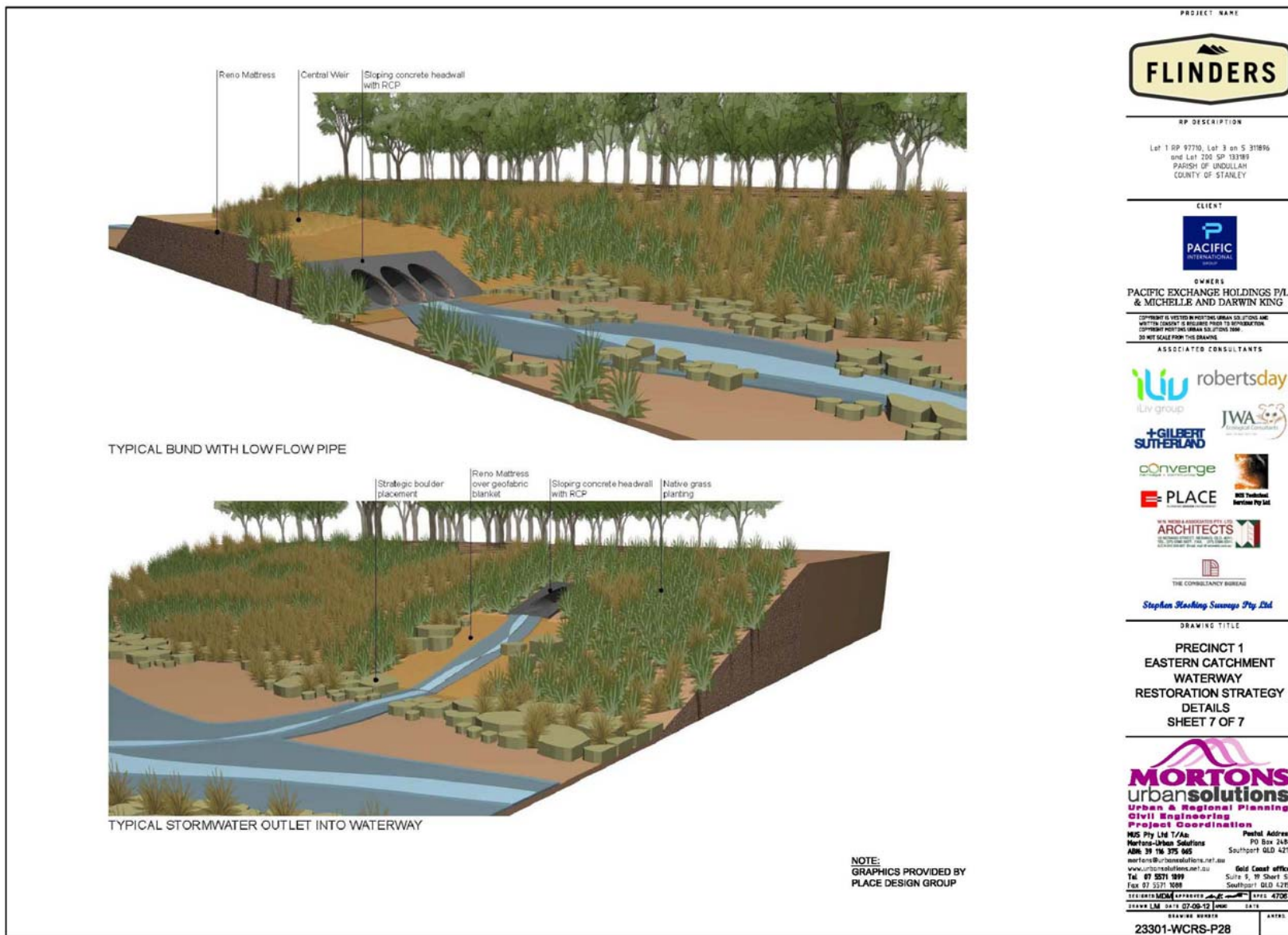
PRECINCT 1
EASTERN CATCHMENT
WATERWAY
RESTORATION STRATEGY
DETAILS
SHEET 6 OF 7



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REVISIONS
NO. DATE BY
1 07-08-12 JLM
2 23-01-17 JLM
3 23-01-17 JLM

23301-WCRS-P27





5.3 Dispersive Soil Treatment

Gilbert & Sutherland have prepared a Soils Site Based Management Plan (SSBMP) (**Reference 10**) that outlines the treatment of the dispersive soils present onsite. This SSBMP has been updated by Wholistic Environment to incorporate the lake (**Reference 11**). The reports describe the identification and treatment of dispersive soils with gypsum, lime and/or dolomite for use within the earthworks. Following treatment, the previously dispersive soils are suitable to be incorporated into the development with no future treatment required.

It must be noted that simply covering dispersive soils with a mechanical product will not stop erosion. The soil chemistry needs to be neutralised and then both cross-sections and profiles be reshaped to provide a hydraulically stable surface for the expected flows into the future.

The identification and treatment of dispersive soils is relatively simple and inexpensive and its treatment entails the use of a calcium-based product (gypsum, dolomite, or lime) that permanently, over time, corrects the physical instability and the associated qualities that are hostile to plants.

The topsoils are generally stable but most of the subsoils are dispersive. Chemical correction of the dispersive subsoils will also make these soils more suitable for plant growth. This is important as the plants will provide long-term protection against erosion.

5.4 Natural Channel Design

The principle of Natural Channel Design (NCD) is based on providing the required hydraulic conveyance of a drainage channel and floodway while maximising its potential environmental values. This wholistic approach combines the disciplines of hydraulic engineering, fluvial geomorphology and in-stream and riparian ecology. NCD also encompasses non-scientific/engineering principles such as community requirements. Refer Brisbane City Council's Natural Channel Design 2003 document.

A principle focus is on alternatives to hard armouring of waterway banks. The project team's intent for the proposed waterway rehabilitation is to stabilise the waterways and as much as possible have them look and behave like natural waterways. Therefore during the detailed design phase of the waterway rehabilitation, natural channel design techniques will be incorporated where practicable.

Natural Channel Design techniques aim to dissipate energy and divert the higher velocities away from the waterway banks. This is achieved via straightening the overall stream reach whilst maintaining meandering for the lower flows, strategically locating felled trees and rootballs along the banks, and the use of cross vanes and v-weirs to name a few of the common structures. When properly designed these structures increase habitat diversity along the waterways.

Photos: Cross-vane examples – United States Department of Agriculture, 2007



5.5 Clearing, Revegetation and Rehabilitation

To facilitate the lake and the corridor re-profiling works, clearing of existing vegetation is inevitable. The re-profiling works will be specifically designed to minimise clearing wherever possible, particularly the clearing of habitat trees identified by the project's Ecologist.

The lake has been intentionally located in the most eroded area of Precinct 1 to minimise impacts beyond those areas already requiring stabilisation of the existing waterways. Clearing of areas that do not involve civil works (ie stable areas) will also require clearing works although this will generally be limited to the clearing of weeds. Given the extent of proposed works, the WCRS will be completed in stages. Progressive rehabilitation and revegetation will commence at the completion of each re-profiling stage.

Whilst some areas will not be amenable to revegetation as a result of the rock structures placed on the banks, the large majority of the waterway corridor areas will be rehabilitated and revegetated. Plants used in the revegetation programs will be chosen based on the species mix which originally occurred along the waterway. These plant communities have been selected based on a review of Queensland Department of Environment and Resource Management (DERM) "pre-clearing" maps (refer **Figure 7**). These maps show the distribution of plant communities (regional ecosystems) across the landscape prior to clearing activities in Queensland commencing.

Whilst no clearing of remnant vegetation is envisaged as part of the WCRS, future detailed investigations into waterway stability may require its removal. Any clearing of remnant vegetation will be carefully considered and if unavoidable will be detailed in future Vegetation Management Plans and Tree Clearing Applications to EDQ.

Rehabilitation and revegetation of the site will be designed to reflect the ecological values identified within SHG's ecological reporting with a focus on developing within lower value areas and retention / rehabilitation of the highest priority areas.

Future ecological reporting will be prepared to provide further detail on the proposed strategies ensuring the long term sustainability of the project. This reporting will include a Natural Environment Overarching Site Strategy, Vegetation & Fauna Management Plans, Open Space Management Plan and Environmental Management Plan.

5.6 Habitat Values

It is intended that once rehabilitated, the Natural Areas and Waterway Corridors will provide habitat values for flora and fauna, and fauna movement opportunities between habitat patches on and off the site. Several significant species that are either expected to utilise the Flinders area or were sighted during targeted investigations include (but not limited to) the:

- Koala;
- Grey Headed Flying Fox;
- Greater Glider;
- Brush Tailed Rock Wallaby
- Large-eared Pied Bat
- Swift Parrot;
- Migratory Birds; and
- Spot-tailed Quoll.

It is important to note that no threatened fauna species were observed as occurring within the vicinity of the proposed lake area and no existing habitat for these species was observed (refer **Reference 7**).

The re-establishment of primary koala habitat on the site will be facilitated by the planting of primary koala food trees including Queensland blue gum (*Eucalyptus tereticornis*), gum-topped box (*E. moluccana*) and small fruited grey gum (*E. propinqua*).

The retention of hollow-bearing habitat trees will provide denning sites for gliders and hollow nesting birds. The development of new tree hollows will occur as more eucalypts mature in retained areas of regrowth and remnant vegetation.

The rehabilitation of the waterway corridors will also provide habitat for amphibious species including the green-thighed frog. The inclusion of the lake will provide additional habitat values for aquatic fauna.

The rehabilitation of a mosaic pattern of understorey vegetation, as well as the restoration of important ground cover characteristics including hollow logs (sourced from hollow trees removed during development of Precinct 1), will provide habitat for quolls and other ground dwelling fauna.

These principals for restoring habitat values will be incorporated into the Rehabilitation Strategies that will be implemented with the development of each Neighbourhood and the adjoining waterway corridors.

5.7 Landscape

Beyond the rehabilitation works associated with the waterway banks and DEHP stream protection zones, there will be a landscape zone (a Major Linear Park in EDQ terminology). This zone will include an extensive off-road shared pathway system that will promote education and recreation activities through outdoor opportunities such as fitness, and fauna and flora identification within the natural environment. It is also proposed that there will be stormwater management devices within the landscape zone that will be designed and landscaped to facilitate stormwater treatment.

The landscape zone will be landscaped to address the proposed bushfire management strategies using species prevalent in the area and drawing on the natural setting of Flinders.

5.8 Bushfire Management

Generally a 20m separation distance around the edge of development is proposed to address the potential bushfire hazard risk. In locations where this arrangement is not proposed, a 6m wide cleared zone with fire trail will be implemented in accordance with the recommendations of a bushfire management plan.

5.9 Stormwater Management

BMT WBM have prepared two reports (**References 6 & 12**) addressing the mitigation of potential impacts on stormwater quantity and quality as a result of the proposed development. The measures are summarised in the following two sections.

5.9.1 Flooding – Post-Development

BMT WBM's post-development flood modelling, detailed in their '*Flood Impact Assessment*' report (**Reference 6**), outlines the proposed mitigation strategies associated with post-development flood detention.

Photo: Eastern Catchment waterway a few days after heavy rainfall



The lakes are located in the eastern catchment of Precinct 1 is an integral part of the stormwater management strategy with other online structures (ie road crossings or bunds within waterways) contributing to the overall flood detention strategy.

Drawing 23301-WCRS-P25 and P26 contained with **Figure 6** provide a conceptual details of the stormwater structures proposed for flood management within the waterway and a detail of

the proposed treatment of a stormwater culvert outlet from development into the waterway. These details may apply upstream of the lake and in the western catchment.

BMTWBM's post-development flood report summarises that, the proposed online lake system, can successfully mitigate the effects of the development to ensure that there is a no net increase in peak flow at the boundary of the site or increase in flood level downstream of the site.

5.9.2 Stormwater Quality Management

As an integral component to the Flinders development, stormwater quality management needs to be carefully considered, particularly with respect to the dispersive soils present on-site. An assessment of the site constraints and opportunities identified that bio-retention basins would form the primary stormwater management measure (SMM) for the site. Ideally, these will be integrated into open space areas immediately downstream of areas proposed for development.

The Stormwater Quality Management Plan has provided the area of bioretention required for each sub-catchment to ensure the stormwater quality management objectives (SQMOs) are met. The SQMOs are derived from the State planning policy (DSDIP 2014) and require reductions in total suspended solids (TSS), total phosphorus (TP), total nitrogen (TN) and gross pollutants (GP) loads of 80%, 60%, 45% and 90% respectively. Water quality modelling was undertaken using Version 6.1 of the MUSIC modelling software.

5.10 Cultural Heritage Surveys

Cultural Heritage surveys and monitoring will be undertaken as per the Cultural Heritage Management Plan.

The approved Cultural Heritage Management Plan outlines a protocol if significant items are found and this document will be adhered to as part of the WCRS works.

5.11 Public Access

The waterway corridors are an important feature of the Flinders development and will be promoted and celebrated where possible. There are several locations along the waterway where rocky outcrops make great features and it is intended that meandering nature trails connect to these to allow the public to enjoy the natural features of the development.



Photo: Rock outcrop with small rock pools following rainfall.



5.12 Maintenance Periods and Dedication to Council

As outlined in Section 2 of this report, the WCRS has been split into three separate zones; waterway, stream protection and landscaping. Logan City Council will ultimately take ownership of all three zones following the Maintenance periods.

Given the nature of the work proposed in the waterway and stream protection zones in comparison to the landscape zone, it is considered appropriate that different maintenance periods apply to reflect the different risk profile associated with the proposed works.

As suggested by ULDA (now EDQ) at the time of writing the original report, it was considered to base the duration of the periods on specific events. However, given the uncertainty associated with the timing of events (ie. we could wait 5 years for a 1 in 5 storm to unsuccessfully eventuate) and potential disagreement as to what level of a storm actually represents, it is proposed the periods are based on a timeframe (as is normally the case with open space works).

Minimum timeframes are proposed in Table 2. Longer periods may be considered on a site specific basis.:

Table 2: WCRS maintenance and dedication timing

Landscape Zone	Waterway Zone	Stream Protection Zone
Establishment Period		
6 months	12 months	12 months
Maintenance Period		
12 months	24 months	24 months
Dedication		
Dedication to Council at the completion of the relevant maintenance period		

6.0 MITIGATION OF POTENTIAL IMPACTS

The strategies proposed for the WCRS to mitigate the potential impacts are outlined in the following sections.

6.1 Erosion & Sediment Control

Given the results of the preliminary investigations performed to date, Wholistic Environment have provided an updated *Site Based Management Plan for Dispersive Soils* (**Reference 11**). This document outlines over-arching strategies for dealing with the sodic soils identified onsite. The proposed strategy to address sodic soils within the waterways is as follows:

- Planning - identification through soil sampling & careful works programming;
- Chemical amelioration of dispersive soils;
- Precise re-compaction above optimum moisture content;
- Diversion of in creek (where possible) and overbank stormwater;
- Burial;
- Progressive revegetation.

Proposed management strategies to minimise the release of sediment and sediment-laden water include rehabilitation via revegetation and soil treatment, landscaping, and bank reprofiling which will result in a more stable and diverse environment than that which currently occurs. Following completion of construction of the waterways in accordance with this WCRS it is expected the water quality of the waterways will be significantly improved. Background monitoring will be performed to provide an accurate pre-construction base line.

The stream rehabilitation will be progressive in terms of both disturbance and stabilisation utilising best practice techniques. This will include the use of bunds upstream and downstream of a work area with pump-around or passive flow bypass.

The construction and maintenance of temporary sediment basins will be critical in the initial erosion and sediment management of the site.

Photo: Existing waterway's sand bed load





6.2 Dust

Flinders (Precinct 1) is typical of a rural area, with the main source of air pollution expected to be from dust or suspended particles. Potential sources of dust associated with the proposed works include:

- Dust from the removal of topsoil and extraction of bank material;
- Wind-blown dust from the stockpiles;
- Fugitive dust generated during the excavation of the banks; and,
- Dust from the construction traffic accessing the site.

Given the isolation of the site from neighbouring residences, modelling of air quality impacts is not considered necessary.

Mitigating measures will include the following:

- Watering of unsurfaced roads, stockpiles and the excavation face.
- Prompt rehabilitation of disturbed areas.
- Minimising stockpiles and covering stockpiles where long term stockpiling is proposed (either with an appropriate geofabric or with vegetation).

Monitoring is to be undertaken in response to complaints by the Contractor with additional increased mitigation measures implemented when required in response to adverse environmental conditions or complaints.

6.3 Waterway & Lake Water Quality

Water quality impacts are a potentially significant issue associated with the works proposed within the WCRS. The proximity of the works within and adjacent to the watercourses increases the importance of appropriate management and mitigation measures as the opportunity to treat impacted water prior to it leaving the site is limited.

The primary management strategies for water quality management include:

1. **Planning** - The risk of water quality impacts will be reduced dramatically simply by the undertaking sensitive works in the dryer months of the year (typically June – September). Detailed planning of surface water control and erosion and sedimentation controls for each stage of works will also minimise the risk of adverse impacts.
2. **Minimising the spatial extent of disturbance** – The works would be staged to ensure that in the event of rainfall the area to be stabilised is manageable. The area exposed is directly related to the risk of downstream water quality impacts. Progressive clearing will be a key component to minimising the impacts associated with earthworks. The area disturbed during any stage of works will be limited to that which can be completed within 4 weeks of commencement in the dry season (June – September) or 2 weeks in the wetter months (October – May).
3. **Drainage control** – Diverting water around and through work areas is critical to minimising the mobilisation of fine sediments, especially for dispersive soils.
4. **Sedimentation control** - Sediment control techniques/measures will be implemented as a last line of defence to capture and retain sediment in the works area during low flow events.
5. **Rapid stabilisation following disturbance** – Disturbed areas will be progressively stabilised and revegetated following works to minimise the risk of ongoing erosion or damage to the watercourse.

Water quality and stormwater runoff into the lake is a very important component of the lake design. Conceptual strategies have been prepared and outlined by BMT WBM in their Concept Lake Management Plan (**Reference 13**).

6.3.1 Ground Water

Any groundwater encountered during works will be pumped to a holding pond, irrigated or discharged downstream if the water quality criteria are met.

The risk of groundwater contamination is considered to be minimal as the most significant potential contaminant is sediment and suspended sediment. These are not transferred to groundwater. Nutrients associated with the use of fertilisers or organic soil products and mulches are able to be managed by applying only the necessary concentration in combination with prudent and targeted application.

6.3.2 Surface Water

Existing water quality at and downstream of the site indicates that surface water is already significantly impacted, particularly by sediment. Discharge from the site should be considered in this context.

Surface water impacts will primarily be managed as described above and as outlined in BMT WBM's Stormwater Management Plan (**Reference 12**).

6.4 Local Fauna

A range of native fauna species utilise the waterway corridors for foraging and habitat purposes, including significant species such as the green-thighed frog (*Litoria brevipalmata*) and the koala (*Phascolarctos cinereus*).

Photo: Green-thighed Frog & Koala (Source Wikipedia)



The following strategies will be implemented to ensure native fauna are considered during the re-profiling, lake and rehabilitation works in the waterway corridor:

1. Inspections of all habitat trees prior to removal;
2. A qualified spotter/catcher is to be present when all trees are removed;
3. All observable tree hollows are to be salvaged when the habitat trees are removed. These hollows can be utilised in other nearby mature trees;



4. No tree is to be removed whilst a koala is in the tree. Removal can proceed when the koala has vacated the tree; and

The rehabilitation works will significantly improve the conditions for all site fauna and in particular species known to utilise the corridor habitats. It is considered that there will be a substantial increase in the area of habitat for native fauna including significant species such as koala, squirrel gliders and green-thighed frogs resulting from these works.

6.5 Noise

Works will not extend outside of the proposed operational times of 6:30am to 6:00pm.

A complaints register will be established and reviewed/actioned by Management on a weekly basis with regular noise assessments and audits to be conducted in response to complaints.

6.6 Construction Access

Where possible, machinery will work from the top of the waterway banks. However, given the nature of the works and instability associated with the banks, construction machinery will need to work primarily from within the waterway.

Designated entry and exit points into the waterway will be determined and machinery/vehicles will be restricted to these locations.

7.0 IMPLEMENTATION

The following sections outline the manner in which the proposed stabilisation and re-establishment strategies (refer **Section 5**) will be implemented within Flinders (Precinct 1).

7.1 Waterway Description

In order to assign appropriate treatments and develop staging of the proposed works, the waterways will be reviewed based on their soil types and current conditions. An example of these is provided Table 7.1 below which reviews the Eastern Catchment of Flinders (Precinct 1):

Table 7.1 – Eastern Catchment Summary

Adjacent Neighbourhoods & Brief Description	Stream Orders	Soil Types
Area 1		
NH1, NH3A, 3B, 3C & 3D and NH6B Includes the main discharge point of the eastern catchment from the site and includes areas of significant erosion.	1, 2, 3 & 4	Mixed Tenosols, Kurosolc, Sodosols, Sodic Dermosols, Dispersed Sodosols, Kurosols and Tenosols of Low Sodidity
Area 2		
NH2, NH4 and NH3A Centrally located and includes significant erosion.	1, 2 & 3	Sodic Dermosols, Dispersed Sodosols, Sodosols, Kurosols and Tenosols of Low Sodidity.
Area 3		
NH5, NH2, NH4 and NH9A Important location as it adjoins the neighbourhood activity centre and the district sport and recreation parks. Includes areas of significant erosion.	1, 2 & 3	Sodosols, Kurosols and Tenosols of Low Sodidity.
Area 4		
NH4, NH9A, NH9B and H1 Located high in the catchment with only a few localised areas of erosion.	1, 2 & 3	Kurosols and Tenosols of Low Sodidity
Area 5		
NH4 and H2 Located high in the catchment with only a few localised areas of erosion.	1, 2 & 3	Kurosols and Tenosols of Low Sodidity, Sodic Dermosols and Dispersed Sodosols.

Photo: Existing waterway erosion to the east of NH4.



If the erosion in the photo above is left untreated, erosion within the waterway will continue as a result of the combination of dispersive soils and columnar structure.

7.2 Waterway Stabilisation

Given the variability of instability witnessed onsite, it is likely that the Flinders (Precinct 1) works will involve the implementation of a combination of the strategies proposed in **Sections 5.2 to 5.6**. The proposed corridor re-profiling works will be assessed on a case by case basis for each stage of each waterway with the proposed works detailed within future operational works drawings.

To limit the amount of sediment runoff into the lake, it is proposed that the waterways upstream of the lake will be assessed and areas of instability addressed as part of the lake construction works. This will help improve water quality within the lake and minimise ongoing maintenance of the lake.

It is noted again that the proposed WCRS treatment options have been developed collaboratively and are the result of a combined multi-disciplinary approach to the stabilisation works. All areas of the waterways will be assessed by the project team and appropriate treatments will be developed and implemented.

Observations to date have indicated that the majority of the re-profiling works will be required in the lower part of the catchment where the soil conditions are more susceptible to erosion and the stream velocities are greater.

As the Waterway Corridor Restoration works progress; the proposed works will be adjusted as required to ensure the most appropriate treatments are implemented at the time. All other drainage features within the development areas will be removed and drainage will be provided via stormwater pits and pipes.

It is proposed that future Reconfiguration of a Lot Development Applications will nominate the associated area of the waterway to be restored (via a balance lot) concurrently with the adjacent lots to be created. Details of the proposed Waterway Restoration Works in accordance with this strategy will be provided with associated Operational Works Applications.

Photo: Existing waterway erosion typical around NH1.



7.3 Clearing and Revegetation

Section 5.5 notes that clearing of vegetation will be required to facilitate the waterway stabilisation works. If offset planting is required, the offset will occur along the retained waterway corridors and within the Natural Areas. Offsets will be calculated as per the required legislation and conditions of approval provided by EDQ.

Clearing works will be performed in accordance with relevant Vegetation Management Plans and the endorsed Natural Environment OSS.

Currently there is no proposed clearing of remnant vegetation for the WCRS works within Flinders (Precinct 1).

7.4 Stormwater Management

The proposed hydraulic structures within Flinders (Precinct 1) will include a number of road crossings and an 'online' storage facility (i.e. the recreational lakes). The location and details of the road crossings will be confirmed as part of the detailed design phase of the project.

Stormwater management devices will be designed generally in accordance with the conceptual details shown on Drawings 23301-WCRS-P25 and 23301-WCRS-P26 contained within **Figure 6**. It is noted the conceptual details shown within **Figure 6** are subject to future detailed design and approval.

Stormwater runoff will be managed in accordance with the strategies outlined in BMT WBM's Stormwater Quality Management Plan (**Reference 12**).

8.0 CONCLUSION

The Waterway Corridor Restoration Strategy proposed within this report has been developed with a multi-disciplined approach aimed at restoring the waterways to a stable and sustainable condition which aims to preserve or re-establish the natural amenity of the existing waterways.

The inclusion of recreational lakes will provide a greater amenity outcome for future residents of Flinders (Precinct 1) through the increased opportunity for a variety of recreational uses.

Whilst this report outlines proposed strategies for stabilisation and re-establishment, the Project Team remains cognisant that the WCRS must be flexible and adaptive. The Project Team will monitor and learn from the works progressively undertaken to ensure that best practice is followed during the rehabilitation of Flinders' (Precinct 1) waterways.