PARADISE WATERS, DEEBING HEIGHTS
PRECINCT A

PRELIMINARY WATERWAY STABILITY ASSESSMENT

DesignFlow
Prepared for Stockland
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Potential implications of climate change

Unless expressly stated otherwise, historical climate data has been used in, or underpins, the analyses that are presented in this report. The historical climate is not necessarily a valid indicator of future climate, which may contain prolonged periods that are wetter or drier than the historical record used for this analysis. There is significant uncertainly surrounding how climate, and in particular, rainfall, will be impacted by various levels of greenhouse gas accumulation in the atmosphere. Rainfall has a much greater spatial variability than temperature and some areas are likely to become wetter whilst other areas become drier. Further to this there may be changes in the seasonality and intensity of rainfall. Such changes in climate could affect the conclusions and recommendations of this report.

Inherent natural variability in soils and plants

Where particular types of soils are recommended, such recommendations are based on information provided by soils suppliers, laboratories and published industry guidelines. There can be inconsistencies in the behaviour of soils under field conditions compared to laboratory conditions, and, for both natural and blended soils, many soils are non-homogenous and properties and behaviour can be variable. Where particular plant species have been recommended, such recommendations are based on botanical knowledge and observations of similar species growing in similar, but not identical conditions. Plants can be sensitive to subtle changes in climate, hydrology, soil and surrounding ecological conditions. Further to this, plant health is often closely linked to the level of maintenance provided. No warranty or guarantee, whether explicit or implied is made with respect to the suitability or performance of soils or plant species recommended in this report

Table of Contents

1 INTRODUCTION ... 1
1.1 RIPLEY VALLEY UDA – INTERIM LAND USE PLAN REQUIREMENTS ... 2
1.2 PURPOSE OF THIS DOCUMENT ... 3
1.3 STRUCTURE OF THIS DOCUMENT ... 4
1.4 SCOPE OF ONGOING INVESTIGATIONS ... 4
2 PRELIMINARY SITE AND WATERWAY APPRAISAL ... 5
2.1 GENERAL ... 5
2.2 VEGETATION ... 5
2.3 SOILS ... 5
2.4 CATCHMENT ... 7
2.5 DEEBING CREEK WATERWAY ... 10
2.6 EXISTING DAM ... 10
2.7 WATERWAY ASSESSMENT ... 13
3 PRELIMINARY WATERWAY STABILISATION STRATEGY ... 19
3.1 GENERAL ... 19
3.2 PRESERVING WATERWAY CORRIDORS ... 21
3.3 MANAGING CHANGES IN HYDROLOGY ... 21
3.4 STABILISATION TECHNIQUES ... 22
4 WATERWAY STABILITY ASSESSMENT - PRECINCT A ... 27
4.1 DESIGN OBJECTIVES ... 27
4.2 PERFORMANCE ASSESSMENT ... 29
5 CONCLUSION ... 31
6 REFERENCES ... 32

List of Tables

Table 1: Interim Land Use Plan Requirements 3
Table 2: Deebing Creek catchment soil summary 6
Table 3: SEQ Regional Plan waterway stability design objective 27
Table 4: Peak 1 year ARI discharge comparison 29
Table 5: Preliminary shear stress comparison for 1 year ARI 30

List of Figures

Figure 1: Site Locality 2
Figure 2: Indicative soil profiles in Precinct A 7
Figure 3: Paradise Waters topography and drainage (structure plan) 8
Figure 4: Catchment plan 9
Figure 5: Existing dam 12
Figure 6: Waterway reach layout 14
Figure 7: Existing waterway layout 15
Figure 8: Reach 1 Assessment 16
Figure 9: Reach 2 Assessment 17
Figure 10: Reach 3 Assessment 18
Figure 11: Preliminary waterway stabilisation strategy 20
Figure 12: Rock chute configurations 23
Figure 13: Bank stabilisation configuration - full and partial height 24
Figure 14: Battering and revegetation configurations 25

1 INTRODUCTION

Creeks are naturally mobile systems that are continually undergoing erosion, deposition and realignment due to the natural forces of water in both low flow and flood conditions. Under natural conditions the stream, vegetation and in-stream ecology adapts to these changes as they occur slowly in an undisturbed catchment.

When land clearing and urbanisation occurs, larger and more frequent flows occur within the stream, accelerating the naturally slow stream forming processes causing increased erosion and sediment transport. Vegetation has less ability to re-establish and stabilise banks and so the system becomes unbalanced. In most urban streams this results in bed erosion and widening of the waterway.

It is therefore necessary to manage waterways within new urban areas appropriately in order to provide a new balance that considers both the natural and urban impacts on the stream morphology. This may involve:

- Minimising the change in hydrology (thus minimising the risk of waterway instability)
- Rehabilitating waterways
- Stabilising eroded sections of waterway

The Paradise Waters development site is located in the Deebing Creek catchment (Figure 1). Much of Deebing Creek and its tributaries have undergone significant erosion to the dispersive erosive soils, clearing of riparian vegetation, waterway disturbance (road and cattle crossings) and hydrologic/land use change. The development of the Paradise Waters site will significantly increase impervious area in the catchment and result in further significant hydrologic change if left un-mitigated. Careful management of the hydrology and waterway environment is required to avoid exacerbating, and where possible improving, the current erosion and waterway stability issues.

This document presents the findings of the preliminary waterway stability assessment for the waterway adjacent to Paradise Waters Precinct A. The preliminary assessment is provided to support the Development Application for Precinct A and represents the first stage of an ongoing waterway assessment and stabilisation strategy for the broader Paradise Waters site.

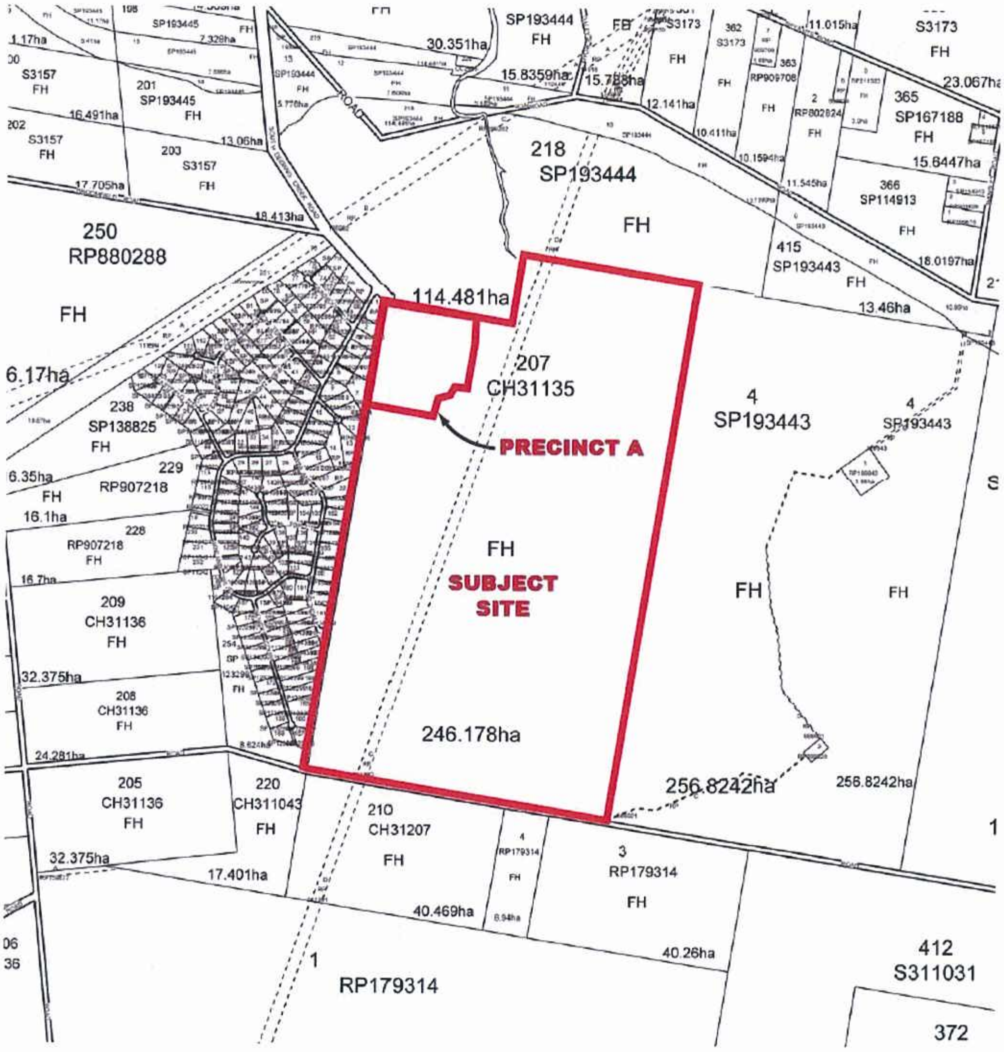


Figure 1: Site Locality

1.1 RIPLEY VALLEY UDA – INTERIM LAND USE PLAN REQUIREMENTS

The Paradise Waters development is located within Precinct 7 of the *Ripley Valley Urban Development Area Interim Land Use Plan* as defined by the Urban Land Development Authority (ULDA) pursuant to the Urban Land Development Authority Act 2009. The *Ripley Valley Urban Development Area Interim Land Use Plan* identifies a number of key principles and requirements of development to contribute to the environment and sustainable development. The principles identified in Section 5.6 of the Plan which are applicable to waterway stability are that developments deliver protection of amenity, ecological values and natural systems.

Specific requirements outlined in the *Interim Land Use Plan* that related to waterway stability are summarised in Table 1. The table also provides the response to the requirements in the form of proposed waterway stability outcomes. The remainder of this document summarise these outcomes in detail.

Table 1: Interim Land Use Plan Requirements

Requirements	Proposed Waterway Stability Outcome
Maintain the safety of people and property from subsidence, contamination, landslip, saline and dispersive soils.	Specific objectives have been established in relation to stream stability impacts from development discharges. These objectives are consistent with the SEQ Regional Plan Implementation Guideline No.7 and the recently released State Planning Policy for Healthy Waters.
Maintain and enhance the functioning and characteristics of the hydrological network including the riparian ecology of Deebing Creek and its secondary tributaries.	Riparian buffers have been maintained either side of the waterway as per current Ripley Valley Structure Plan. Stabilisation and rehabilitation of the waterway is proposed as part of development to ensure long term functionality as a conveyance and ecological corridor.
Maintain and enhance the environmental values of the receiving waters and wetlands by sound catchment management practices.	Waterway stabilisation and rehabilitation is proposed for the site with best practice management of urban stormwater quality and flows.
Appropriately manage floodwater and stormwater.	As above

1.2 PURPOSE OF THIS DOCUMENT

This report represents the first step in the creation of a waterway stabilisation strategy for the Paradise Water site. It provides a preliminary assessment of the current waterway stability issues associated with the upper reaches of Deebing Creek and presents a preliminary waterway stabilisation strategy. This strategy is to be refined as part of ongoing investigations.

The report also provides a rapid assessment of the hydrologic influence that the development of Precinct A has on waterway stability. The assessment is based on initial site inspections and hydraulic/hydrologic modelling for Precinct A and documented in preliminary format in order to support the Development Application of Precinct A.

1.3 STRUCTURE OF THIS DOCUMENT

This preliminary waterway stability assessment is documented in the following sections:

- SECTION 2 Provides background information relating to the site and catchment and summarises the current waterway condition.
- SECTION 3 Describes the preliminary strategy to mitigate waterway stability issues and identifies stabilisation techniques to be used in specific problem areas.
- SECTION 4 Presents the preliminary quantitative hydrologic assessments undertaken for Precinct A to illustrate the fact that Precinct A will not influence the stability of the waterway.

1.4 SCOPE OF ONGOING INVESTIGATIONS

Ongoing investigations involve:

- assessment of dispersive soils
- detailed geomorphic assessment
- detailed review of hydrologic change
- identification of the potential changes in waterway form
- details of mitigation measures (hydrologic control and stabilisation/revegetation

This work is being completed in a collaborative fashion between DesignFlow (hydrologist/engineering/stormwater management/ecology), Water Technology (geomorphologists/hydrologists), Landloch (soil scientist) and RPS (landscape architects).

The result of the ongoing investigations will be an integrated plan for managing the waterway which considers:

- dispersive soils
- revegetation and riparian function
- waterway stability
- stormwater management
- flood management
- public open space and pedestrian linkage

2 PRELIMINARY SITE AND WATERWAY APPRAISAL

2.1 GENERAL

The preliminary site appraisal was undertaken to assess the current state of the waterways and catchments draining to the waterway. The focus on the appraisal was the reaches of the waterway adjacent to Precinct A and represents a qualitative assessment only.

The findings of the appraisal provided in the following sections highlight the significant factors influencing waterway stability adjacent to Precinct A and downstream in Deebing Creek. The appraisal has been based on the current best information available on the site and represents the first part of a larger waterway stability assessment that is required for the entire Paradise Waters development site.

2.2 VEGETATION

The broader site has been largely cleared of vegetation on the lower to mid slopes with scattered trees and grasses throughout these areas. Regrowth vegetation exists along the lower slopes adjacent to the main waterway corridor. This vegetation is currently partially mapped (Property Map of Assessable Vegetation by DERM) as high value regrowth vegetation, however much of this is at risk from destruction due to the major erosion occurring in this location. The vegetation directly adjacent and within the waterway is broad described as below:

- The upper bank vegetation (top half of waterway bank) is generally one of the following:
  - Unvegetated in locations of recent erosion
  - Grass/weed covered
  - Regrowth covered of varying quality
- The lower bank (bottom half of waterway bank) is generally grass/weed covered with isolated tree regrowth.
- The invert of the waterways is generally un-vegetated (in locations of recent scour/deposition) or grass/weed covered.

For full details of site vegetation refer to the *Ecological Assessment Precinct A – 'Paradise Waters', South Deebing Creek Road, Deebing Heights* (RPS, October 2010).

2.3 SOILS

According to the *Soils of Ipswich Field Guide* (ICC, 2010), the soils within Deebing Creek catchment comprise predominantly sodosols described as alkaline and sodic soils with sharp texture contrast (dispersive). The summary description of these soils from the field guide is reproduced in Table 2.

Table 2: Deebing Creek catchment soil summary

Soil Characteristic	Comments
Landform and Distribution	Widespread on plains and low hills
Key Features	Sharp contrast between sandy topsoils and clay-rich subsoils
Erosion	Highly erodible. Vulnerable to sheet, tunnel and gully erosion due to highly dispersive subsoils
Erosion and Sediment Control	Surface cover should be maintained as much as possible. On-site drainage should be diverted to reduce water flow velocity and to separate clean from dirty water. Sediment controls for coarser (sandy) materials may include sediment fences, but finer materials may require sediment basins and the use of flocculants to settle out clays
Fertility and Plant Growth	Generally low to very low nutrient status. Plant available water is very low. Plant growth is impeded by poor subsoil drainage due to high clay content, and is also impeded by tough clay subsoil

Source: Soils of Ipswich Field Guide (ICC, 2010),

The *Broad Geotechnical Appraisal* (Morrison Geotechnic, 2010) undertaken for Paradise Waters Precinct A provides further clarification of the soil conditions present. Generally, the topsoils comprise silty and clayey sands and are typically highly erosive due to their loose consistency (although not dispersive). These topsoils overly alluvial and residual soils (sand clays and clayey sands) which are dispersive (Emerson Class 2 or 3) and generally highly erosive when exposed to water. Once exposed, these dispersive soils can result in significant bed and bank erosion from overland and channelised flow.

The site inspections confirmed the dispersive nature of the soil and the erodible nature of the waterway banks. The photos shown in Figure 2 identify the shallow topsoil overlaying dispersive soils below which are commonly found along the waterway and gullies adjacent to Precinct A.

Figure 2: Indicative soil profiles in Precinct A

2.4 CATCHMENT

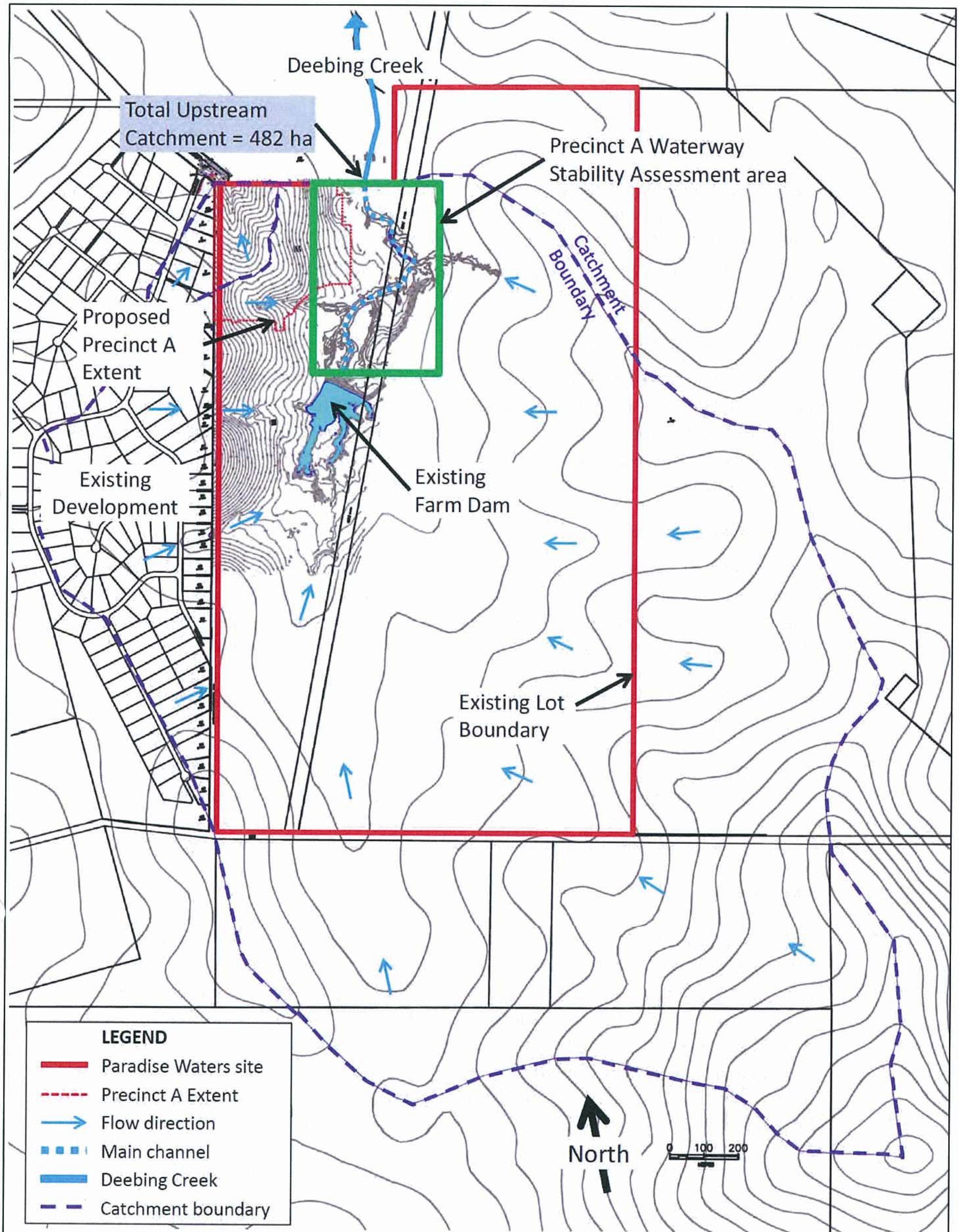
The topography across Precinct A and the broad site can be characterised as being moderate slopes (4-10%). The slopes give way to more gentle slopes (1-4%) within the waterway corridor which is illustrated in Figure 3.

The proposed Precinct A site is defined by a ridgeline that runs north-south creating a local catchment divide as shown in Figure 4. The majority of this development area drains east towards the waterway corridor at the upper reach of Deebing Creek. Post development drainage aims to maintain these current catchments as far as practical and provide appropriate water quality and flood detention infrastructure at key discharge locations.

The waterway channel at the northern boundary of the Paradise Waters site conveys flows from an upstream catchment of 482 hectares into the upper reaches of Deebing Creek. The contributing catchment comprises mainly forested and open pasture grazing land with a small portion of the catchment to the west comprising rural residential land use. A significant portion of this catchment enters the existing farm dam which plays a significant role in the instability of the waterways adjacent to Precinct A (refer Section 2.6 for details).

Precinct A is 14ha which is just under 3% of the total catchment to the discharge point (Figure 4).

Figure 3: Paradise Waters topography and drainage (structure plan)



DesignFlow	PARADISE WATERS PRECINCT A WATERWAYSTABILITY ASSESSMENT CATCHMENT PLAN	Date: 10/12/10	Sketch No.: FIGURE 4

2.5 DEEBING CREEK WATERWAY

The waterway through the site is the upper reach of Deebing Creek. The main waterway invert varies from around 55mAHD to 48mAHD in the vicinity of Precinct A. The waterway has undergone bed incision and bank erosion in the past. This erosion has exposed the dispersive soils which exist on site resulting in large changes in channel depth and width. Refer Section 2.6 for details.

2.5.1 Designated watercourse

Information received from the Department of Environment and Resource Management (Mark Beasley, 2010) indicates that under the *Water Act 2000*, Deebing Creek ceases to be a formally designated watercourse at the northern boundary of the Paradise Waters site. Therefore any works within the watercourse south of this point on the Paradise Waters site does not trigger a Riverine Protection Permit.

2.5.2 Waterway corridors

Department of Environment and Resource Management (DERM) vegetation mapping identifies the main waterway adjacent to the Precinct A as a 3rd and 4th order stream. The *Ipswich City Council Ripley Valley Structure Plan* mapping identifies the upper portion of Deebing Creek as a river and this extends to the existing dam.

In accordance with the Ripley Valley Structure Plan, the following waterway corridors have been applied:

- 50m vegetation protection and rehabilitation buffer/corridor has been applied (from surveyed top of bank) either side of the waterway to the existing dam
- 30m either side of the waterway centreline upstream of the existing dam

2.6 EXISTING DAM

An existing farm dam upstream of Precinct A forms a primary hydraulic feature within the lower portion of the main drainage line through the site. The dam receives flows from over 75% of the upstream contributing catchment (360ha +). It is unclear if the dam was constructed prior to or in response to the migration of head cut erosion within the waterway (refer Section 2.7) but is it clearly having major impacts on the hydrology and general morphology of the downstream channel. A number of actions have been taken to manage these impacts but rather than improving the situation that have cause further scour and erosion within the downstream waterways.

Figure 5 illustrates the issues associated with the existing dam. In summary:

- It is assumed the dam was created to supply water for grazing purposes.
- Waterway appears to be the original waterway alignment.

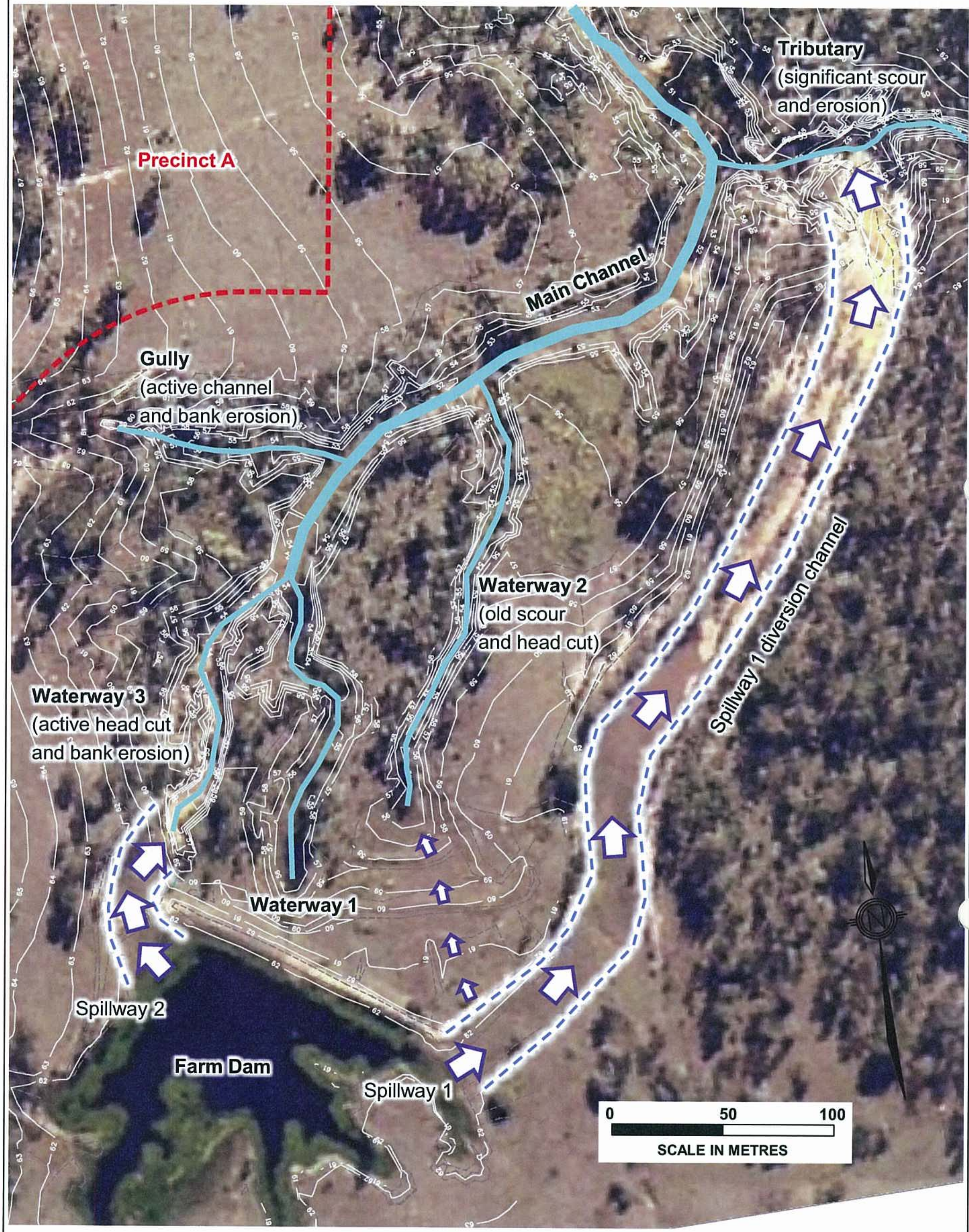
- As part of dam construction a spillway appears to have been created on the western end of the dam wall (Spillway 1). This may have resulted in the historic scour and creation of the eastern waterway (Waterway 2).

- In response to this, a diversion channel appears to have been created to convey Spillway 1 flows to the north to a small tributary (and bypass Waterway 2). This has resulted in a large change to the hydrology within the tributary causing massive scour and incision to the bed of this waterway. This erosion is still active and required significant works to stabilise.

- In response to this, Spillway 2 was created to reduce the flows to Spillway 1, resulting in the scour and creation of the western waterway (Waterway 3). The erosion of this waterway (head cut) is very active and threatens the integrity of the dam wall.

The dam forms an important feature in the drainage and waterway stability adjacent to Precinct A and must be considered in the overall strategy to manage the future flows through the site.

It is worth noting that upstream of the existing dam there are no significant waterway stability issues at the moment.



DesignFlow	PARADISE WATERS PRECINCT A WATERWAYSTABILITY ASSESSMENT EXISITNG FARM DAM FUNCTION	Date: 10/12/10	Sketch No.: FIGURE 5

2.7 WATERWAY ASSESSMENT

2.7.1 Summary

The waterway in the vicinity of Precinct A has undergone significant channel degradation and reformation over a number of decades. The key factors that appear to have contributed to the stream changes include:

- historical clearing of site for grazing resulting in change in stream flows;
- farm dam flow diversion and spillway discharges (refer Section 2.6);
- highly dispersive soils; and
- waterway disturbance as a result of stream crossings (downstream of site) and access to the waterway by livestock.

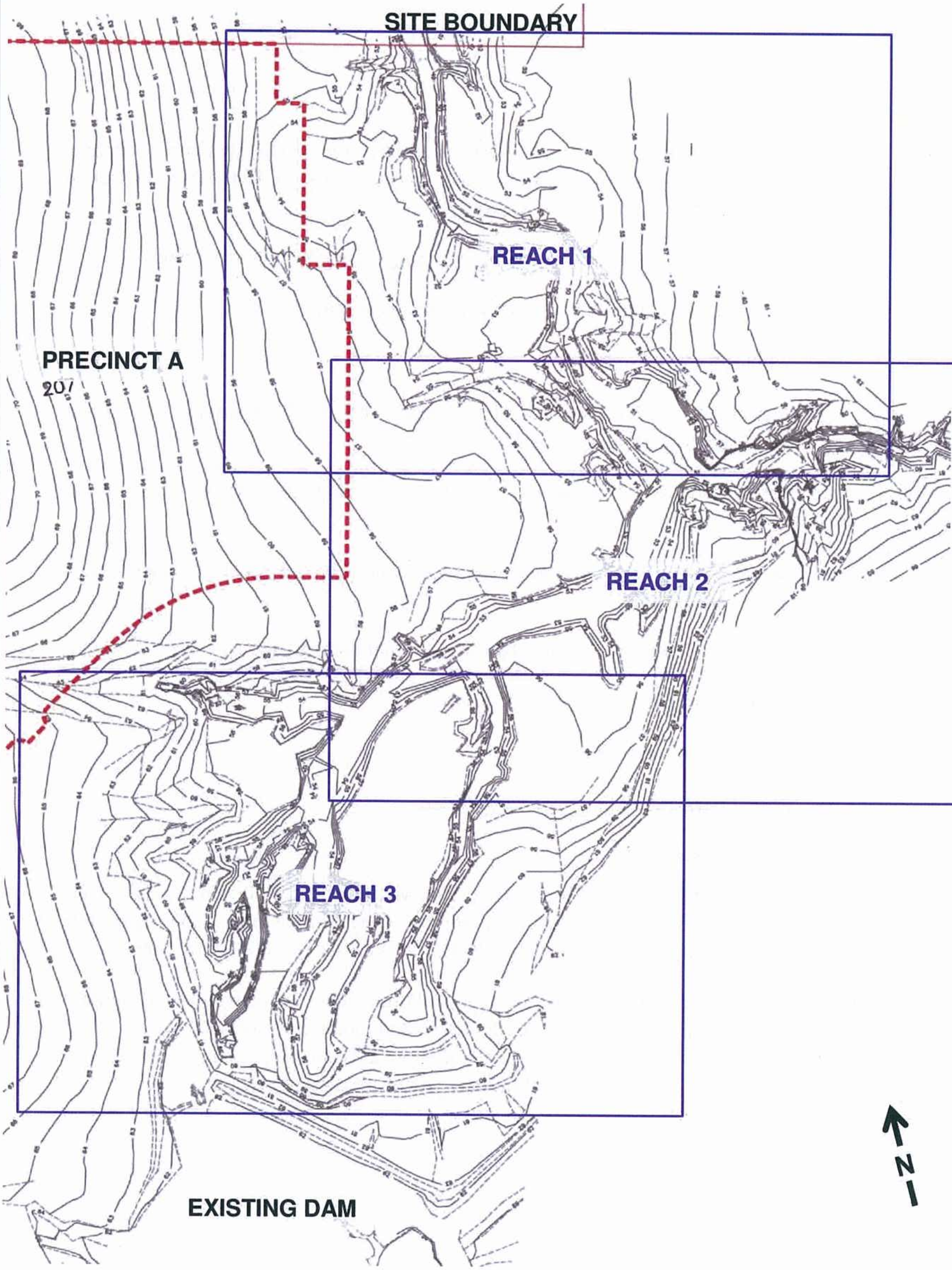
The current waterway within the Precinct A study area can be broadly defined as having the following elements:

- Existing farm dam forming upstream boundary of this particular assessment (refer Section 2.6)
- Side gullies/drainage lines joining the main channel laterally
- Isolated sandstone/bedrock protrusions
- Localised bank and bed scour
- Pocket remnant and regrowth vegetation

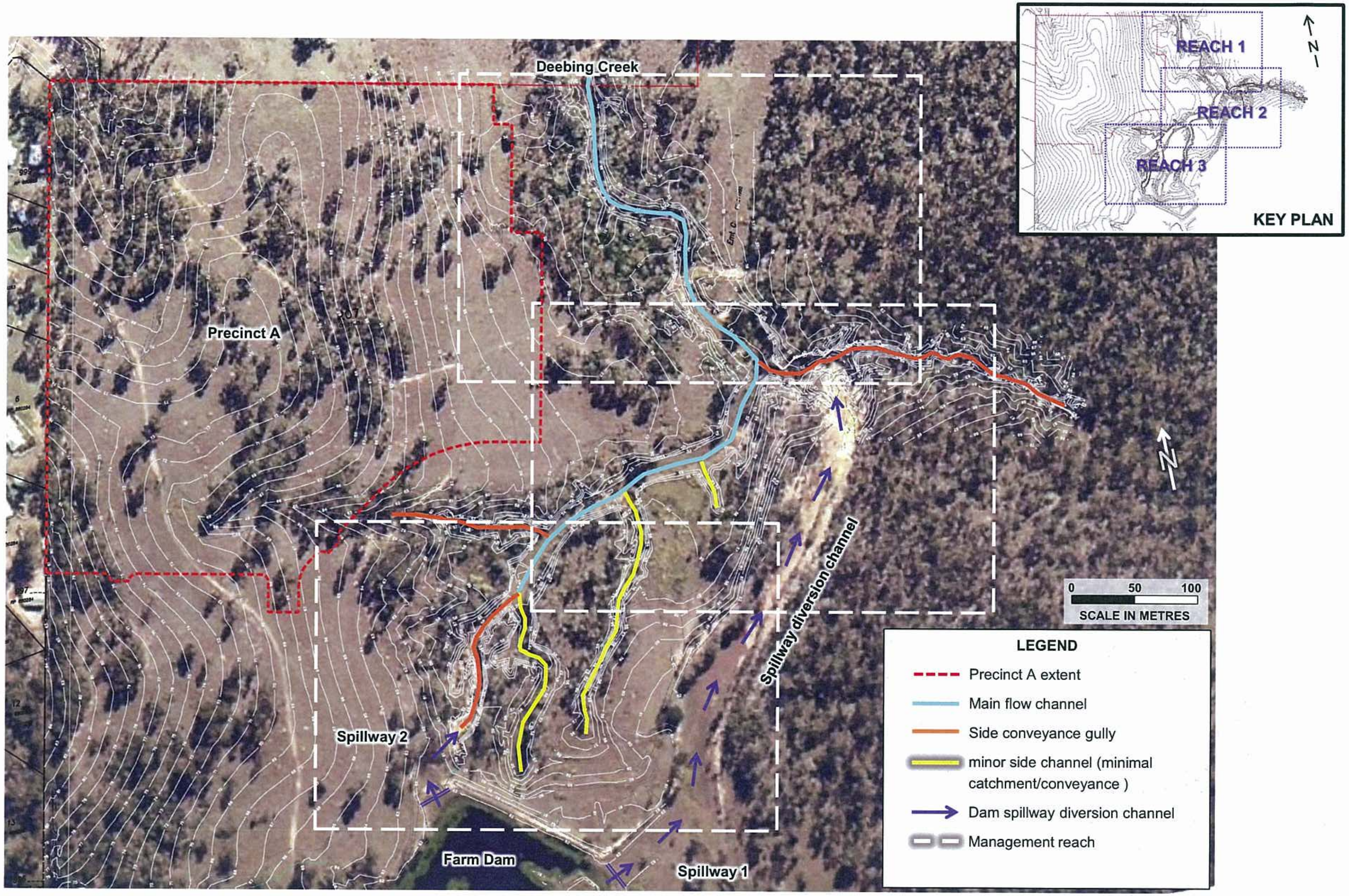
2.7.2 Reach Assessment

For the purpose of this assessment, the waterway adjacent to Precinct A has been divided into three reaches based on the predominant waterway form, bank vegetation condition and general appearance. Figure 6 illustrates the extent of these reaches.

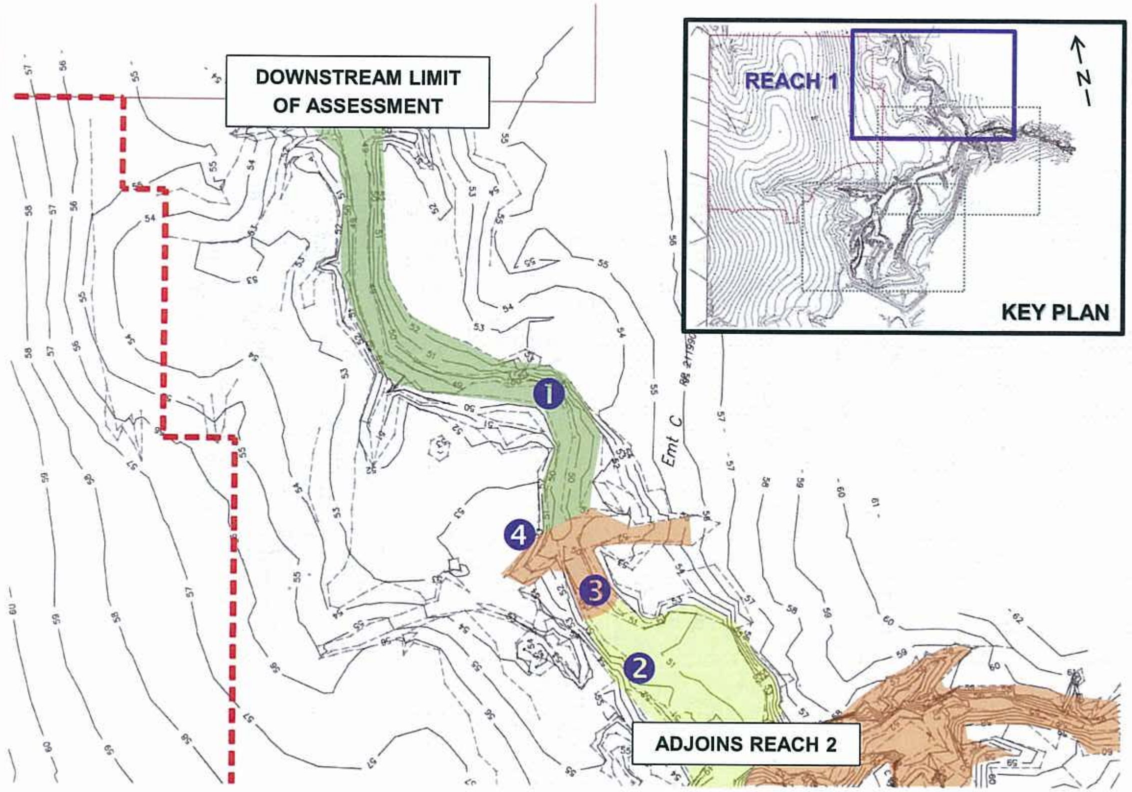
The outcome of the preliminary assessment of these reaches is documented in Figure 7 to Figure 10. This assessment is preliminary and qualitative only based on field inspections. Further hydrologic, geomorphic and soil assessment is being undertaken as part of ongoing investigations to confirm the state of the waterway.



DesignFlow	PARADISE WATERS PRECINCT A WATERWAYSTABILITY ASSESSMENT WATERWAY REACH LAYOUT	Date: 10/12/10	Sketch No.: FIGURE 6



DesignFlow	Project: PARADISE WATERS PRECINCT A WATERWAYSTABILITY ASSESSMENT EXISTING WATERWAY LAYOUT	Date: 10/12/10 Scale: NTS	Sketch No.: FIGURE 7



LEGEND

- Precinct A extent
- Active bed incision and/or bank erosion/undercutting
- Localised active bank erosion with stable bed
- Wide stable channel with localised toe of bank erosion/undercutting
- Stable relatively inactive channel
- Photo location

NOTES:

1. Contours sourced from detailed site survey and are subject to change in highly erosive areas of site.
2. Reach assessment represents the dominant stream and bank condition and does not identify small scale localised stability problems.

VISUAL CONDITION (refer to plan for photo location)

COMMENTRY

- Single main channel with flat grade
- Downstream characterised by moderately steep banks with dense vegetation and mature trees extending behind banks (photo 1)
- Upstream widens to broad channel with restabilised banks, partially battered back with full grass/shrub vegetation (photo 2)
- Previous bank erosion/scour evident in mid to upper reach but not visually active - established vegetation of upper and lower banks.
- Minor advancing head cut erosion face in channel (photo 2 & 3)
- High sediment load in stream bed from upstream erosion/sediment transport.
- Some gully erosion where vehicle/livestock crossings have occurred (photo 4)

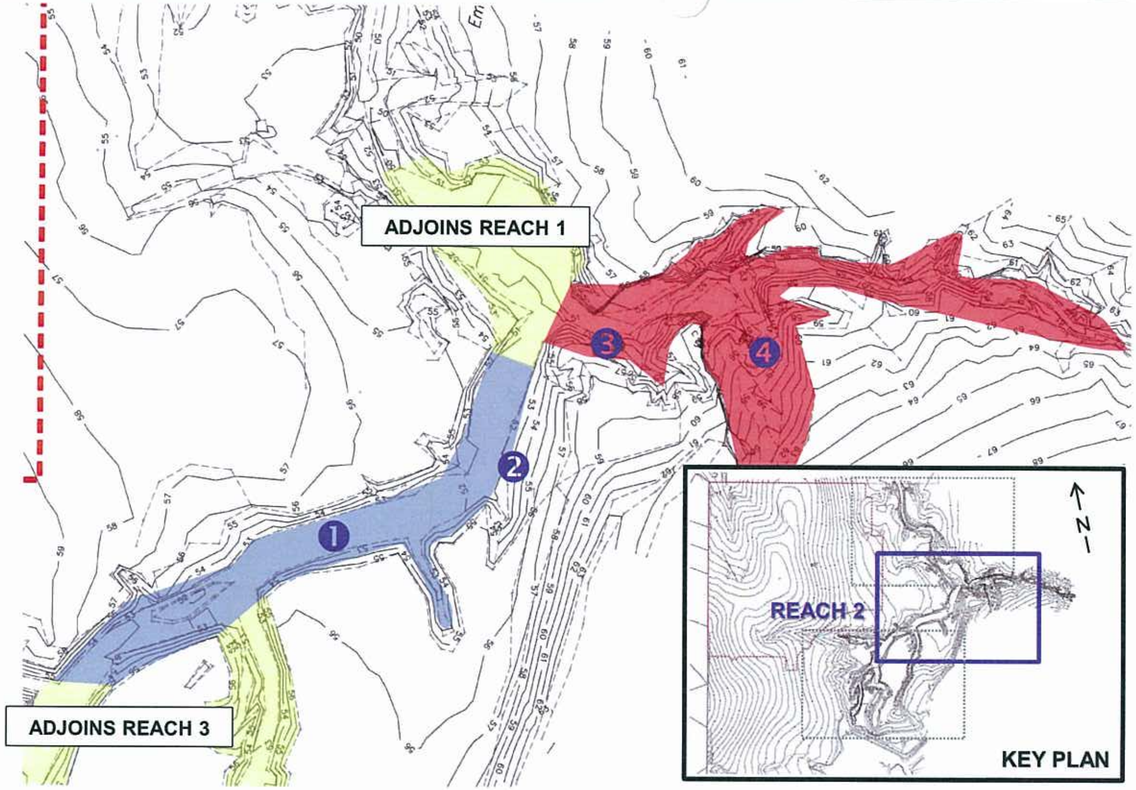
PRIMARY EROSION/STABILITY ISSUES

- Sedimentation deposition in stream bed
- Advancing head cut (minor)
- Minor undercutting of toe of bank in localised areas
- Lack of bank vegetation cover in some locations
- Minor zones of exposed dispersive soils

SUMMARY

This reach appears to be in a reasonably good state of recovery with low stream bed gradient and dense vegetation on lower and upper banks. Localised areas of bank (toe) scour and minor head cut indicate potential for further damage where stream hydrology is altered.

DesignFlow	Project: PARADISE WATERS PRECINCT A WATERWAY STABILITY ASSESSMENT REACH ASSESSMENT – REAC	Date: 10/12/10 Scale: NTS	Sketch No.: FIGURE 8



LEGEND

- Precinct A extent
- Significant active bed incision and bank erosion/undercutting
- Localised active bank erosion with stable bed
- Wide stable channel with localised toe of bank erosion/undercutting
- Stable relatively inactive channel
- Photo location

NOTES:

1. Contours sourced from detailed site survey and are subject to change in highly erosive areas of site.
2. Reach assessment represents the dominant stream and bank condition and does not identify small scale localised stability problems.

VISUAL CONDITION (refer to plan for photo location)


1


2


3


4

COMMENTRY

Main Channel:

- Main channel is wide and flat with retreat/laying back of banks allowing vegetation to establish (photo 1)
- Bend in channel coincides with side gully (at outside of bend)
- Appears to be in state of recovery after historical incision phase (has worked upstream)
- Sediment aggradation in channel bed - well vegetated
- Tongue of sandstone/bedrock protrudes into channel at lower end of reach forming resistant toe of bank in this location (localised)(photo 2)

Side Gully:

- Side gully undergoing major active erosion with significant incision exposing large face of dispersive soils >4m high (photo 3 & 4)
- Broad erosion area with head cut extending significant distance up side channel/gully
- Vertical movement of erosion limited by sandstone bedrock, however surface flow deflected to toe of undercut exacerbating batter/wall collapse (photo 4)
- Major impacting flows occurring from upstream gullies plus spillway diversion channel from farm dam
- Surface flows over face of exposed dispersive soils causing fluting (photo 3)

PRIMARY EROSION/STABILITY ISSUES

Main channel:

- No major issues – general riparian revegetation required

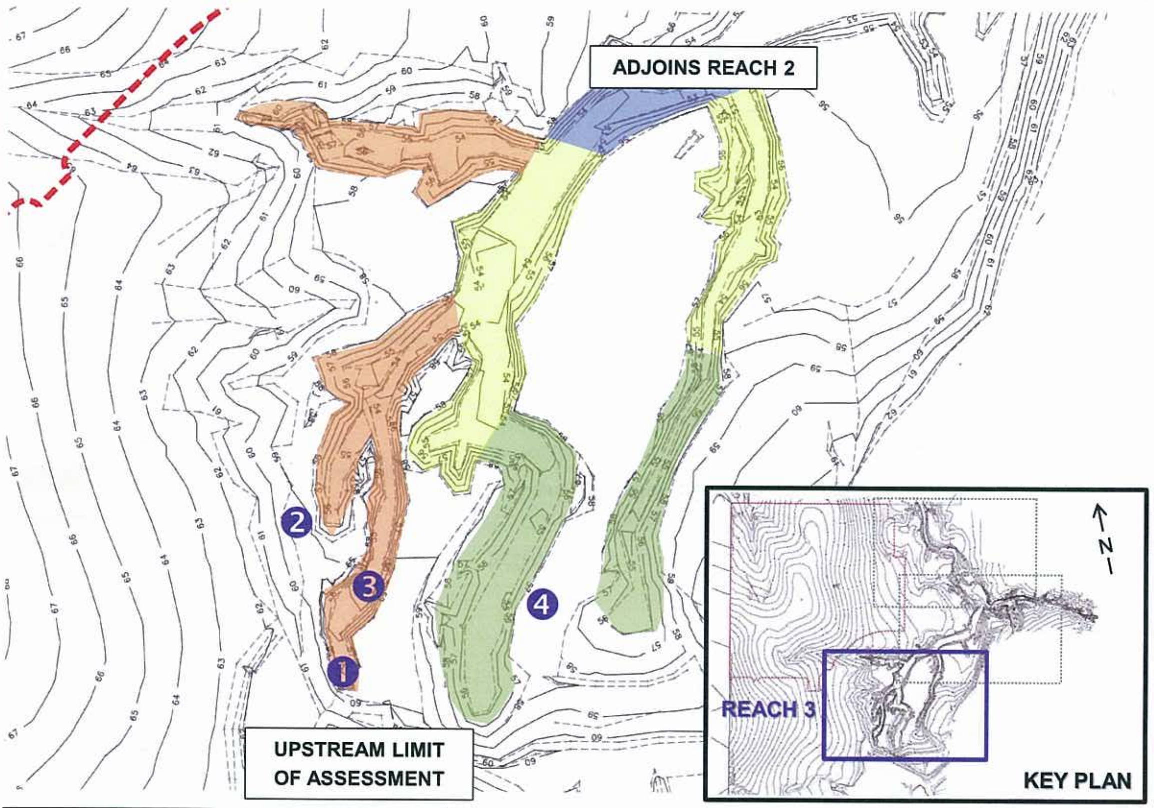
Side Gully:

- Major gully incision and undercutting at toe of bank/collapse of banks
- Major erosion gully off main channel – significant loss of soil, vegetation and stability
- Sediment transport downstream likely impacting in stream fauna/flora

SUMMARY

The main channel is in state of recovery from historical bed incision and appears in relatively stable condition while the side gully is undergoing significant erosion. Being on the outside of the main channel bend, the gully is further prone to erosive flows and bank failure.

DesignFlow	Project: PARADISE WATERS PRECINCT A WATERWAY STABILITY ASSESSMENT REACH ASSESSMENT – REACH 2	Date: 10/12/10 Scale: NTS	Sketch No.: FIGURE 9



LEGEND

- Precinct A extent
- Active bed incision and bank erosion/undercutting
- Localised active bank erosion with stable bed
- Wide stable channel with localised toe of bank erosion/undercutting
- Stable relatively inactive channel
- Photo location

NOTES:

1. Contours sourced from detailed site survey and are subject to change in highly erosive areas of site.
2. Reach assessment represents the dominant stream and bank condition and does not identify small scale localised stability problems.

VISUAL CONDITION (refer to plan for photo location)


1


2


3


4

COMMENTRY

- Main channel forks into numerous channels as a result of overflows/spillways from upstream dam.
- Western branch (western spillway from dam) undergoing significant incision/head-cut erosion which has extended up to the toe of the dam wall (photo 1 & 3).
- Tunnelling occurring behind top of western bank with sinkholes forming at up to 5m behind bank (photo 2).
- Central branch (photo 4) in stable condition and vegetated. Assumed to be former main channel of waterway. Currently not receiving flow from dam (some seepage may be occurring trough dam wall)
- Eastern branch not as defined as western and central branches. Not currently receiving major flows. Cut off from eastern spillway flows by bund directing flows northward along diversion channel to Reach 2 erosion gully.
- Main erosion occurring in western channel as head-cut and undercutting of bank (and subsequent collapse) with some over bank fluting evident from sheet flows.

PRIMARY EROSION/STABILITY ISSUES

- Substantial incision of flow paths leading to widening of channel (and promoting follow on erosion effects below)
- Major advancing head cut toward dam wall (western channel)
- Fluting erosion of banks (surface flows)
- Undercutting at toe of bank
- Slumping, terracing and collapse of banks
- Tunnelling and sink holes behind banks

SUMMARY

This forms the upper reach of Precinct A and appears to be the active front for the main channel head cut erosion/channel incision. Numerous smaller channels branch here potentially indicating the previous watercourse (prior to dam). The western spillway discharge from existing dam appears to be the primary cause of incision with overbank surface flows contributing to channel instability. Secondary 'branch' channels from main channels are relatively stable and appear to receive only minor flows (inflows cut off by dam wall and eastern spillway bunds).

DesignFlow	Project:	PARADISE WATERS PRECINCT A WATERWAY STABILITY ASSESSMENT REACH ASSESSMENT – REAC	Date: 10/12/10 Scale: NTS	Sketch No.: FIGURE 10

3 PRELIMINARY WATERWAY STABILISATION STRATEGY

3.1 GENERAL

In response to the waterway stability issues described in Section 2.7, Stockland is committed to delivering a strategy for rehabilitating the waterway. The development of the strategy is ongoing but is broadly summarised in Figure 11 and the following sections of the report.

The strategy elements described are preliminary only and will be investigated further as part of a detailed waterway assessment for the broad Paradise Waters site. The strategy has been based on the transition of the waterway to an urban creek under fully developed conditions. Therefore, the strategies provide a compromise between protection (or improvement) of waterway ecology and protection of future infrastructure.

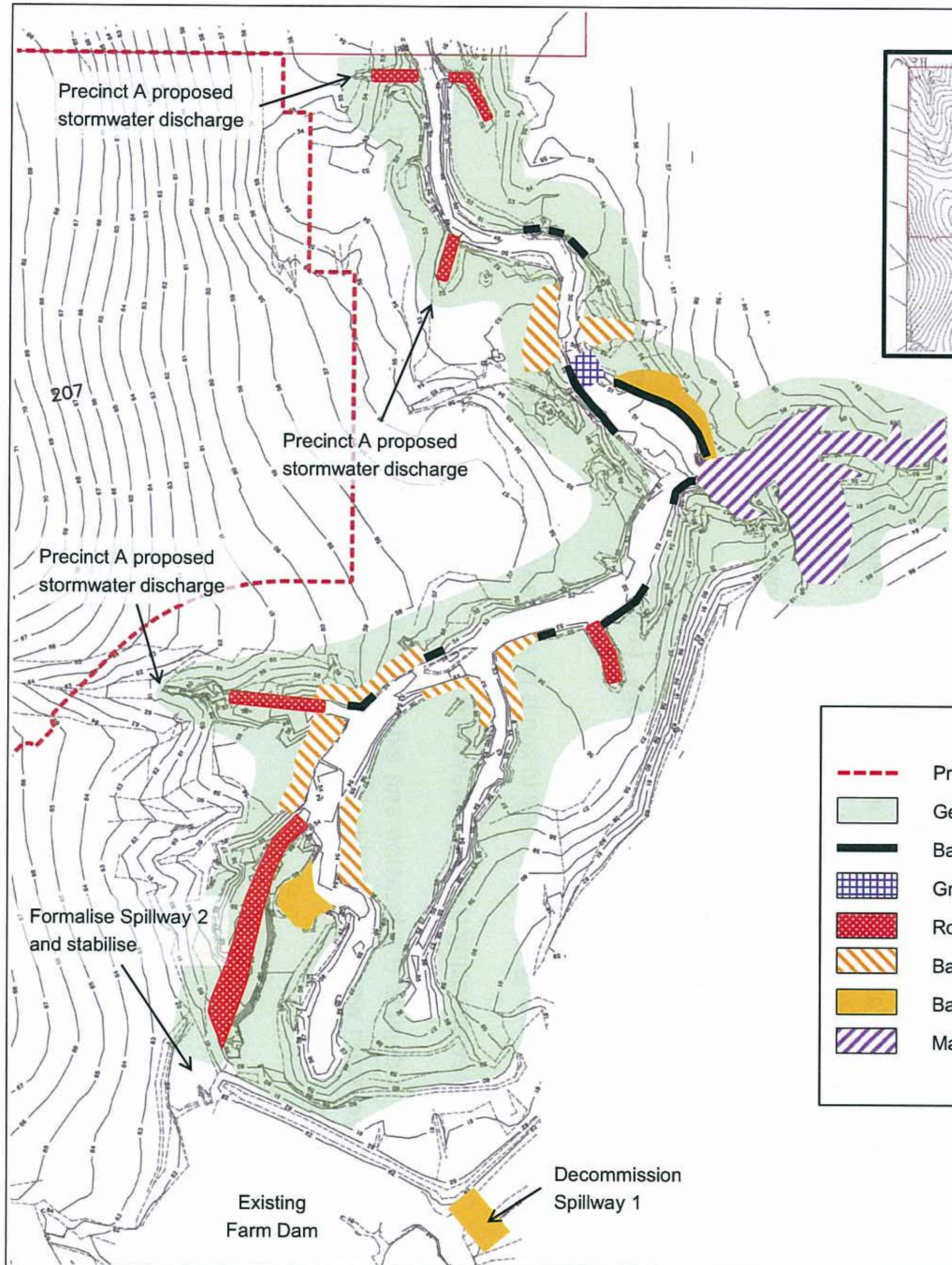
It is important to note that any stabilisation strategy should be developed in conjunction with the stormwater management strategy and flood management strategy to ensure that concentrated inflow to the waterway (from stormwater outlets or overland flow paths) is appropriately managed with scour protection and energy dissipation where required.

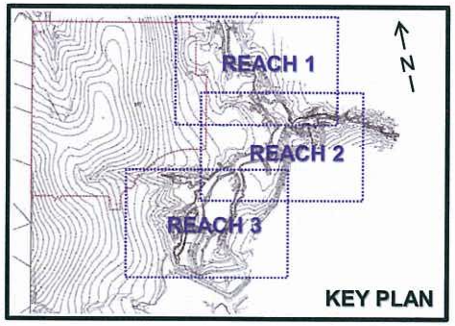
The strategy presented here relates to the stability of waterways adjacent to Precinct A urban footprint and do not address specific protection of future major structures such as bridges or road culverts. Protection of such structures is beyond the scope of this particular report but will be considered as part of the ongoing investigations. It is critical to ensure the design of structures carefully consider the location of these in relation to the stream stability strategy elements as they can have major impacts on the local stream hydraulics and stability.

The preliminary waterway stabilisation strategy involves the following:

- Preservation of waterway corridors
- Managing changes in hydrology (and associated shears stress within the waterway)
- Stabilising the waterway in zones of active scour and erosion
- Revegetating the waterway banks

Figure 11 depicts the location and extent of the proposed preliminary stabilisation and revegetation works. The following sections briefly describe the relevant elements of the preliminary strategy.





NOTES:

1. Significant areas of dispersive soils identified onsite. All exposed dispersive soils to be treated and/or covered with topsoil (and potentially clay) and revegetated.
2. It is assumed that all waterway rehabilitation works identified on this plan are accompanied by topsoil placement and planting within and adjacent to the proposed works.
3. Where specific rehabilitation works are not identified on this plan, topsoiling and replanting of riparian corridor should still be undertaken to cover dispersive soils and stabilise batters.
4. All preliminary rehabilitation works are indicative only to address broad scale reach stability issues and will be refined as part of detailed investigation.
5. For the purpose of this preliminary strategy, flow management in Reach 3 (below dam) assumes dam will remain in place. Ultimate management and flow strategy to be investigated as part of detailed waterway stability assessment.
6. Contours sourced from detailed site survey and are subject to change in highly erosive areas of site.
7. Reach assessment represents the dominant stream and bank condition and does not identify small scale localised stability problems.

DesignFlow	Project:	PARADISE WATERS PRECINCT A WATERWAY STABILITY ASSESSMENT PRELIMINARY STABILISATION STRATEGY	Date: 10/12/10 Scale: NTS	Sketch No.: FIGURE 11

3.2 PRESERVING WATERWAY CORRIDORS

A key part of the preliminary strategy is preserving appropriate waterway corridors. This allows the creation of riparian vegetation which is critical for stabilisation creek banks and allows the creek to move or widen if required and restabilise without impacting of urban infrastructure (services, roads, dwellings).

As outlined in Section 2.5.2, the following waterway corridors have been adopted for Precinct A in accordance with the Ripley Valley Structure Plan (refer Figure 3):

- 50m vegetation protection and rehabilitation buffer/corridor has been applied (from surveyed top of bank) either side of the waterway downstream of the existing dam
- 30m either side of the waterway centreline upstream of the existing dam

3.3 MANAGING CHANGES IN HYDROLOGY

Urban development increases both the volume and frequency of stormwater runoff. An important consequence of these effects is the potential for increased erosion of the bed and banks of natural waterways downstream of urbanising areas. Without control measures in place, this increase in erosive potential typically leads to channel enlargement and a reduction in aquatic habitat value (Water by Design, 2007).

To limit the change in the erosion potential of Deebing Creek as a result of the Paradise Waters development, changes in hydrologic that may cause this erosion must be limited. This can be done by setting meeting all or a combination of the following objectives:

- <u>Waterway stability objective</u> – Limit the post development peak 1yr ARI event discharge within the waterway to the pre-development peak 1yr ARI event discharge (SEQ Regional Plan Implementation Guideline No. 7).
- <u>Shear stress</u> – Preserving the shear stress within the waterway for the 1 year ARI.
- <u>Stream erosion index</u> – Preserving the erosion potential index (EPI) of the waterway following development by ensuring the stream erosion index (SEI) is equal to 1.0.

Section 4 presents the quantitative assessment completed for Precinct A in relation to the waterway stability objective and shear stress. The nature of the SEI required detailed hydrologic assessment which is being undertaken as part of the ongoing investigations.

3.4 STABILISATION TECHNIQUES

The stabilisation techniques identified as most suitable for the waterway erosion found onsite are:

- Rock chutes (bed and grade control)
- Bank stabilisation
- Battering and revegetation
- Stormwater outfall protection

For full details and indicative designs for each treatment, refer to *Erosion Treatments for Urban Creeks* (BCC, 2004). The information provided below is a summary of the details presented in this Brisbane City Council document.

All techniques will involve covering the dispersive soils with topsoil (and potentially clay capping) to minimise the contact of water with the soils.

3.4.1 Rock Chutes (bed and grade control)

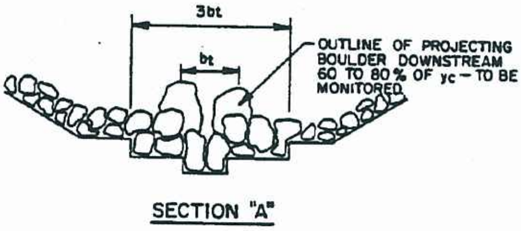
This technique involves constructing a rock structure across the full width of the channel with a rock cascade immediately downstream. This structure prevents the migration of head cut erosion upstream and avoids further scour hole creation at the change in bed level.

The rock downstream of the structure provides a stabilised flow path for relatively steep or concentrated flow paths. The selection of rock size and grading is critical in the success of these systems to ensure both conveyance and energy dissipation is sufficient while avoiding localised scour in in rock voids. Rock chutes may be partially vegetated to improve aesthetics.

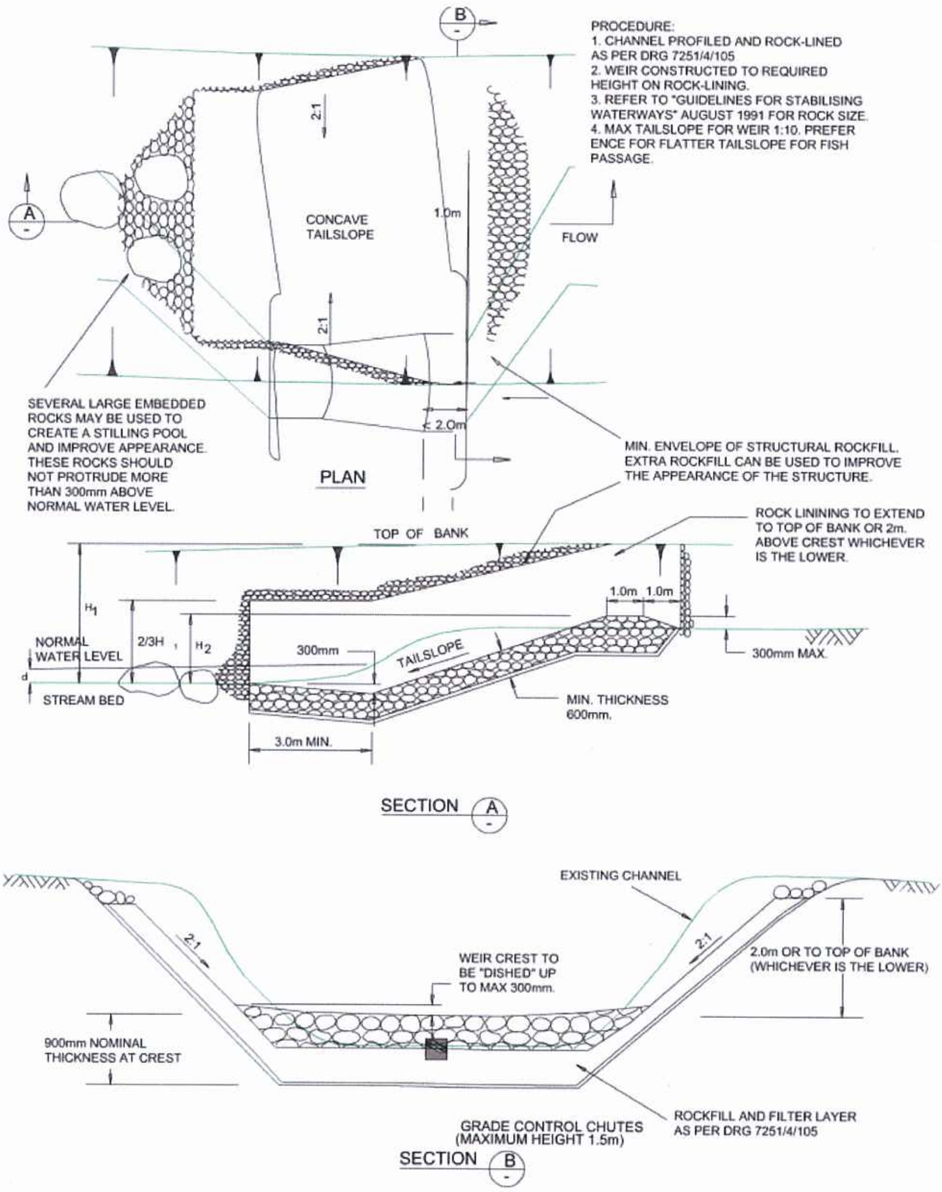
As well as bed and grade control, rock chutes are suitable for lateral inflow gullies and stormwater outlets to the main waterway.

When rock chutes are used for bed control they may comprise one or more steps depending on the channel slope and depth of existing head cut. Figure 12 provides an indicative configuration and section of this structure.

Rock chutes are proposed at a number of locations within the Paradise Waters waterway to limit the risk of future head cut (or bed incision).



(source: BCC, 2004)



(source: Melbourne Water)

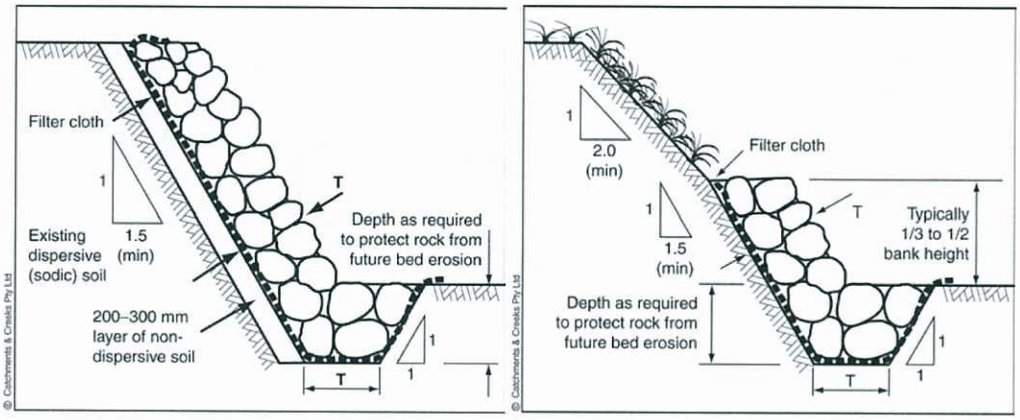
Figure 12: Rock chute configurations

3.4.2 Bank Stabilisation

Bank stabilisation (comprising rock beaching) specifically targets bank erosion at either the toe of bank (low flows) or full height of bank (high flows). The rock beaching acts as an armour to erosive flows and must be constructed on an appropriately graded batter to avoid structural stability issues and to promote (where desirable) vegetation growth within rock voids.

Where bank stabilisation is proposed on the outside bends of waterways, particular attention must be given to the high velocity flows in these areas and the potential that deflection of flows from beaching can have immediately downstream of rock areas and on opposite banks (in tight meanders). Rock beaching can be used in conjunction with rock chutes where both channel and bank stability is at risk.

Given the size of the channel through the Paradise Waters site (as a result of historic incision and erosion), it is expected that the depth of flow during minor storm flows will only be minimal and major storms are anticipated to be contained with the primary banks (confirmed by the flood modelling, refer Water Technology 2010). It is therefore unlikely that full rock beaching will be required to manage the frequent flow flows (up to 1yr ARI). Partial rock beaching will be adopted (refer Figure 11) to manage potential erosion at the toe of batters with upper banks being laid back, sealed (clay), topsoiled and revegetated.



(source: BCC, 2004)

Figure 13: Bank stabilisation configuration - full and partial height

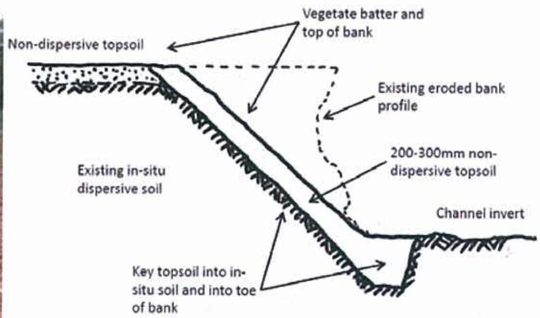
3.4.3 Battering and revegetation

Where bank erosion has resulted in steep or vertical slopes, this is usually accompanied by loss of vegetation and further susceptibility to erosion. By laying back the banks (through earthworks) and providing dense vegetation, the stability of the banks can be improved. Vegetation selection on the lower bank (and into channel edge) is important to promote additional protection during flow (such as grasses and sedges that lay over during flows and protect soils).

In urbanising waterways where flow regimes are altered, it may be beneficial to provide battering/revegetation in conjunction with rock beaching to ensure the stream remains stable in the long term and to protect adjacent infrastructure such as pathways and boardwalks.

For the Paradise Waters site, the use of batter and revegetation will be delivered by:

- over-excavation
- treatment of the dispersive soils (gypsum other to be guided by soil scientist)
- placement of topsoil (and potentially clay layer to seal the dispersive soils - to be guided by soil scientist)
- placement of suitable mulch (pinned down)
- vegetation installation and establishment.



(photo: BCC, 2004)

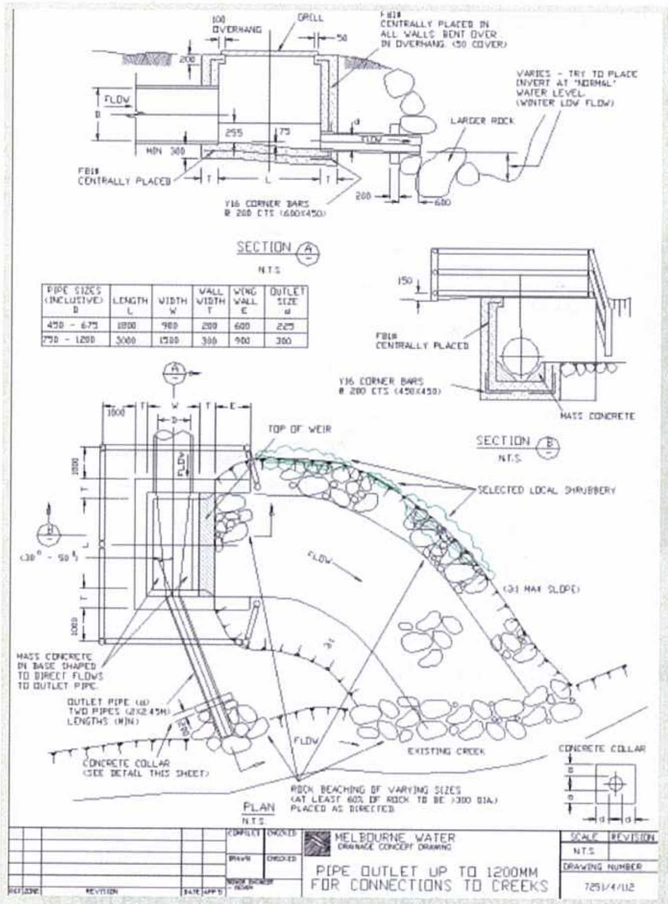
Figure 14: Battering and revegetation configurations

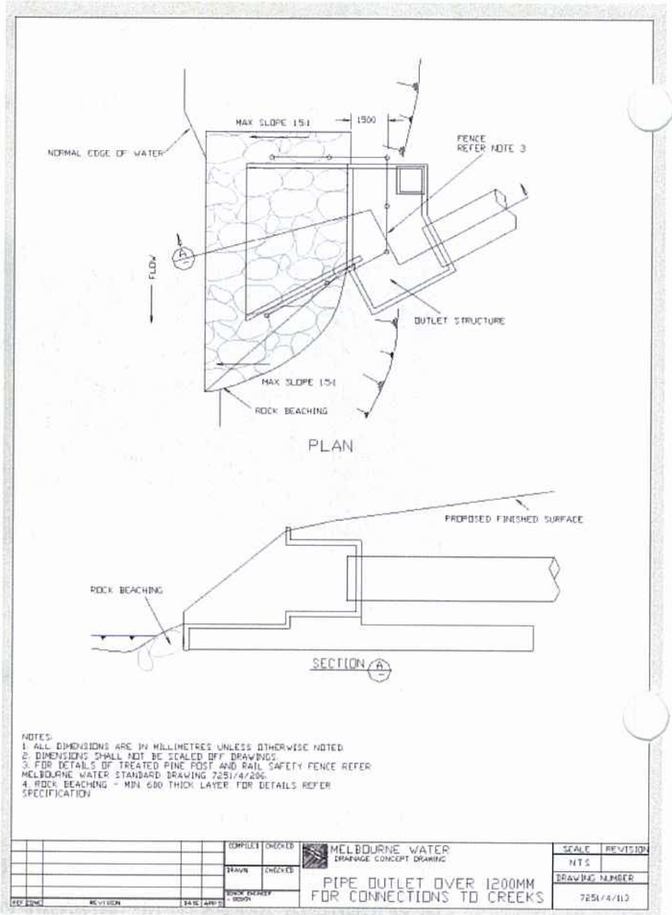
3.4.4 Stormwater outfall protection

The location of stormwater outfalls and discharges to the waterway from the development needs to be carefully considered to avoid local scour of the bank and bed of the waterway. There are many examples in Ipswich of bed and bank failure as a result of stormwater outfalls. The following will provide a basis for the design of the stormwater outfalls at Paradise Waters:

- Minimise the number of stormwater outfalls to the waterway.
- The pipe or drain should be angled to generally follow the waterway flow direction.
- The invert of the pipe and drain should match the invert of the waterway.

- Appropriate rock protection and/or rock chute provided at the stormwater outfall.
- Co-locate the stormwater outfalls with existing tributaries or scour points in the waterway. This means the stabilisation of these tributaries and the stormwater outfalls can be provided in a single location (dual use of rock protection).
- Provide appropriate flow diversion and energy dissipation as per diagrams below provided by Melbourne Water.





4 WATERWAY STABILITY ASSESSMENT - PRECINCT A

As outlined in Section 3, managing the hydrologic change associated with the development Paradise Waters is an important part of the stabilisation strategy for the waterway both within and downstream of the site.

The purpose of this section of the report is to illustrate how the waterway stability hydrologic objectives established for Paradise Waters have been achieve for Precinct A. This ensures Precinct A can effective stand alone as a development approval in the knowledge that there is no change in waterway stability risk within or downstream of the site as a result of developing Precinct A.

4.1 DESIGN OBJECTIVES

The objectives identified below are all aimed at managing the erosive forces within waterways following development of urban areas. They have been derived from current best practice urban stormwater management and research into stream stability in Australia.

For the purposes of the Precinct A, compliance with the waterway stability objective of preserving the 1yr ARI flow within the waterway and the associated shear stress have been illustrated.

Given the lack of suitable stream flow information for Deebing Creek, a rigorous assessment of stream erosion index has not yet been undertaken. This is the focus of the ongoing waterway stabilisation investigations which is dependent on whether a suitable believable artificial stream record can be created.

4.1.1 1 year ARI flow

The current waterway stability management objective identified in the *South East Queensland Regional Plan – Implementation Guideline No. 7* targets the reduction of post development peak 1 year ARI discharge as described in Table 3.

Table 3: SEQ Regional Plan waterway stability design objective

Criterion	Design Objective	Recommended Application
To reduce the impacts of urban development on channel-bed and bank erosion by limiting changes in flow rate and flow duration within the receiving waters.	Limit the post-development peak one-year average recurrence interval (ARI) event discharge within the receiving waters to the pre-development peak.	Applicable where runoff from or within the site passes through or drains to an unlined non-tidal watercourse or wetland.

4.1.2 Sheer Stress

An accurate determination of the erosion potential is by assessing shear stress exerted on the bed and banks of a stream under a range of flow conditions. Pre and post development peak shear stress can be readily assessed as part of flood modelling undertaken for developments. For Precinct A, the objective is to ensure the shear stress under the 1yr ARI does not change as a result of the Precinct A development.

4.1.3 Stream Erosion Index

The Stream Erosion Index (SEI) is a performance indicator of the impact that changes to hydrological processes can have on erosion potential within a stream. It is recommended by the Department of Environment and Climate Change (DECC) in New South Wales for designated growth centres in Sydney. No specific erosion index of this nature has been developed for streams in Queensland. However, as outlined in *Developing design objectives for urban development in South East Queensland* (Water by Design, 2007) the waterway stability objective (1 year ARI) is based on achieving a SEI of 1.0.

In a recent review of current Stream Erosion Index (SEI) methods for the Sydney Metropolitan Catchment Management Authority (SMCMA) by Alluvium and DesignFlow (2009), it was concluded that an alternative SEI definition (by Brookes and Wong, 2009) should be adopted as a simple approach to assessing stream erosion potential from changes to catchment hydrology (from urbanisation). This method relates the erosion potential of a stream to both the duration and magnitude of shear stress above an erosion threshold. For the Paradise Waters development site an SEI of 1 is preferred (no or minimal change in erosion potential).

As noted in Section 4.1, accurate assessment of the stream erosion index requires a relatively accurate and robust time series of stream flow. This is not available for Deebing Creek and so assessment of SEI has not been undertaken. This is the focus on ongoing investigations.

For the purposes of Precinct A, the waterway stability objective (1yr ARI) is considered to provide adequate protection of the waterway given that objective is aimed at minimising the erosion potential (or in other words ensuring SEI = 1).

4.2 PERFORMANCE ASSESSMENT

The impacts of Precinct A development on the waterway stability in the northern portion of the Paradise Waters site has been broadly assessed against the water stability objective (1yr ARI) and shear stress objective identified in Section 4.1. More detailed and rigorous assessment of these objectives will be undertaken as part of the overall site waterway stability strategy currently underway.

4.2.1 1 Year ARI

The *Flood Management Plan – Paradise Waters Precinct A* (Water Technology, 2010) provides a detailed assessment of the pre and post development discharges for a range of locations downstream of the proposed Precinct A development. The applicable 1 year ARI results for the development boundary (at Deebing Creek) are provided in Table 4.

Table 4: Peak 1 year ARI discharge comparison

Location*	Node*	Peak Discharge (m3/s)		Change (%)
		Existing	Developed	
Development Boundary (Deebing Creek)	C43	17.5	17.4	-0.6

*For location and node details, refer to Flood Management Plan – Paradise Waters Precinct A (Water Technology, 2010)

The results show a slight reduction in peak flow for the 1 year ARI event at this point in the catchment which may be attributed to the fact that as a result of urbanisation of Precinct A, the hydrograph peak from this portion of the catchment occurs quicker than the corresponding peak from the larger upstream catchment. Thus, the overall catchment 1 year ARI peak is reduced as a result of the Precinct A development. But it must be also recognised that as the remainder of the Paradise Waters site is developed there inevitably be an increase in 1yr ARI flows within and downstream of the site. Managing this increase is the focus of the ongoing investigations.

4.2.2 Shear Stress

A preliminary assessment of channel shear stress was undertaken as part of the overall flood modelling for the site to determine the impacts of Precinct A. Table 5 provides the pre and post development shear stress results for 3 locations within the reaches described in Section 2.7.

Table 5: Preliminary shear stress comparison for 1 year ARI

Reach[1]	Chainage[2]	Channel Shear Stress (N/m^2)	
		Existing	Developed
Reach 1	0.0	75.0	74.8
Reach 2	321.7	87.1	86.6
Reach 3	514.6	23.2	23.3

1. refers to management reaches adopted for this report – refer Section 2.7
2. Chainage refers to HEC RAS cross sections in *Flood Management Plan – Paradise Waters Precinct A* (Water Technology, 2010)

The comparison of shear stress results shows that as a result of the slight reduction in peak flows leaving the site (refer to) at chainage 0.0, the corresponding shear stress also reduces. However, as further development occurs upstream these shear stresses will inevitably increase as the hydrograph peaks from future urban areas coincide. Therefore the preliminary assessment of the waterway stability impacts of Precinct A can remain valid until such time as further development proceeds. It does however provide an indication of the stand-alone impacts of Precinct A which are neutral (no impact) for the local waterway in the short-term.

5 CONCLUSION

This document presents the findings of the preliminary waterway stability assessment for the waterway adjacent to Paradise Waters Precinct A. The preliminary assessment is provided to support the Development Application for Precinct A and represents the first stage of an ongoing waterway assessment and stabilisation strategy for the broader Paradise Waters site.

Much of the Deebing Creek waterway within the site has undergone significant erosion to the dispersive erosive soils, clearing of riparian vegetation, waterway disturbance (road and cattle crossings) and hydrologic/landuse change. The development of the Paradise Waters site will significantly increase impervious area in the catchment and result in further significant hydrologic change if left un-mitigated. Careful management of the hydrology and waterway environment is required to avoid exacerbating, and where possible improving, the current erosion and waterway stability issues.

A preliminary stabilisation strategy is proposed for the waterway involving:

- Preservation of waterway corridors
- Managing changes in hydrology (and associated shears stress within the waterway)
- Stabilisating the waterway in zones of active scour and erosion
- Revegetating the waterway banks

Performance assessment of Precinct A has found there will be no changes in the 1 yr ARI flow within the waterway or the associated shear stress. This means the creation of Precinct A will not impact on the erosion potential within the waterway. This will change as subsequent Precincts within the Paradise Waters site are developed and the management of these impacts is the focus on ongoing investigations.

6 REFERENCES

Alluvium and DesignFlow (2009). *Review of the stream erosion index for NSW.* Draft final report.

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DesignFlow

4 July 2011

Jacqui Carter
Stockland
Level 4/99 Melbourne Street
South Brisbane QLD 4101

Dear Jacqui

RE: PARADISE WATERS STORMWATER DESIGN REQUEST FOR INFORMATION RESPONSE

This letter is provided in response the following items contained in the SKM and ULDA request for information dated 20th December 2010. Please refer to the responses provided to Bradlees and contained in their letter for all other stormwater related items.

Request for information item (focus of this letter)

Stormwater Management Plan: Section 5.1.1	It is stated that bioretention basins have been sized for the development only, but flows from external catchments will also enter the basins. While these catchments are described as 'small' they could significantly impact on the basin's performance.	Please provide the total and impervious areas of external catchments, and show their effect on basin performance. Alternatively, demonstrate how external catchments flows can be bypassed around the bioretention basins.

Response

In response to this item, further details of how the external catchment to the west of Precinct A is being dealt with are provided in the following figures:

- Figure 1 illustrates the location and size of the external catchments.
- Figure 2 presents the original stormwater strategy contained in the DesignFlow (2010) Stormwater Quality Management Plan for Precinct A Paradise Waters
- Figure 3 presents the updated stormwater strategy for Precinct A including how the external catchments are considered. Please note the location and size of the stormwater management systems has not changed since the original DesignFlow (2010) SQMP (presented in Figure 2).
- Figure 4 illustrates how 'stormwater quality flows' (<0.5yr ARI) will be diverted around Bioretention Basin A.
- Figure 5 presents the MUSIC model structure and results.

In summary:

- For <u>Bioretention Basin A</u> the external rural residential catchment (4.16ha) low flows can be readily bypassed around the system via a low flow pipe. This ensures the bioretention system will not accept external flows (up to 0.5yr ARI). The larger flood events (greater than 0.5yr ARI) will still enter the flood detention storage located within/above the bioretention basin.
- For <u>Bioretention Basin E</u> an external rural residential catchment (2ha) will enter the bioretention system from the drainage system. There is no way of diverting this external catchment around Bioretention Basin E in a cost effective manner.

The MUSIC modelling has been updated to including the external catchment (2ha) in the catchment draining to Bioretention Basin E (refer Figure 5). The model was also updated to represent the current urban design. It was found the stormwater quality objectives were still achieved in this system without any increase in bioretention size as illustrated in the table below. The MUSIC model is attached to this letter.

Treatment Train Effectiveness - Discharge

	Sources	Residual Load	% Reduction
Flow (ML/yr)	88.9	78.5	11.6
Total Suspended Solids (kg/yr)	20.1E3	2.42E3	87.9
Total Phosphorus (kg/yr)	40.2	10.5	73.9
Total Nitrogen (kg/yr)	202	105	48.1
Gross Pollutants (kg/yr)	2.50E3	0.00	100.0

Please call Nic Smith or myself on (07) 5528 1148 if you would like to discuss any aspect of this letter.

Yours sincerely

Shaun Leinster
DesignFlow

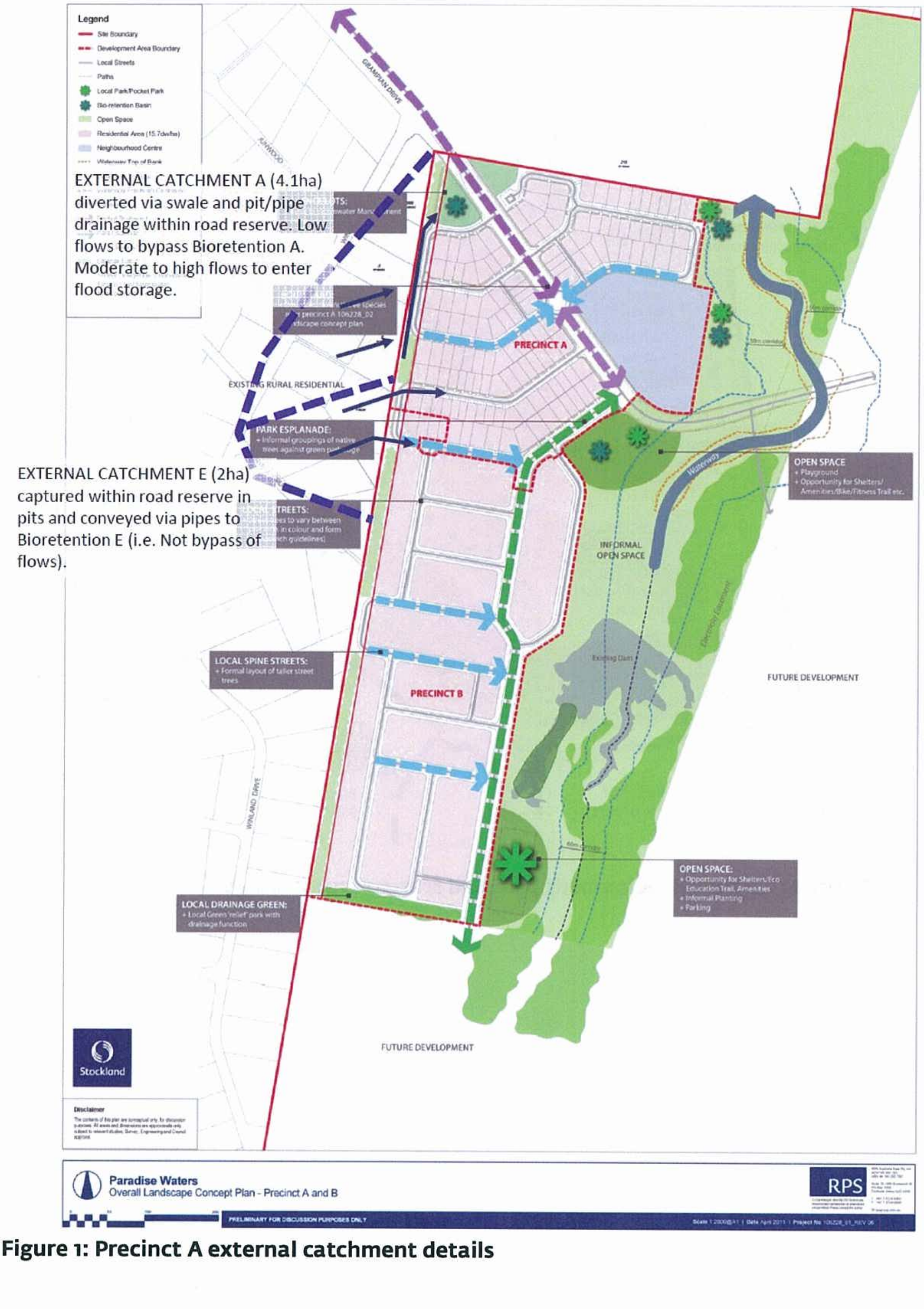

Figure 1: Precinct A external catchment details

Figure 2: Original development plan and stormwater strategy

Figure 3: Updated development plan and stormwater strategy

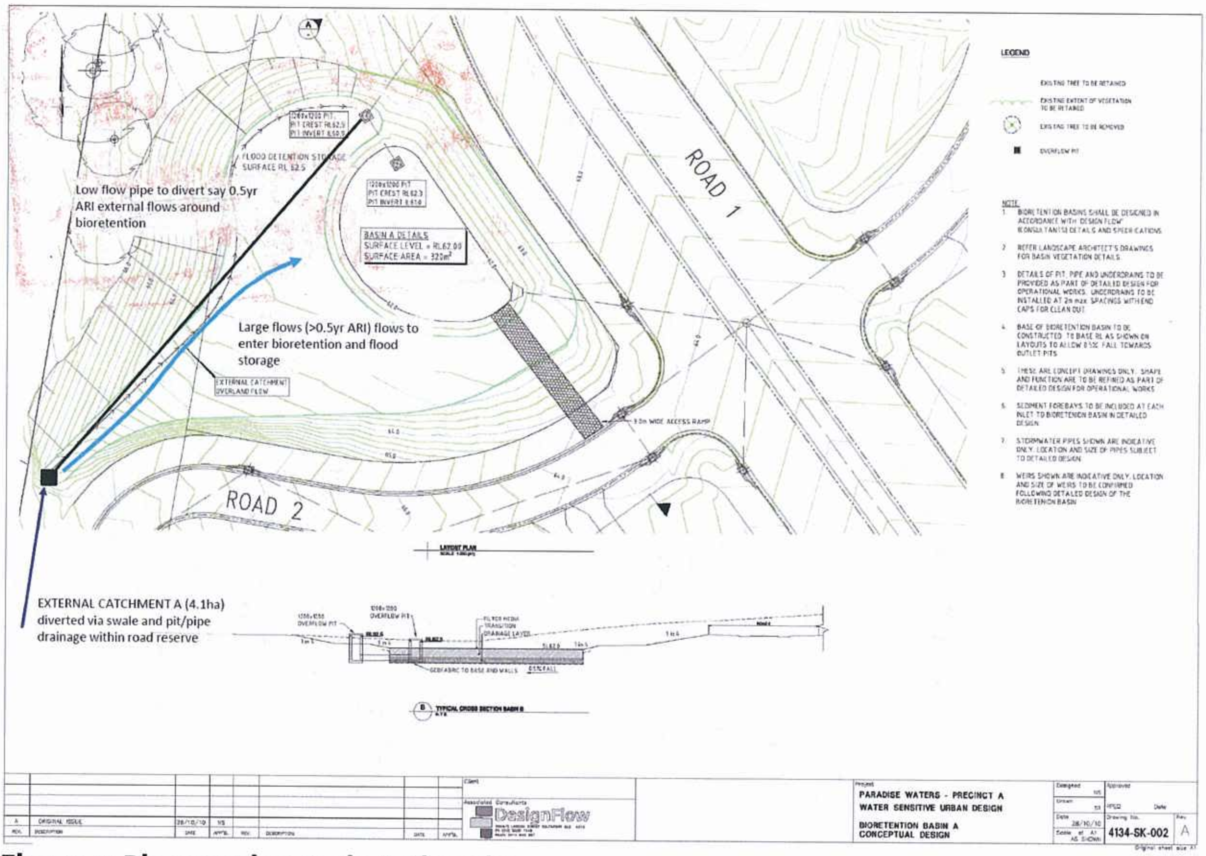

Figure 4: Bioretention Basin A diversion

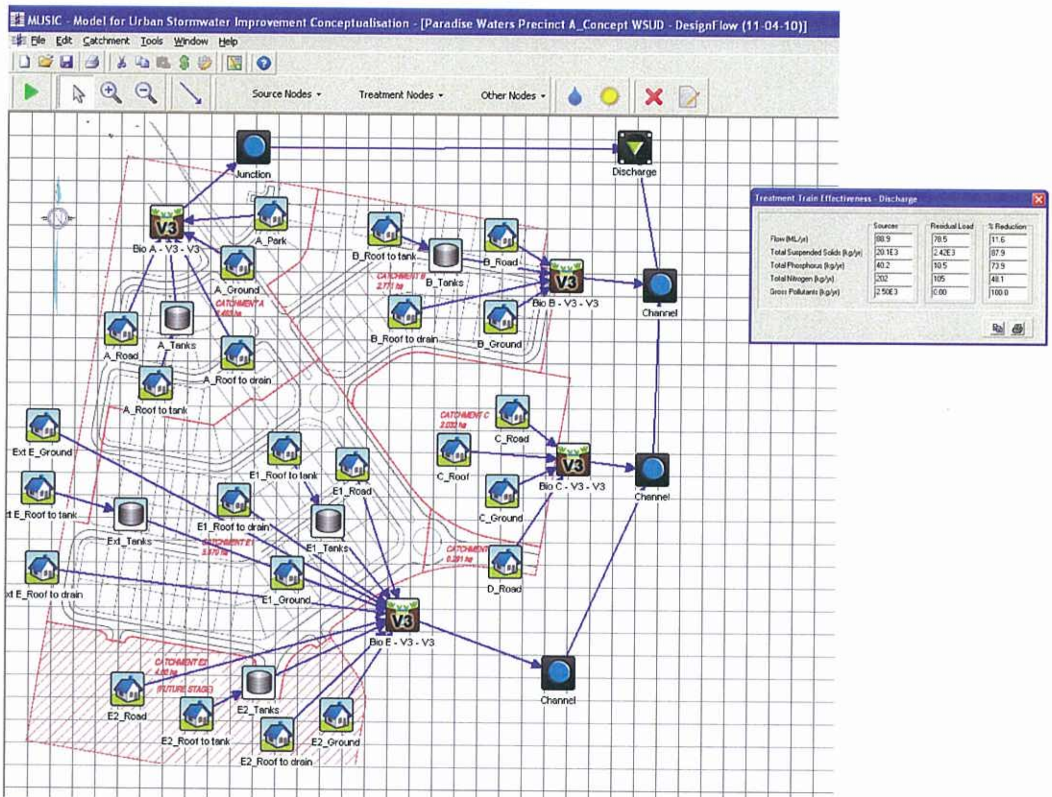

Figure 5: MUSIC Model structure