PLANS AND DOCUMENTS
referred to in the PDA
DEVELOPMENT APPROVAL

Approval no: DEV2022/1341

Date: 5 June 2023

Queensland Government

YARRABILBA PRECINCT 4F

STORMWATER MANAGEMENT PLAN

VERSION 2

DesignFlow

Prepared for Lendlease

March 2023

Document Control Sheet

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Disclaimer

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

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1 INTRODUCTION

The Yarrabilba Priority Development (PDA) is located within the Logan City Council area and occupies a former pine plantation located south of Logan Village. The Yarrabilba PDA was declared by regulation under the Economic Development Act (2012). Yarrabilba is part of a regional growth area identified in the South East Queensland Regional Plan, which identifies a need for a further 70,000 dwellings across a number a localities in the Logan City Council area by 2031. The Yarrabilba development aims to provide approximately 17,000 dwellings for a population of 45,000.

Precinct 4F (subject site) covers an area of approximately 27.3 hectares (ha) which includes just under 15 ha of development lots, 3.5 ha of balance lots, 8.2 ha of roads and around 0.8 ha of open space and stormwater treatment areas.

This document presents the stormwater management strategy for the subject site to meet the requirements set out in the Context Planning Area Strategy. These are generally consistent with the S*tate Planning Policy*, *Yarrabilba Total Water Cycle Management Strategy* (DesignFlow, 2021) and *Yarrabilba Stormwater Infrastructure Master Plan* (DesignFlow, 2021). This report provides details of the proposed stormwater treatment measures including location, conceptual sizing and functional earthworks.

This report focusses on the construction phase erosion/sediment control and operational phase stormwater quality and waterway elements specific to Precinct 4F. Flood management has been addressed separately in *the Yarrabilba (Quinzeh Creek) Flood Study – Version 1* (DesignFlow, 2017) as the flood management strategy spans numerous current and future precincts requiring site wide planning. No flood infrastructure is required within the subject precinct.

2 FURTHER ISSUES RESPONSE

The EDQ further issues email of 10/01/2023 (Gabrielle Shepherd: *Further Issues - DEV2022/1341 Yarrabilba ROL Precinct 4F*) and subsequent Engineering review response email of 16/03/2023 highlighted the following items, responses and acceptance/non-acceptance relating to stormwater management. Where initial responses where not accept by EDQ, additional information is provided within this updated report as indicated under each issues/response.

Stormwater Management Plan (item 2 in further issues email):

i. **Indicate** the parameters of the secondary drainage link for the sediment basin and wetland (low-flow and high-flow bypass). The high-flow bypass is to be determined based on the detention capacity of the whole system, via a hydrograph assessment. The wetland outlet is to be based on design flow outlet.

Further Issues Response*: Initial high flow bypass estimates stated to be conservative given slight improvement of treatment efficiency with revised modelling methods and optimisation of treatment systems can occur at detailed design phases*

IS Assessment: Not accepted by IS. Conservative assumption/justification not accepted by IS. Flow rate will change based on height of hydrograph (due to varying head) and high flow bypass system will need to be assessed via hydrograph.

Additional Response:

Secondary links and high-flow bypass rates have now been updated in a revised MUSIC model based on detailed design of existing (downstream) precinct pipe drainage and peak discharge estimates of future development areas contributing to treatment (refer to Table 6, Section 4.3.4 in this SMP). All bypass occurs upstream of treatment via generic nodes in MUISC for clear identification.

All overflow weirs in treatment systems are modelled conservatively large (in accordance with the *MUSIC Modelling Guidelines*) to avoid over estimation of treatment performance due to extended detention depths above weirs. This is appropriate for functional design stage to support ROL application and no hydrograph assessment is warranted at this time. Detailed design will be undertaken with the appropriate hydraulic assessment of the overall treatment system with supporting MUSIC model verification. Wetland low flow outlet (orifice) is sized for minimum 48 hour notional detention time in accordance with the *MUSIC Modelling Guidelines*.

The updated MUSIC model assessment and supporting explanations are provided in Section 4.3 of this revised *Stormwater Management Plan – Version 2*.

ii. **Indicate** the parameters of Swale 4F2 and 4F3. No details have been provided. The natural gully of the balance parcel (to the east of the development) is considered a natural waterway formation and cannot be considered as part of the treatment train. Where a specific water quality treatment device is proposed in the balance parcel (ie. grass swale), appropriate mechanisms to allow Council to access these swales for future maintenance (i.e. easements) are required to be shown on the ROL plan **OR** provide confirmation if these swales are only temporary and to be maintained by Lendlease until such time as the ultimate treatment train is constructed in the future precinct to the east.

***Further Issues Response**: Swales confirmed as temporary measures only and not to be handed over to Council*

IS Assessment: Accepted by IS

iii. The SMP references the Yarrabilba (Quinzeh Creek) Flood Study (Design Flow, March 2017). This report does not sufficiently address the waterway stability in accordance with the State Planning Policy. **Amend** the SMP to include assessment of waterway stability.

***Further Issues Response**: The previously approved P5 SMP-V2 extended south to broadly cover the area now known as precinct 4F with the specific drainage line relating to P4F being the 'Southern Tributary'. The assessment and management strategy remains relevant and is valid for Precinct 4F.*

IS Assessment: Not accepted by IS, while previous data from P5 SMP-V2 may be relevant it is to be included/referenced in current Precinct 4F SMP.

Additional Response:

Section 6 - Waterway Management of this revised *Stormwater Management Plan – Version 2* has now been added which includes the previous data and assessment relevant to the waterway reaches downstream of Precinct 4F (as documented in the previously approved *Precinct 5 Stormwater Management Plan – Version 2* (DesignFlow, 2017).

iv. The *Yarrabilba (Quinzeh Creek) Flood Study* (Design Flow, March 2017) indicates that the critical duration at Location ID 15 is 3.5-4.5 hours for 2 year ARI storm event. The waterway stability assessment is to address the stormwater impact for short-duration storm event for the localised catchment.

***Further Issues Response**: This model was run for a range of durations from 60 minutes to 12 hours to capture the critical duration event throughout the site and catchment. All outputs from the model are mapped as the maximum envelope of all durations and is therefore valid for this assessment within the local drainage line.*

IS Assessment: Accepted by IS

3 SITE CHARACTERISTICS

3.1 LOCATION

Development Precinct 4F lies in the central eastern portion of the Lendlease site bordering the southern edge of existing Precinct 4 as shown in Figure 1. The precinct covers a total area of 27.3 ha.

3.2 TOPOGRAPHY, CATCHMENTS AND DRAINAGE

The existing topography across the majority of the precinct exhibits fairly consistent grades of around 5-6% generally falling westward from the ridgeline on the eastern portion of the site. The western boundary of the precinct is bounded by an existing vegetation drainage line falling to the north. A minor portion of the site falls east and southeast from the dividing ridgeline drainage into a future development precinct. Stormwater drainage, water quality and flood management of this area will be integrated into the subsequent stage strategy where the continuation of roads, pipe drainage and lots will occur as part of future design. Elevations vary from 56mAHD to 38mAHD within the site. The ridgeline forms the catchment boundary between the Quinzeh Creek (Logan River) and Albert River catchments. The site and topography is shown in Figure 2.

Precinct 4F sits generally within Catchment 4 of the broad Yarrabilba development site as defined in the *Yarrabilba (Quinzeh Creek) Flood Study - Version 1* (DesignFlow, 2017).

3.2.1 Lawful Point of Discharge

The lawful point of discharge for stormwater from Precinct 4F is directly north into existing Precinct 4 drainage network and the adjacent tributary of into Quinzeh Creek as illustrated in Figure 1. This watercourse is a drainage feature under the Water Act (2000). This Quinzeh Creek remains within the Yarrabilba site until such time as it discharges north of the site (between Precinct 3A and 3C) near Steele Road approximately 3 km downstream of Precinct 4F.

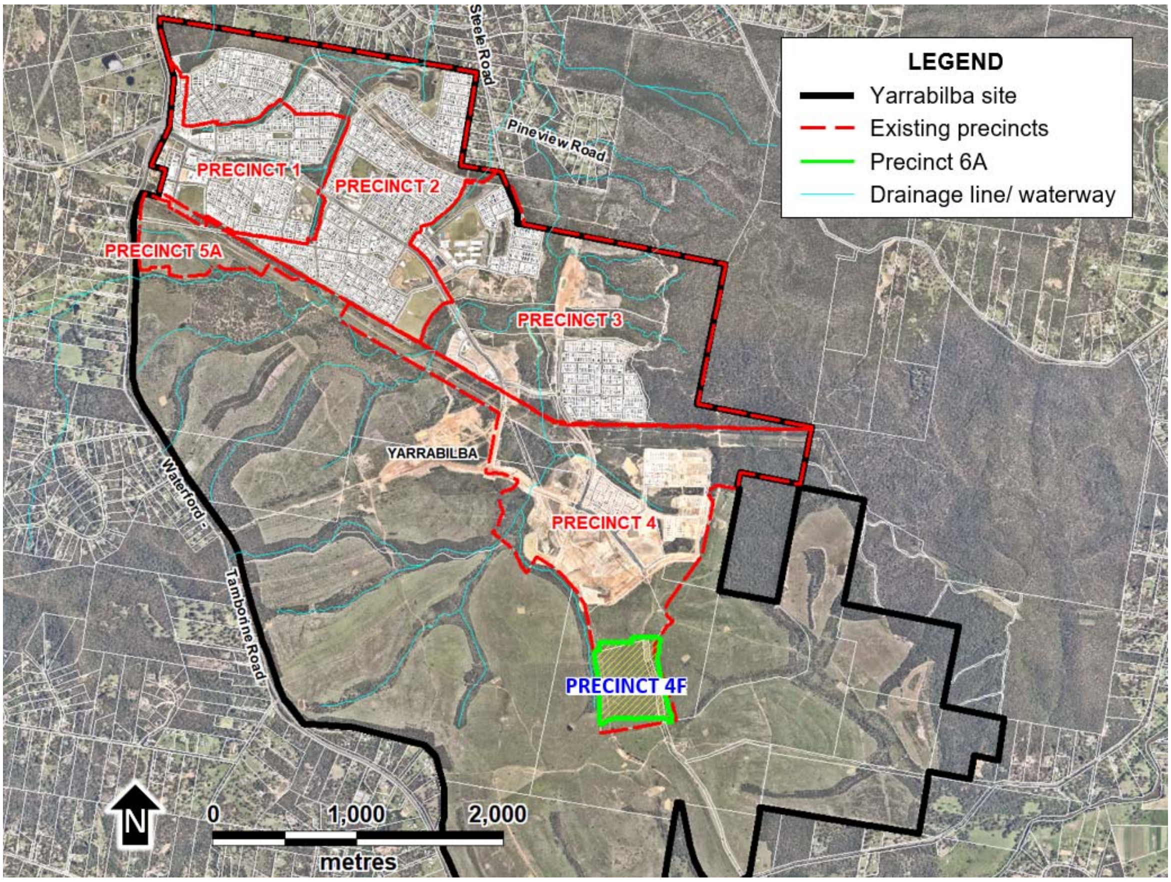


Figure 1: Yarrabilba Precinct 4F locality

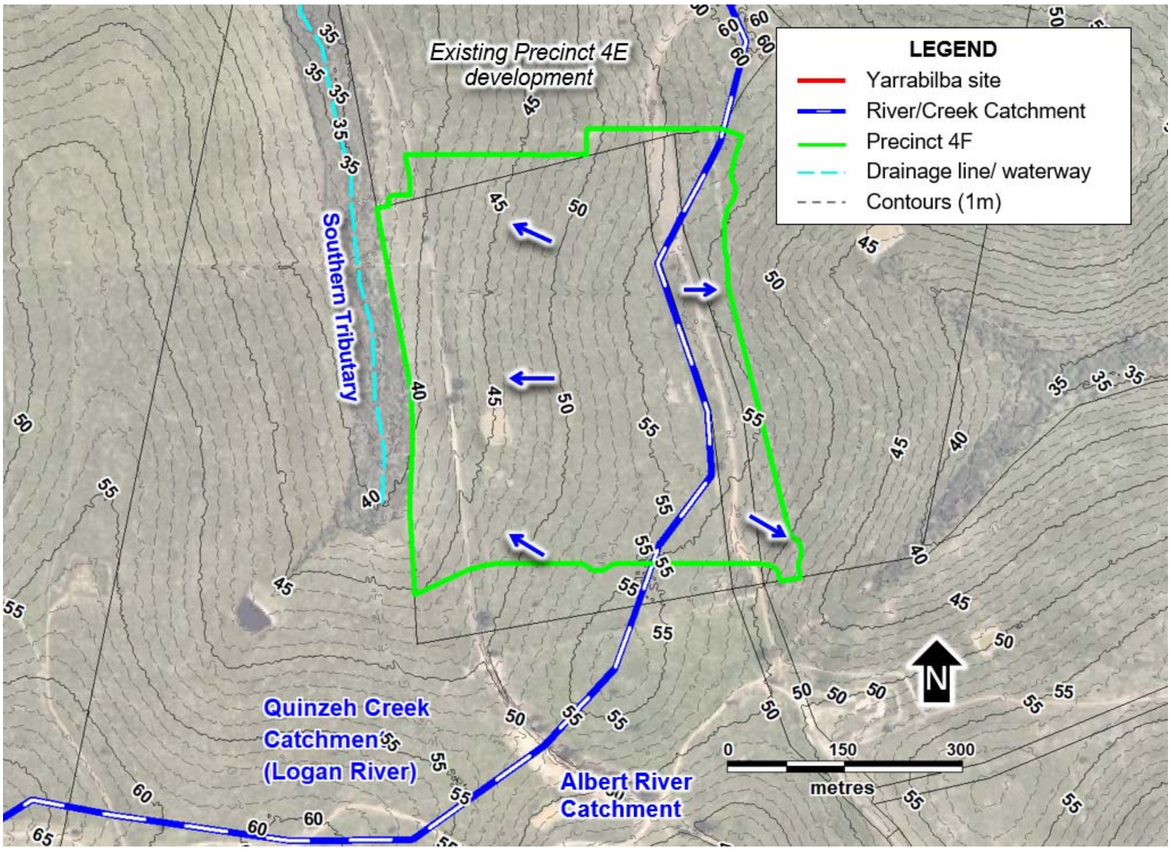


Figure 2: Existing topography, catchments and drainage

3.3 GEOLOGY AND SOILS

Geological mapping indicates Precinct 4F is located across two geological units:

- Woogaroo sub-group (RJbw)
- Alluvium (Qa)

Broad scale geotechnical investigations completed across the site (Bowler, 2004) indicate subsurface soils are typically sands overlying silty clays and weathered sandstones. The soil conditions for much of Precinct 4F are not expected to vary significantly from those encountered in the balance of Precinct 3 and 4 previously (i.e. those within the lower slope development zones). The alluvium zones (southern edge of P5 MIBA north) have often displayed deep sand zones in localised areas of previous precincts where historic channel/creek incisions have been filled with sediment eroded from upslope catchments. Further site specific geotechnical investigations will occur within Precinct 4F to confirm soil conditions for civil engineering design.

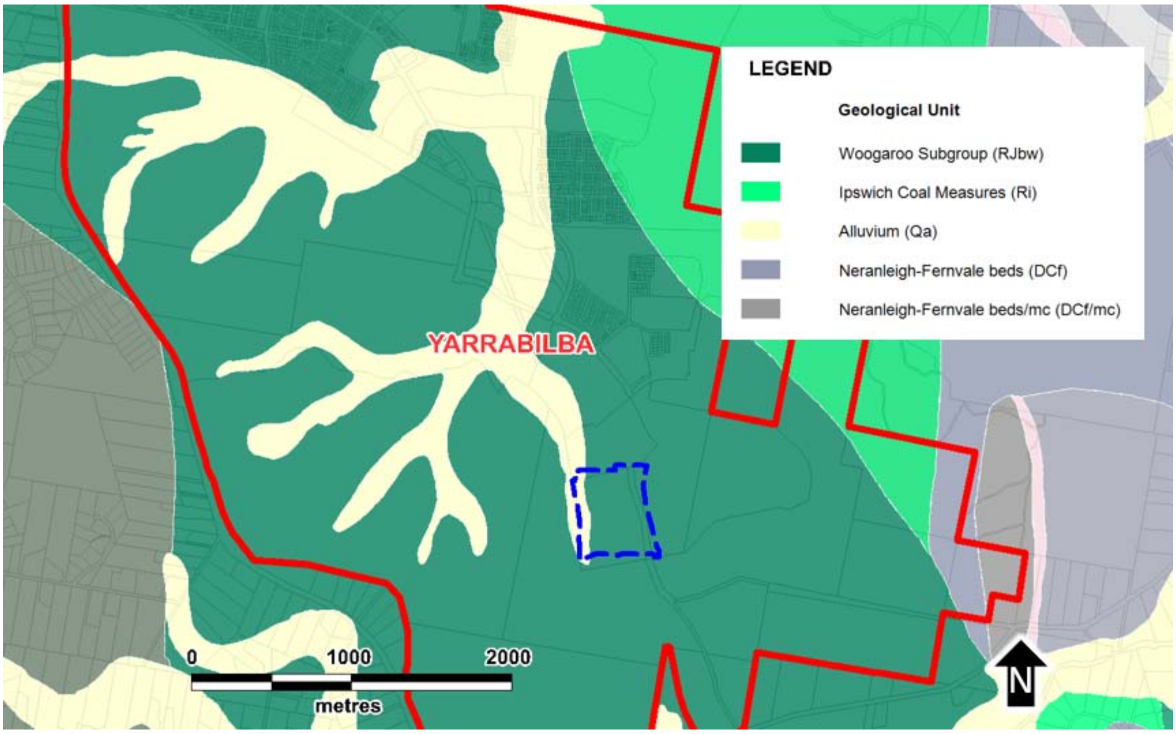


Figure 3: Geology and soils

3.4 VEGETATION

The majority of the Yarrabilba site was previously pine plantation, with most vegetation associated with grassland or pine and eucalypt/acacia regrowth of limited ecological value. Historical aerial imagery illustrates grassland and pine areas represent roughly 80% of the existing land use across the Yarrabilba site, which have subsequently been covered with regrowth. Moderate to dense vegetation generally occurs along drainage lines in the development area.

Vegetation management will generally be undertaken in accordance with *Yarrabilba Development: Natural Environment Site Strategy* (Natura Consulting, 2012) which highlights vegetation management procedures with regards to clearing approvals, revegetation, monitoring/compliance and design requirements. Strategy 14 in the CPAS provides the individual mapping for waterway, flora and fauna constraints as well as bushfire setbacks for the Precinct 4F development.

3.5 WATERWAYS

There are no mapped waterways within Precinct 4F boundary however the existing drainage line west of the precinct boundary (referred to as the southern tributary) has been included in the site planning for the purpose of assigning the minimum waterway buffers set out in the *Stormwater Infrastructure Master Plan* (DesignFlow, 2021). In conjunction with existing vegetation and bushfire considerations, the development extent has been defined outside this waterway corridor.

The overall condition of the southern tributary waterway is generally rated as a mix of poor (upper reaches) to average (lower reaches) with some areas of good condition (middle reaches) in the *Yarrabilba General Waterway Condition Assessment* (DesignFlow, 2021) and future management/rehabilitation will be critical to the improvement of this waterway for long term ecological and geomorphological benefits.

Previous review of this southern tributary is also provided in *the Yarrabilba Precinct 5 Stormwater Management Plan – Version 2* (DesignFlow, 2017) which has since been renamed to Precinct 4. Some natural regeneration of waterway vegetation is likely to have occurred in this area in recent years since the removal of grazing livestock.

3.6 PROPOSED DEVELOPMENT

The proposed development covers an area of approximately 27.3 hectares (ha) which includes just under 15 ha of development lots, 3.5 ha of balance lots, 8.2 ha of roads and around 0.8 ha of open space and stormwater treatment areas. The precinct layout is shown in Figure 4.

YARRABILBA

PRECINCT FOUR - APPLICATION FIVE BOUNDARY
STAGE BOUNDARY
OPEN SPACE
LOCAL STAGE ROAD
PATHWAY CONNECTION
VILLAGE ROAD
MAJOR ROAD

LAND USE	AREA (ha)
Residential	14.84 ha
Open Space	0.92 ha
Road - Major Road	1.60 ha
Road - Collector Road	2.69 ha
Road - Local Street	4.29 ha
TOTAL	24.33 ha

MINIMUM RESIDENTIAL DENSITY - 22.73 ha, 331 dw, 14.6 dw/ha
MAXIMUM RESIDENTIAL DENSITY - 22.73 ha, 331 dw, 14.6 dw/ha

LOT YIELD BY LOT TYPE

LOT TYPE	No.	No.%	AREA	AREA%	MINIMUM	MAXIMUM	AVERAGE
T1	15	4.53%	10631.73m²	7.16%	640.00m²	891.28m²	706.78m²
T2	13	3,93%	7907,44m²	5,33%	576,00m²	751,23m²	606,28m²
T3	5	1,51%	3145,53m²	2,12%	576,00m²	699,00m²	629,11m²
C2	56	16,92%	26009,53m²	17,52%	444,00m²	611,31m²	464,46m²
C3	51	15,41%	27736,59m²	18.69%	505.16m²	778,59m²	543,65m²
PV	58	17.52%	24340.38m²	16.40%	396.97m²	592.34m²	419.66m²
V	32	9,67%	11417,46m²	7,69%	336,00m²	519,49m²	356,61m²
TT3	4	1,21%	2971,66m²	2,00%	691,64m²	762,67m²	742,91m²
TCY2	23	6,95%	6860,50m²	5,97%	350,00m²	502,41m²	385,24m²
TCY3	22	6.65%	10144.87m²	6.84%	400.00m²	596.94m²	461.13m²
TPV	19	5.74%	6124.98m²	4.13%	312.50m²	413.04m²	322.58m²
TV	21	6,34%	6011,13m²	4,05%	262,50m²	386,25m²	286,24m²
TCD	12	3,63%	3113,11m²	2,10%	202,50m²	373,28m²	259,43m²
TOTALS	331	100%	149418,31m²	100%	202,50m²	891,28m²	446,40m²

NOTE:
MINIMUM DWELLINGS is based on the development of one dwelling on each single family and multi-family strata (MFS) lot.
MAXIMUM DWELLINGS is based on the development of one dwelling on each single family lot, and three dwellings on each multi family strata (MFS).

DENSITY calculations include the area of residential lots, local roads and credited park. The boundaries, roads and pathways shown hereon are subject to detailed engineering design, final survey and approval of subsequent development applications by the relevant authorities.

PRECINCT FOUR - APPLICATION FIVE
RECONFIGURATION OF A LOT

lendlease

File No. YAR-P04 Dgn No. YAR-P04-ROL5-ROL-220907 Date 07 SEPT 2022

Figure 4: Precinct 4F proposed layout

4 STORMWATER QUALITY

4.1 DESIGN OBJECTIVES

The stormwater quality management objectives that apply to the operational phase of Yarrabilba Precinct 4F are listed in Table 5 as defined by *the Yarrabilba – Stormwater Infrastructure Master Plan* (DesignFlow, 2021), which are consistent with the State Planning Policy (DSDIP, 2017).

These objectives require the reduction of pollutant loads discharged from the development site once all construction works are complete. These load reductions are aimed at protecting the environmental values of downstream receiving waterways from the impacts of urban stormwater runoff.

Table 1: Stormwater quality objectives

Pollutant	Discharge criteria (% reduction in mean annual load)
Total suspended solids (TSS)	80%
Total phosphorous (TP)	60%
Total nitrogen (TN)	45%
Gross pollutants (GP)	90%

4.2 STORMWATER QUALITY MANAGEMENT STRATEGY

A stormwater management strategy has been developed for Precinct 4F based on a review of the site characteristics, constraints, masterplan for the proposed development zones and discussions with Lendlease. The proposed strategy has been developed in collaboration with the design team to ensure the proposed strategy is well integrated with both engineering and landscape aspects of the design.

The stormwater treatment strategy integrates with the existing development, drainage and treatment basins to the north (Precinct 4D and 4E) as well as providing a local bioretention basin at the south western corner of the site.

When developing the treatment strategy, a number of key principles were considered:

- Adopt multiple use open space principles where possible
- Locate treatments in waterway buffer zones, where applicable, as per *Yarrabilba – Stormwater Infrastructure Master Plan* (DesignFlow, 2021)
- Adopt similar treatment philosophy as per Precinct 1, 2,3 and 4 developments to retain consistency across the development
- Integrate with landscape outcomes
- Minimise the impact on existing vegetation and ecosystems

Figure 5 shows the overall proposed treatment strategy for Precinct 4F with details of treatment provided in Table 2 and the relevant flood immunity provided in Table 3. Further details of performance assessments of the proposed treatment strategy are presented in Section 4.3.

Two minor catchments 4F2 and 4F3 discharge east from the site to future development precinct(s) and associated stormwater treatment basins. While no formal stormwater treatment infrastructure will be provided at these interim outlets in the short term, provision of natural grassed overland flow paths has been considered in the overall strategy and reported in Section 4.3.5.

Table 2: Stormwater treatment elements

Treatment Type and ID	Size	Catchments	Comment
Bioretention Basin 4F1	800 m²	4F1a, 4F1b	Proposed basin in Precinct 4F
Bioretention Basin 4E1	800 m²	4E1	Existing basin in Precinct 4E treating part of Precinct 4E and part Precinct 4F
Sediment Pond 4D1/6E1 [1] Wetland 4D2 Bioretention 4D3-4D5	800/400 m² 1500 m² 3 x 1000 m²	4D1, 4E2, 6E1 [1]	Large scale integrated treatment system

Note:

1. northern future development catchment 4F1 from version 1 of SMP was renamed to catchment 6E1 (and sed pond 6E1) to avoid naming double up with southern catchment 4F1a/b.

The concept design for the proposed bioretention basin (Bio 4F1) has been documented in the functional design plans by KN Group (Appendix A). Key design parameters are summarised in Table 3. These are subject to detailed design as part of operational works. The existing treatment basins in Precinct 4D and 4E (refer to Figure 5) have been documented previously as part of Precinct 4 (formerly Precinct 5) and not reproduced here.

Table 3: Bioretention Basin 4F1 concept design levels summary

Parameter	Concept Design
Area	800 m²
Surface level	RL43.0
Bunds	RL44.0 (min.)

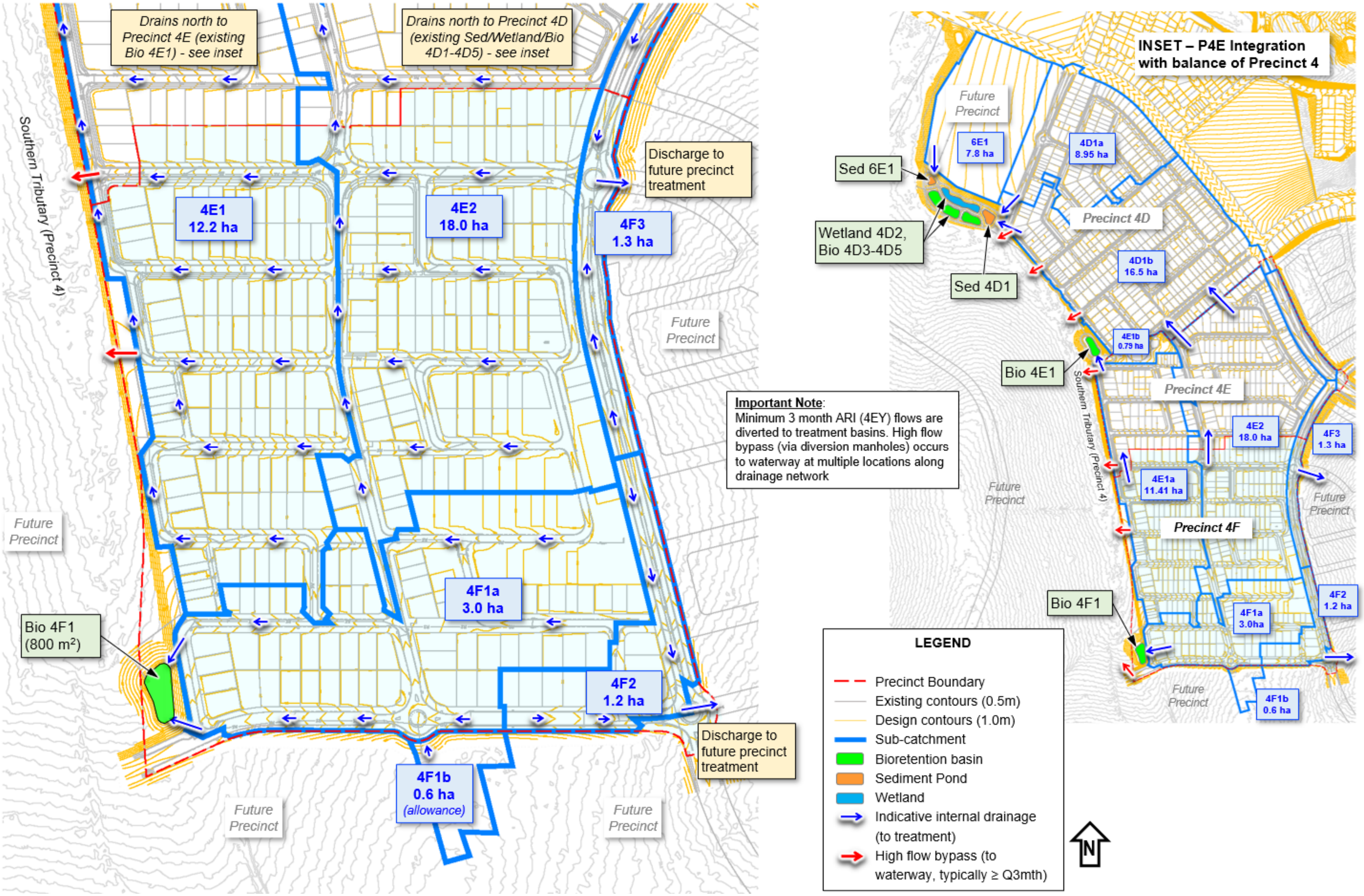


Figure 5: Precinct 4F stormwater quality management strategy

4.3 STORMWATER QUALITY ASSESSMENT

MUSIC modelling was conducted to assess the stormwater treatment performance of the proposed treatment strategy. MUSIC Version 6.3 was used for the assessments.

4.3.1 Model Structure

The structure of the MUSIC model is shown in Figure 6 with the general data provided in Table 4.

MUSIC model parameters were adopted generally in accordance with the *MUSIC Modelling Guidelines* (Water by Design, 2010) using 10 years (1990-2000) of modified Shailer Park meteorological data. Six minute rainfall data and monthly average evapotranspiration data was used. The Shailer Park station was selected for adoption as it is the closest rainfall station to the site with 6 minute data. The rainfall data set was modified to generate a data set closer representing Logan Village rainfall. The Shailer Park 6 minute rainfall was reduced by a factor of 0.849 to produce a rainfall data set with a similar annual total to Logan Village (950mm) for the period considered. Discussion of this was provided in Section 5.1 of the *Precinct 1 Stormwater Management Plan* (DesignFlow, 2011) and has been consistently used in all subsequent applications since that time.

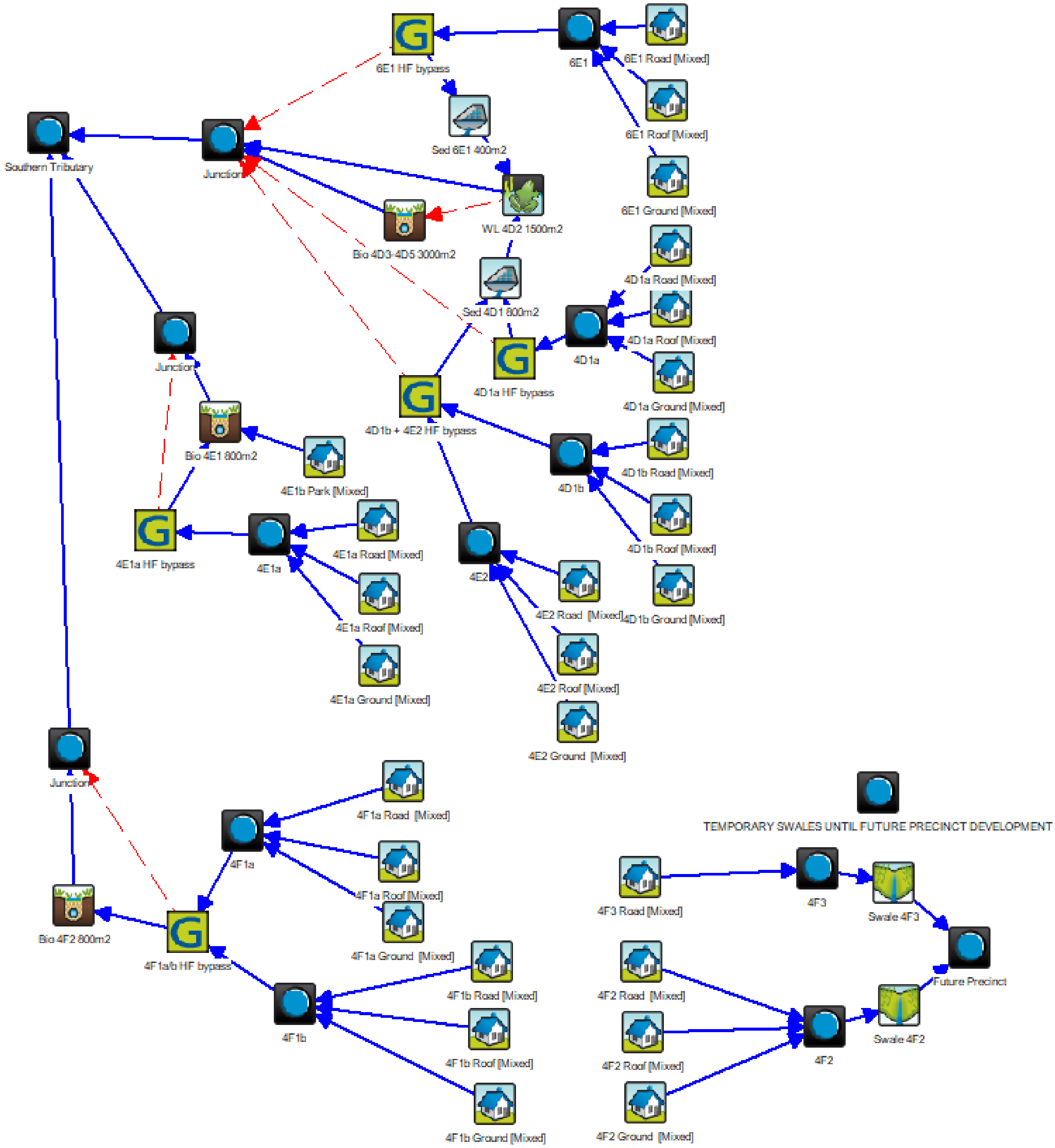


Figure 6: MUSIC model layout

Table 4: MUSIC modelling parameters

Parameter	Value
Source Data	
Rainfall data set	1990-99– Modified Shailer Park Station 040715
Modelled time step	6 minute
Mean annual rainfall 1990-2000	950 mm
Potential evapotranspiration	1,446 mm
Soil properties (runoff generation parameters)	Table 3.7 Music Modelling Guidelines (as appropriate depending on land use)
Pollutant concentrations (base flow and storm flow concentration)	Table 3.8 Music Modelling Guidelines (as appropriate depending on land use)
Percent impervious	Table 3.5 and 3.6 Music Modelling Guidelines (as appropriate depending on land use)
Treatment Devices	
Bioretention	Filter media depth = 0.6 m Extended detention depth = 0.3 m Extended detention area = Bio area (when stand-alone) or Bio + wetland + sed pond (when in combined system) Seepage = 0 mm/hr TN content 400 mg/kg Orthophosphate content 30 mg/kg Overflow weir width = bio area/10
Sediment Basin	Extended detention depth (EDD) = 0.01 m (extended detention depth over 0.01m is included in bio basin where linked) Evaporative loss 75% of PET Notional detention time = <0.1hr (upstream of wetland or bio) Overflow weir width = sediment pond area/10
Wetland	Extended detention depth = 0.1m (extended detention depth over 0.1m is included in bio basin where linked. refer assumptions in Section 4.3.2) Permanent pool = 0.3 m (average) Inlet pond volume = 0 (upstream sediment basins) Notional detention time = 48 hr Evaporative loss 125% of PET Seepage = 0 mm/hr TN k = 200 m/yr, TN C*=0.75mg/L Overflow weir width = wetland area/10

4.3.2 Assumptions

1. A split catchment approach was adopted for modelling. Split land use percent imperviousness is generally in accordance with Table 3.5 in MUSIC Modelling Guidelines (Water by Design, 2010/2019).

2. Bioretention default values for TN and OP content have been adopted as 400mg/kg and 30mg/kg respectively as per Water by Design advice (and in line with MUSIC Guideline 2019)

3. High flow bypass thresholds (based on existing detailed design flows or future development estimates) are set at Generic nodes upstream of all treatment nodes for easy identification. Refer to Section 4.3.4 for details.

4. Sediment ponds (Sed 4D1 and Sed 6E1 adjacent to existing Precinct 4D) connect via culverts to constructed wetland WL 4D2 (assumed at same water level) with minimal flow restriction (i.e. minimum allowable 0.01m extended detention adopted in MUSIC with large pipe and weir connection to freely convey inflows)

5. Wetland WL 4D2 is connected to multi-cell bioretention basins 4D3-4D5 via overflow weirs at 0.1m above wetland normal water level (i.e. 0.1m extended detention depth in wetland)

6. Bioretention basin cells 4D3-4D5 are modelled as combined total surface area (where actual design will split these into multiple cells to ensure flow distribution across filter).

7. Bioretention basins 4D3-4D5 have 0.3m extended detention depth before overflowing to discharge. Extended detention area is taken as sum of 'shared' area over bioretention, wetland and sediment pond (see notes regarding extended detention depths assumed above) as bioretention controls rapid water level drawdown for all these systems.

8. For stand-alone bioretention basins (Bio 4E and Bio 4F), standard direct inflow, bio area equal to extended detention area and 0.3m extended detention depth is used.

9. All overflow weirs from all treatment systems have adopted the treatment area/10 for the weir width as per the *MUSIC Modelling Guideline* which ensures conservatively large weirs and avoids any additional treatment resulting from extended detention above weirs. Detailed design will resolve actual weir sizes (as well as pit sizing where applicable) with accompanying MUSIC model verification.

The above assumptions ensure the current functional design of all treatment systems is conservative and allows for more than adequate earthworks, treatment and maintenance space allowances within the current development layout. All systems will be subject to detailed catchment, hydraulic and MUISC model verification at detailed design stage.

4.3.3 Catchment Data

The catchment areas draining to each treatment system have been derived from the urban design and drainage layouts for sub-stages where available. Table 2 previously identified catchments areas contributing to each treatment element. Table 5 below lists the catchment area, land use and percent impervious for each sub-catchment modelled with the detailed breakdown of surface types.

Table 5: MUSIC model catchment split data

Catchment ID	Total Area (ha)	% Impervious	Surface Type	Sub-Area (ha)	Impervious %
4D1a	9.00	60%	Road	2.24	60%
			Roof	3.36	100%
			Ground	3.36	20%
4D1b	16.50	60%	Road	4.13	60%
			Roof	6.19	100%
			Ground	6.19	20%
4E1a	11.41	60%	Road	2.85	60%
			Roof	4.28	100%
			Ground	4.28	20%
4E1b	0.79	5%	Park	0.79	5%
4E2	18.00	60%	Road	4.50	60%
			Roof	6.75	100%
			Ground	6.75	20%
6E1	7.80	67%	Road	2.33	70%
			Roof	2.71	100%
			Ground	2.71	30%
4F1a	6.00	66%	Road	1.50	70%
			Roof	2.25	100%
			Ground	2.25	30%
4F1b	0.60	66%	Road	0.15	70%
			Roof	0.23	100%
			Ground	0.23	30%
4F2	1.50	66%	Road	0.38	70%
			Roof	0.56	100%
			Ground	0.56	30%
4F3	1.30	70%	Road	1.30	70%
Total	*72.8*	*61%*		*72.8*	*61%*

Notes:

1. Catchments 4F2 and 4F3 drain east to future development precinct.
2. Higher density assumed for catchment 6F1 based on Masterplan and subject to future development application.

4.3.4 Secondary Link Data

Table 6 summarises the secondary links used in the updated MUSIC modelling and the relevant high flow bypass (HFB) threshold (where relevant) or flow component (from upstream treatment node). Where HFB applies, a dedicated Generic node has been used in the model to readily identify the bypass location and downstream connection node. All flows above HFB thresholds are diverted around treatment via secondary links.

Table 6: Secondary link data

From Node	To Node	Outflow Components	HFB Threshold	Comment
6E1 HF Bypass	J1	High flow bypass	1.42 m^3/s	HFB estimated at Q2 pipe flow from 7.75 ha future development (allow for medium density)
4D1a HF Bypass	J1	High flow bypass	1.503 m^3/s	HFB as Q2 pipe discharge at 01OUT from KN Group Dwg 21-124-03 and 21-124-16 (P4 ROL1 Stg 4)
4D1b + 4E2 HF bypass	J1	High flow bypass	2.844 m^3/s	HFB as pipe discharge at 05OUT (being a combination of Q3mth diversion and local Q2) from KN Group Dwg 21-124-03 and 21-124-16 (P4 ROL1 Stg 4)
4E1a HF bypass	J2	High flow bypass	0.926 m^3/s	HFB as pipe discharge at HW01/092 (being a combination of Q3mth diversion and Q2 local catchment) from KN Group Dwg 22-153-23 and 22-153-04 (P4E Stg 33)
4F1a/b HF bypass	J3	High flow bypass	0.92 m^3/s	HFB estimated as Q2 pipe flow from 6.60ha residential catchment (no detailed design at yet)
WL 4D2	Bio 4D3-4D5	Weir overflow	N/A	Direct weir connection from wetland to bioretention cells (low flows from wetland via pipe to node J1)

4.3.5 Results

The results of the MUSIC modelling are presented in Table 7. All water quality objectives can be readily achieved with the proposed treatment strategy that integrates with the existing Precinct 4 treatment catchments.

Table 7: MUSIC results

Catchments	Treatment ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction (%)
4D1, 4E2, 6E1	Sed/Wetland /Bio 4D1-4D5	TSS	47000	7240	84.6
		TP	99.6	25.7	74.2
		TN	624	316	49.3
		GP	7840	152	98.1
4E1	Bio 4E1	TSS	10200	2290	77.5
		TP	22.2	6.9	68.9
		TN	140	73.5	47.5
		GP	1750	50.1	97.1
4F1a, 4F1b	Bio 4F1	TSS	5790	988	82.9
		TP	12.4	2.96	76.1
		TN	79.5	34.6	56.5
		GP	996	70.5	92.9
Total Precinct 4F (✓ denotes compliance with water quality objectives)		TSS	63000	10500	83.3
		TP	134	35.6	73.5
		TN	844	424	49.7
		GP	10600	273	97.4

A review of the untreated catchments 4F2 and 4F3 discharging to future development precinct to the east has been undertaken based on flow paths within the natural grassed gullies. For each discharge location, an assume 100m grassed swale has been simulated to represent the upper portion of the natural overland flow paths at the head of the gullies.

Table 8: Interim treatment results (eastern discharge only)

Catchments	Treatment ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction (%)
4F2, 4F3	Swale 4F2, Swale 4F3	TSS	4230	546	87.1
		TP	7.64	2.67	65.1
		TN	33.7	28.6	15.2
		GP	439	0	100

These grassed gullies extend several hundred metres before entering any mapped drainage lines so overall treatment can be expected to be higher. In broad terms that the interim short term discharge from these two locations can be readily managed for TSS and TP with TN shortfalls about 30% below the objective of 45% reductions. This will only occur until the adjacent precinct undergoes development. The contribution of this portion of Precinct 4F (totalling ~2.8ha) is in the order of only 0.5% of the total catchment (~550ha) discharging from the Yarrabilba site to the southeast and will have negligible impact on the short term water quality leaving the broader Yarrabilba site to the south east.

4.4 COMPLIANCE AND CERTIFICATION

Design and construction certification of operational stormwater quality measures is to occur in accordance with the following guidelines:

- Water by Design (2104). *Bioretention Technical Design Guidelines (Version 1.1)* Healthy Waterways Ltd, Brisbane
- Water by Design (2009), Construction and Establishment Guidelines: Swales, Bioretention Systems and Wetlands, SEQ Healthy Waterways Partnership. Brisbane, Queensland.
- Water by Design (2012), *Transferring Ownership of Vegetated Stormwater Assets Version 1*. Healthy Waterways Partnership. Brisbane, Queensland.

5 STORMWATER QUANTITY

Precinct 4F is generally in accordance with the *Yarrabilba (Quinzeh Creek) Flood Study – Version 1* (DesignFlow, 2017). No flood detention infrastructure is required as part of this precinct as it falls within the regional strategy that is managed by Flood Basin 15 (Fauna Way) (approved previously as part of Precinct 3B). No further flood impact assessment is therefore required as part of this stormwater management plan.

A review of the preliminary earthworks design of the proposed development area in relation to local flood levels is provided in Figure 7. This indicates that P4F is well above the 1% AEP flood level being conveyed through the Precinct 4 southern tributary to upper Quinzeh Creek. While the flood mapping below indicates the flood extent ceases just north of the Precinct, the waterway corridor continues to function as an overland flow path from surrounding catchment. Flood mapping is from the regional scale Yarrabilba Quinzeh Creek model and nominally limits the mapped flooding in upper first order waterways.

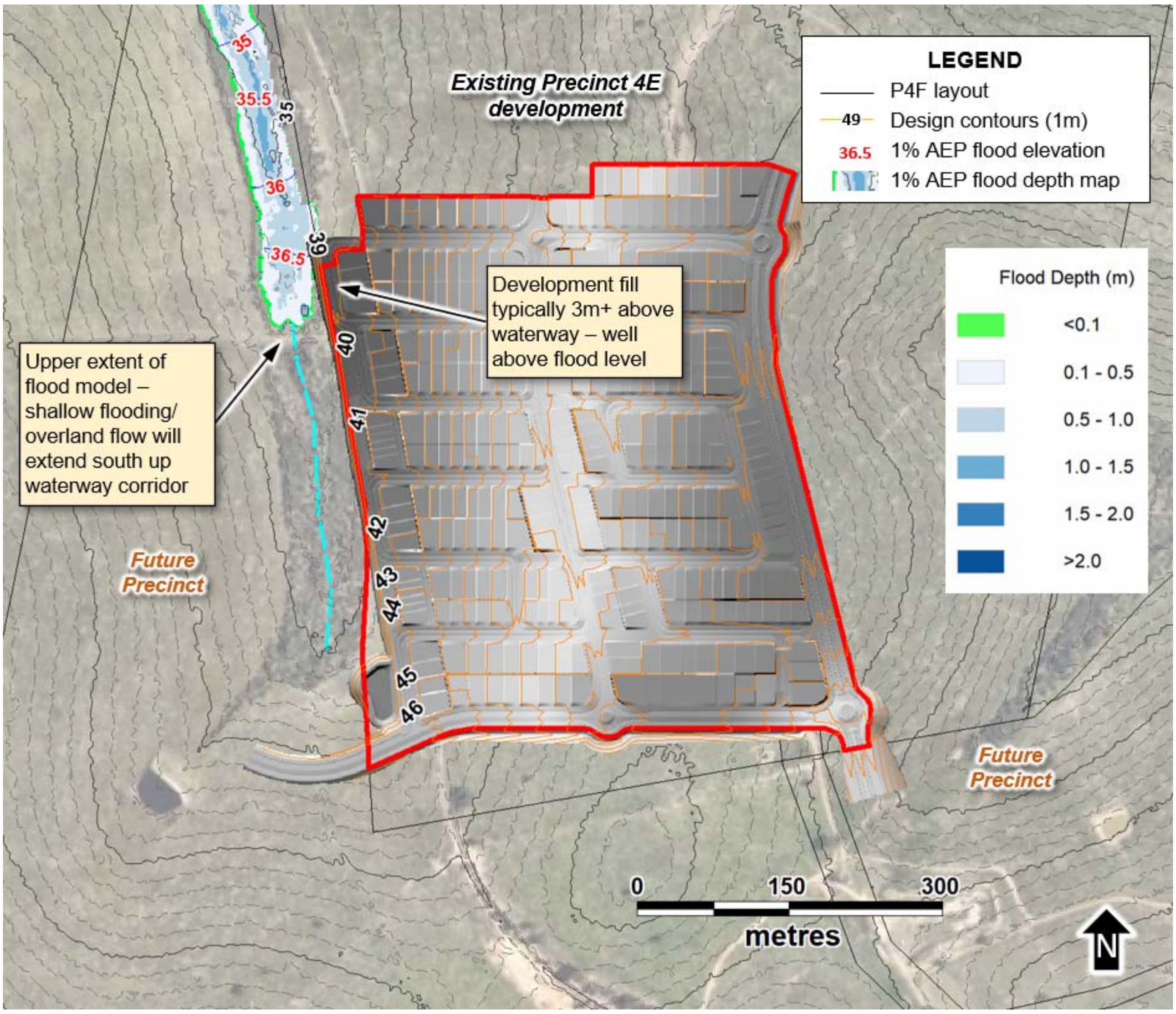


Figure 7: 1% AEP Flood levels and preliminary earthworks

As noted previously in Section 4.2, a minor portion of Precinct4F at the eastern edge drains towards the Albert River catchment. The area of this eastern portion has been reduced from ~4.5ha pre-development to 2.8ha post development. This area represents about 0.5% of the total ~550 ha catchment draining from the south easter corner of the Yarrabilba site. Discharge from this area of Precinct 4F remains within the Yarrabilba site (overland within undeveloped pastures) for a further 2km and does not warrant flood mitigation nor will have any measurable impact of peak discharge from the overall site at the Yarrabilba site boundary. Planning and development of the adjoining precinct will account for this portion of Precinct 4F drainage.

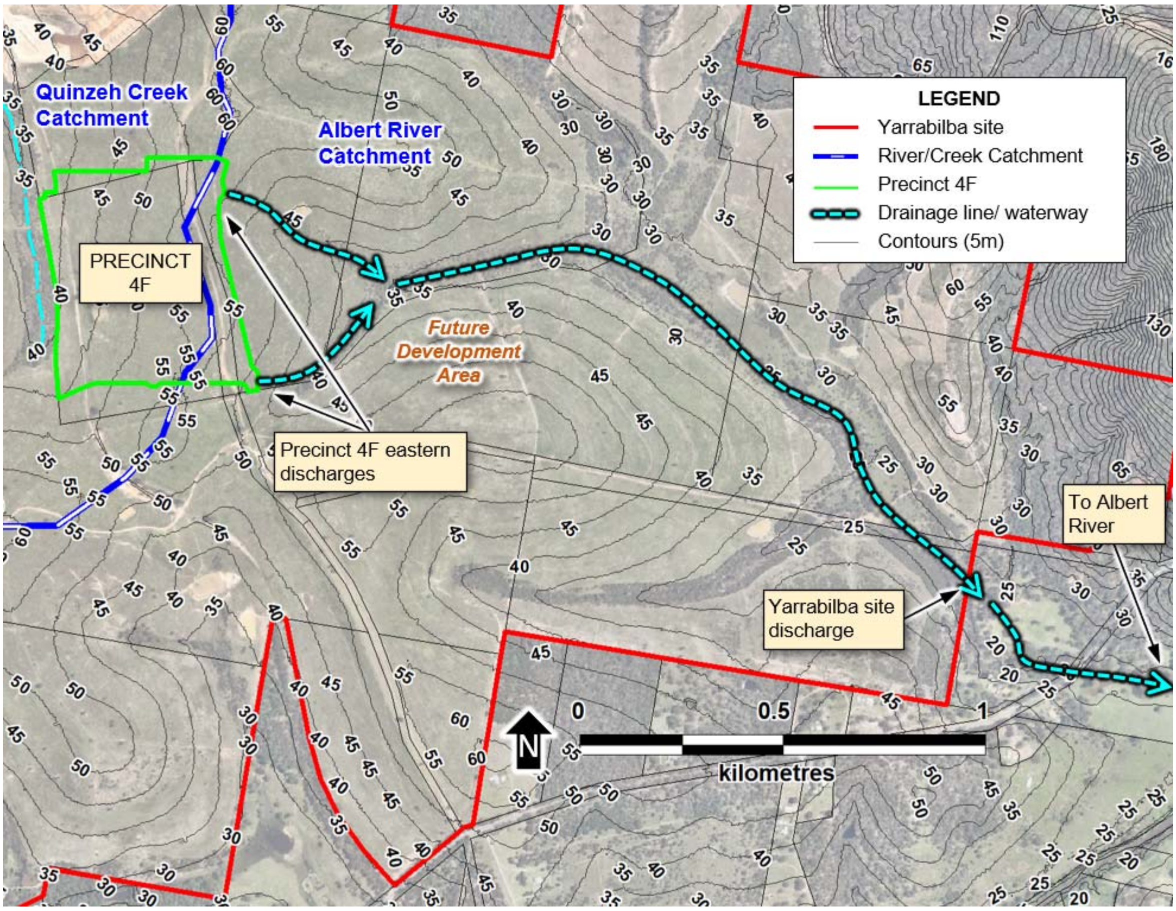


Figure 8: South-eastern site drainage

6 WATERWAY MANAGEMENT

As stated in Section 3.5, no part of Precinct 4F extends into the retained waterway (or buffers). However, in response to EDQ's further issues request (refer section 2), the following information is included from the previous *Yarrabilba Precinct 5 Stormwater Management Plan – Version 2* (DesignFlow, 2017) approved as part of the Precinct 4 (formerly Precinct 5) applications DEV2017/860, DEV2017/904, DEV2021/195 and DEV2022/1280. This has been modified to remove reference to the 'Northern Tributary' (as this relates to the northern portions of Precinct 4 only) and focussed the information on the 'Southern Tributary' to which Precinct 4F (along with precinct 4E approved previously) discharges into. Relevant figures have also been updated to reflect the subject location associated with precinct 4F and downstream waterway.

6.1 WATERWAY OBJECTIVES

6.1.1 Waterway Stability

The waterway stability objectives adopted for the site are based on protecting high value waterways from erosion as a result of increased flow from urban development and providing improvements to average or degraded waterways under developed hydrology. This applies to waterways and drainage lines within the site as well as downstream receiving waterways beyond the development boundary. Due to the large size of the site and significant variation in waterway types and riparian and in-stream condition, the waterway stability objective has been derived for a range of situations as shown in Table 9. These objectives are consistent with the *Yarrabilba Total Water Cycle Management Strategy* (DesignFlow, 2012), *Yarrabilba Stormwater Infrastructure Master Plan* (DesignFlow, 2012) and *State Planning Policy* (DSDIP, 2017).

Table 9: Derived waterway stability objectives

Waterway classification	Waterway Stability Criteria
Site waterway reach in good condition (i.e. well vegetated and stable waterway)	Limit post development 1 year ARI flows in waterway to pre-development conditions*
Site waterway reach in average/poor condition (i.e. poorly vegetated or active erosion)	As per above OR Rehabilitate waterway to convey the post development 1 year ARI flows without the risk of erosion*
External waterways	Limit 1 year ARI flows at site boundary for critical duration event (60 minutes or longer) to pre-development conditions

* Localised increases in 1 year ARI flows can be accepted provided the erosion criteria for sandy vegetated soils (50% cover for native grasses) is achieved in accordance with QUDM. The objective supports the rehabilitation of waterways and allows local increases in 1 year ARI provided the rehabilitation design provides an appropriately stable waterway for the increased 1 year ARI flows.

6.2 WATERWAY STABILITY ASSESSMENT

The stability assessment for the waterways in Precinct 4 has been based on both site investigations and the detailed hydraulic (Tuflow) modelling undertaken as part of the *Yarrabilba (Quinzeh Creek) Flood Study – Version 1* (DesignFlow, 2017) which included modelling of the 1 year ARI discharge as well as velocity and bed shear stress analysis of minor and major flood flows.

The assessment included below is generally confined to those areas of waterway that are within the extent of waterway mapping and or within the modelled floodways. Where the development has allowed for retention of the natural vegetation beyond the mapped waterway, extension of the stability assessment has been undertaken to capture these areas. Further, where waterways are outside the Precinct 4 boundary but receive discharge from precinct 4, these are included in the current assessment (southern tributary).

Details below are supported by the photographic log and waterway reference plan in Appendix B.

6.2.1 Characteristics

The drainage lines within the precinct are characterised by very low gradients with broad shallow profile and minimal low flow channel definition. The upper Quinzeh Creek section within Precinct 4 has an overall average longitudinal gradient of less than 0.25% with many flat areas of no discernible or measurable gradient, including wetland areas. The uppermost portion of this drainage line increases to just under 0.4% which is still very flat. The southern tributary grades at around 0.7%. None of these drainage slopes represent a concern for long term instability due to high velocity.

The overall waterway condition ratings provided in the *Yarrabilba General Waterway Condition Assessment* (DesignFlow, 2013) indicates the main drainage line along the north west portion of Precinct 4 (extension of upper Quinzeh Creek) is in good condition (with the exception of the powerline easement which is and will remain cleared and in poor condition) while the two tributaries (northern and southern) extending up into Precinct 4 to the east were more varied with generally average condition and local areas of poor and good condition along there lengths.

A site investigation was undertaken on 20 April 2017 to further assess the characteristics and condition of the waterways in Precinct 4 since the original work undertaken in 2013. This inspection occurred around 3 weeks after the significant rainfall event of late March 2017 that caused widespread flooding in the surrounding Logan and Albert River catchments. The observations are therefore based on a comparatively wet catchment (as base flow) compared to waterway inspections in previous years and therefore reference to any ponds may be only temporary in nature based on the timing. A brief overview of these findings is provided below with additional information provided in Appendix B. Figure 10 in Section 6.3 provides the waterway layout and chainage locations referred to in the following sections.

Upper Quinzeh Creek Tributary

This waterway forms the major flow path for the southern portion of the Yarrabilba site draining to Quinzeh Creek. The northern extent of Precinct 4 is defined by the major powerline easement infrastructure corridor (100m wide) traversing the waterway which is cleared of remnant vegetation. Localised wet depressions and wheel rutting characterise former access tracks through this area. No major unstable areas were evident due to the very broad flat nature of the waterway and lack of concentrated flow path. Localised areas of iron bacteria were observed, which are characterised by orange/brown slimy deposits.

At the southern edge of the easement, a mapped wetland vegetation community spans the majority of the broad flow path (up to approximately 400m wide) with areas upstream of the mapped wetland exhibiting wetland characteristics with saturated ground conditions and dense wetland vegetation.

The current Wentland Avenue road crossing is approximately 300-350m upstream of the easement. Localised soil disturbance around this bund due to the civil construction occurred with vegetation currently re-establishing in these areas. No significant ongoing erosion or instability issues within the natural drainage line downstream were evident, partly due to the dense groundcover and sedge growth within the wet areas. Upstream of the road bund is characterised by another large flat area of shallow wetland with dense vegetation gradually giving way to scattered ponded/vegetated areas at the fringe (as ground levels increase upslope). Very isolated pockets of bare ground were observed (due to livestock damage) but do not represent any widespread instability or erosion issue and are likely to regenerate naturally once livestock is removed.

Southern Tributary

The southern tributary extends generally south-east to south off the main upper Quinzeh Creek floodway. The lower end (chainage 0-500m in Figure 10) is characterised by a broad cross section, very low gradient with no discernible low flow channel. Scattered saturated areas exist where seepage accumulates in depressions. Dense grass cover interspersed with dense shrubs/immature trees dominates the lower drainage line with no instability evident here. Again (similar to descriptions above), the southern tributary contains iron bacteria (visual observations only) which is more extensive than seen in the northern tributary or Upper Quinzeh Creek. Orange/brown slimy deposits and oily sheens (in stagnant pools) was observed mainly along the low flow channel where it was defined, often masked by groundcover vegetation. As noted previously, the significant rainfall of late March 2017 (3 weeks prior to observations) meant groundwater stores were recharged and low flow seepage was quite prevalent. In areas where groundwater contains iron, this creates ideal conditions for iron bacteria proliferation.

The mid and upper reaches are characterised by localised scour pools between areas of dense undergrowth and scattered trees. Low flow channel(s) are evident periodically along the reach and can often be associated with livestock/wild animal tracks (longitudinal and transverse). Some ponding/scour holes also appear to be livestock watering points and show disturbance and vegetation trampling/dieback at the edges. At approximately 1300m chainage, a ponded zone of approximately 30m wide extending 50m upstream has been formed upstream of a track crossing. Review of previous inspection notes and historical aerial photos indicates that this is very ephemeral in nature, with open water not persisting long term (returns to wet depression via infiltration and low flow seepage to downstream channel).

6.2.2 Modelling

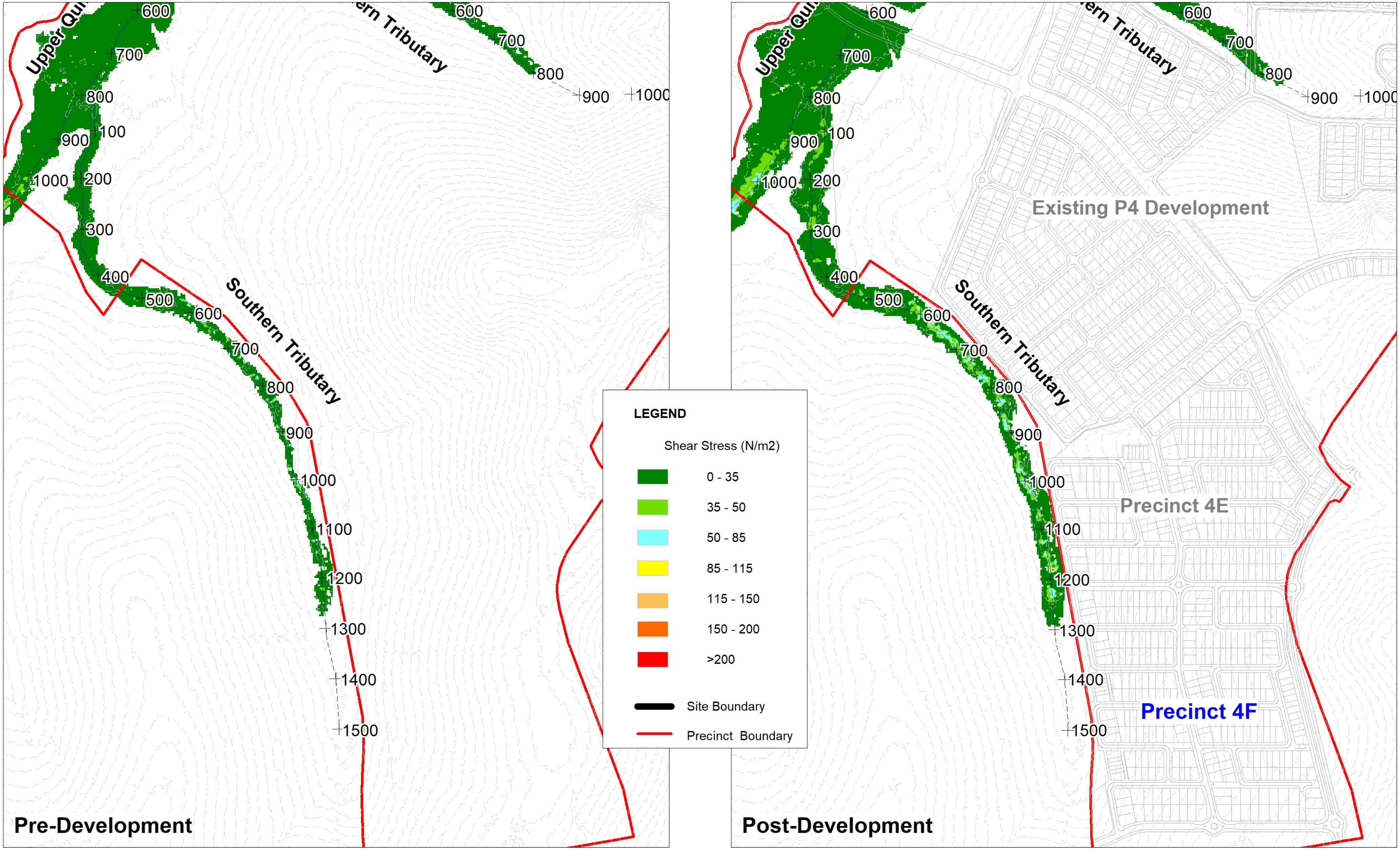
The existing flood model for the Yarrabilba site (within Quinzeh Creek) has been used to extract waterway stability information to assist with the assessment and development of an appropriate waterway stability management strategy. It should be noted however that the resolution of the flood model (3m grid) is such that very localised scour issues will not necessarily be identifiable from model outputs and therefore should not be relied upon solely for the management of specific areas. As noted in Section 6.3, the adoption of both targeted engineering approaches as well as an adaptive monitoring and management of stability issues ensures that the strategy responds to changes over time.

Table 10 provides a broad scale analysis of the flow characteristics at the downstream end of the main drainage lines for pre and post-development catchment conditions. It should be noted that this data is based on the fully developed site conditions (i.e. Precinct 4 plus future adjoining and upstream precincts developed) and therefore Precinct 4 (in the short term) will show lower developed flows and velocities accordingly.

Table 10: 1 year ARI discharge in Precinct 4 tributaries (downstream ends)

	Flow (m^3/s)		Velocity (m/s)	
	PRE	DEV	PRE	DEV
Upper Quinzeh Creek	20.9	24.8	0.57	0.66
South Tributary	3.9	13.9	0.53	0.80

This data indicates that while the peak discharge (at bottom of each drainage line) increases as a result of urbanisation (particularly in tributaries), the actual velocity increases are comparatively small and very low in overall magnitude under both pre- and post-development scenarios. This is in most parts due to the broad flat profile of the drainage lines that can experience significant increase in flow rate with only very minor increase in flow depth and velocity. Further analysis and discussion of the pre and post-development flood modelling is provided in Figure 9 and Section 6.2.3 below.



Prepared by: DesignFlow

For: lendlease

Project: 4494

Yarrabilba Precinct 4F Stormwater Management Plan

Client: Lendlease

Scale: 1 : 1,000 (A4)

Date: 12 September 2017 (Revised 21/03/2023)

Figure 9

1 year ARI Bed Shear Stress Comparison

6.2.3 Discussion

Shear stress modelling provided has been derived from the Quinzeh Creek catchment flood model at a 3m grid to broadly identify the relative shear stress changes and does not specifically account for:

- Minor flow attenuation that occurs within stormwater treatment basins (and the fact that pipe drainage network will input flows generally lower down in the local waterway than the flood model accounts for).
- Very localised spatial variations in vegetation and tree coverage (i.e. Tuflow roughness/materials layers are more broad scale and representative of a total reach)
- Very minor areas of bare soil and scour and/or woody debris causing flow deflection
- Longer term rehabilitation and regrowth of channel vegetation

Due to these constraints and the limited justification for updating the catchment flood model to this level of detail, the bed shear stress mapping was used as a reference point for the development of the Waterway Stability Management Strategy (Section 6.3 below) which indicates that under pre-development conditions, the Southern Tributary shear stresses (in the order of 35-85 N/m2) represents relatively minor and localised instability (i.e. model outputs were broadly correlated with site based investigations/observations of current conditions in Appendix B). Under post-development hydrology, the shear stress magnitude generally remains in this range but over a broader area through the channel invert (refer Figure 7 in Section 5.2.2). The targeted waterway management strategy therefore aims to manage existing scour issues while also allowing rehabilitation/stabilisation to target the expected post development flow regime coupled with an adaptive management strategy that responds to the uncertainties in channel geomorphology.

With comparison to the QUDM permissible velocities (QUDM Table 9.5.2) assuming 50% stable vegetation cover on easily erodible soils, the above post development velocities (at downstream end of reach where flows are greatest) are significantly below the maximum suggested of 1.2m/s and therefore represents low risk in terms of increased susceptibility to broad scale erosion. However, localised areas of scour may be likely where surface features such as mounds, pools or fallen trees create concentrated or high energy flow (beyond the resolution of the abovementioned flood modelling).

Review of bed shear stress data from the minor 1 year ARI flow against threshold values derived by Prosser and Slade (1994) and Prosser *et. al.* (1995) for a number of vegetation types indicate that bed shear stress values derived from the broadscale flood model are below those for tussock and sedges in various states of disturbance (240 N/m^2 undisturbed and 180 N/m^2 disturbed) and bunch grasses long and short (184 to 104 N/m^2 respectively). This evidence suggests that for a range of vegetation types, erosion thresholds are generally higher than modelled for this waterway. However, recognition that higher values are likely due to localised conditions and flow patterns, that are beyond the resolution of modelling and therefore management strategies are adaptive.

Locations where shear stress is at its highest (typically between chainage CH600-CH1300) is also where targeted waterway stability management strategies are focussed. This enables the stabilisation works to ensure post development hydrology is considered. Where the post-development 1 year ARI flow extent is broader than pre-development, bed shear stress is very low (green areas <35N/m² in Figure 9) and does not present risk of instability.

The inclusion of localised detention basins targeting waterway stability of waterways adjoining Precinct 4 is therefore not warranted and the previously proposed waterway stability management strategy remains valid and appropriate for Precinct 4.

6.3 WATERWAY STABILITY MANAGEMENT STRATEGY

As described in Section 6.2.1, the waterways downstream of Precinct 4F are considered to be in varying condition (ecologically) while being relatively stable owing largely to the very low gradients and vegetation cover of these drainage lines. However, localised areas of instability combined with impacts of historical livestock interaction and future increases in flows from development dictates the need to provide protection and improvements to these areas to ensure long term sustainability of these waterways.

The following provides the recommended waterway stability management strategy which can be broadly defined by a number of main actions:

- Removal of livestock access (e.g. exclusion fencing) to waterways and revegetation of degraded areas.
- Areas of very minor instability should be monitored to assess the success of natural regeneration of groundcover vegetation following the removal of livestock from waterways
- Targeted stabilisation (with rock and/or engineering structures) of scour pools and significant areas of instability.
- Scour protection at in-stream structures such as road crossing culverts and stormwater outlet headwalls
- Ongoing monitoring of channel stability as development proceeds (including future adjacent precincts) to guide reactive management of channel stability. Particular attention should be paid to those areas identified as currently eroding and those adjacent to infrastructure

Unlike previous waterway stability concerns in the steep incised gully areas of Precinct 3B and 3C, there is no need for major works associated with drop structures, rock chutes or re-battering of steep banks in Precinct 4 as both the longitudinal and cross sectional profile of the waterways are comparatively broad and flat, presenting minimal erosion and instability risk.

Figure 10 provides the overall precinct waterway stability management strategy that targets the degraded and/or future disturbance areas associated with development. Typical stabilisation techniques applicable to this strategy (and adopted in previous precincts onsite) area described in Section 6.3.1.

6.3.1 Stabilisation Techniques

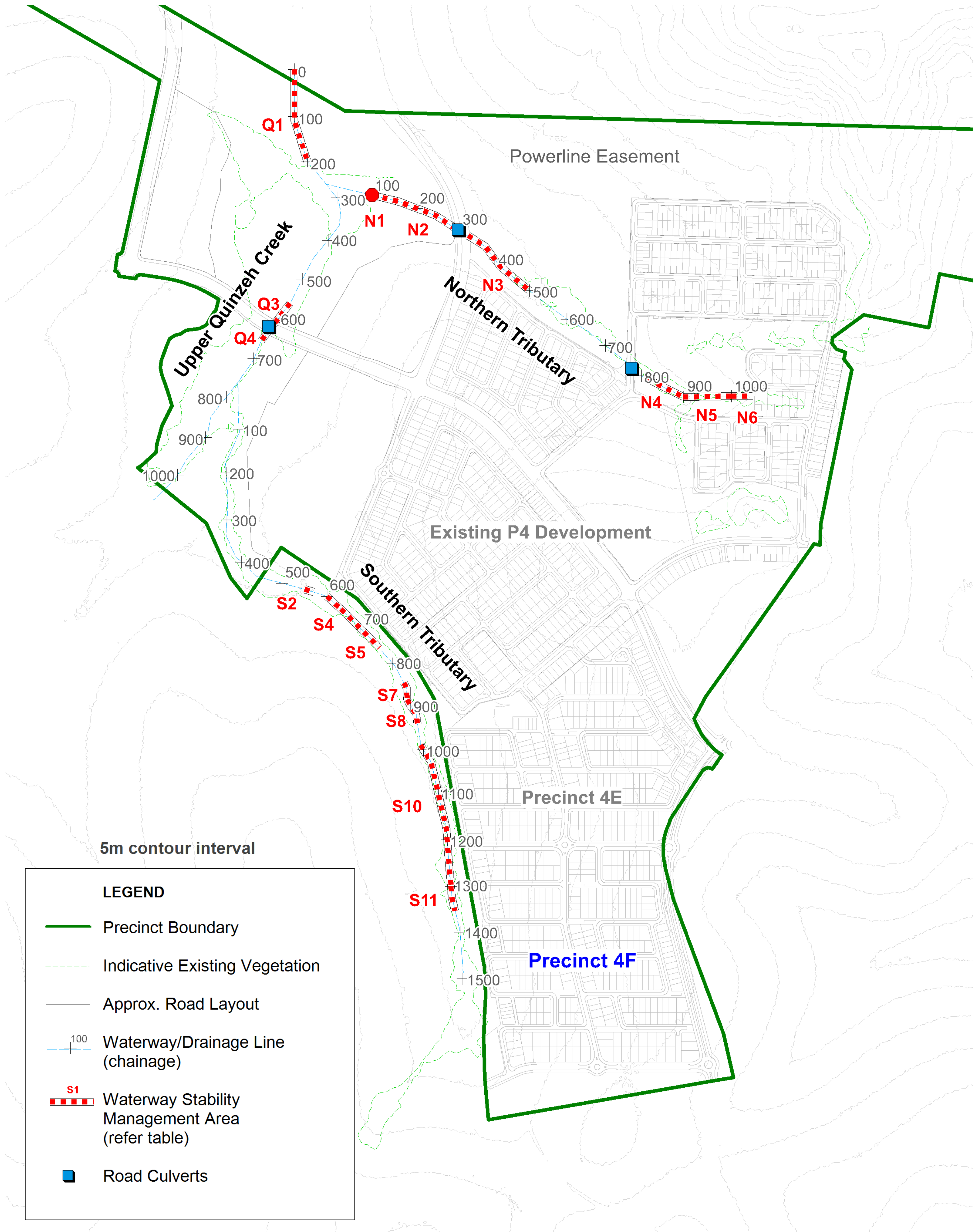
Rock Protection

Scoured areas and incised channels are to be reshaped to flatten vertical edges and placement of rock or rock mattress over geofabric to armour underlying soil. Integrate planting within rock voids where practical. Rock protection must be formed with depressed centre to ensure flows are directed into and through the area and set down slightly below the natural ground level to avoid flow redirection around the edges (creating new scour).

Revegetation

Areas with little or no vegetation cover should be replanted with a mix of locally established species to create both a soil anchor (via roots) as well as flexible grasses that can lay flat during flow (as a surface armouring) to create a stable flow path. This is most appropriate to broad low gradient flow paths (where rock channel linings are not required). The use of pinned down jute or coir mat (not net) prior to planting is required to create a short term soil stabiliser until vegetation is established. Revegetation should also form part of any rock protection works.

In addition to stabilisation, revegetation (and landscape planting of development edges) will be an important part of the management of iron bacteria in waterways. While being a naturally occurring phenomenon in waterways with no known health risks, iron reducing bacteria (and the slimy deposits/oily sheens that result) can be unsightly when adjacent to urban areas. Further, the modification to the frequency and amount of stormwater input to local waterways (and infiltration to groundwater) will have potential to increase the prevalence of the iron bacteria. Vegetative screening is therefore critical to managing the amenity of local waterways.



Waterway Stability Management Strategy Notations

ID	CHAINAGE (APPROX.)	WATERWAY STABILITY MANAGEMENT
UPPER QUINZEH CREEK		
Q1	0-200	Powerline easement rutting/track disturbances - rehabilitation in conjunction with open space/vegetation rehabilitation plans
Q3	550-600	Future road crossing (downstream) - provide well stabilised culvert outlets and rehabilitate any areas from civil works disturbance in conjunction with open space rehabilitation plans. Decommission and/or stabilise existing access tracks traversing waterway.
Q4	600-650	Future road embankment/culverts (upstream) – as for downstream but allow for wetland vegetation rehabilitation
NORTHERN TRIBUTARY		
N1	100	Ponded zone from vehicle track disturbance – revegetate (in conjunction with open space rehabilitation plans) and monitor ongoing stability of confluence zone northern tributary
N2/N3	100-500	Localised animal/livestock tracks – revegetate in [illegible]junction with open space rehabilitation plans
N4	820-900	Historic sediment accumul[illegible] – monitor vegetation regrowth in sediments and ongoing stability [illegible]ed.
N5	900-1000	Narrow low [illegible]nel scoured/created 200-500mm deep – backfill with non-dispersive soil, stabilise with rock/vegetation and monitor stability.
N6	1000-1050	Narrow low flow channel scoured around fallen logs and woody debris 500-900mm deep – backfill with non-dispersive soil, stabilise with rock/vegetation and monitor stability.
SOUTHERN TRIBUTARY		
S2	550-570	Minor scour pool – fill, provide rock channel lining and interplant with grasses/flexible shrubs.
S4	600-630	Established scour pool with mature vegetation – reshape/batter scour pool edges, install rock lining and batter protection, revegetate banks and (depth dependent) plant emergent macrophytes in pool.
S5	630-750	Livestock/animal tracks merging with low flow channel – revegetate tracks, monitor stability of low flow channel following upstream development, and vegetate/stabilise where issues arise.
S7	850-880	Sediment deposition – revegetate and monitor establishment and longer term stability.
S8	880-930	Chain of ponds (scour pools) with establish trees – review habitat value with ecologist and undertake targeted works to stabilise banks, remove/relocated woody debris causing high energy flow, revegetate livestock damaged banks, and monitor zone following upstream development.
S10	980-1300	Intermittent livestock tracks/disturbance zones - revegetate livestock disturbed areas and monitor establishment/stability. Reshape/rock where issues arise.
S11	1300-1350	Ephemeral wetland/pond - review habitat value with ecologist and undertake targeted works to stabilise banks, decommission or stabilise track crossing at downstream edge, formalise ephemeral wetland vegetation, revegetate livestock damaged banks, and monitor zone following upstream development.

Not Relevant to Precinct 4F

Notes:

1. Where no specific waterway stability works are designated, revegetation may still be required in accordance with the vegetation rehabilitation plan.

2. Stormwater outlets from urban drainage/treatment measures are not shown. All outlets are to be stabilised with rock aprons to engineering standards. Refer to civil engineering plans for details.

3. Previous location ID S3 has been removed as instream diversion is no longer proposed as part of stormwater management.

This plan was originally developed for the approved Yarrabilba Precinct 5 Stormwater Management Plan - V2 (DesignFlow, 2017) (when current Precinct 4 was referred to as Precinct 5)

Prepared by: DesignFlow For: lendlease	Project: 4494 Yarrabilba Precinct 4F Stormwater Management Plan Client: Lendlease	N W E S Scale: 1 : 10,000 (A3) Date: 5 July2017 (revised 21/03/2023)	**Figure 10** **Waterway Stability Management Strategy**

Stormwater Outlets

All stormwater headwalls to be provided with rock aprons configured appropriately (in accordance with QUDM) to the size and number of pipes. Where natural channel just downstream of apron is susceptible to further instability, aprons should be enlarged or lengthened beyond unstable area. Further, if instream stabilisation has been identified, the rock apron should be linked to this zone to avoid potential scour between two areas.

Ongoing Monitoring

Where no (or very minor) erosion exists or potential future scour areas may occur based on high bed shear values (refer to Figure 9 previously) consideration should be given to minimising intervention in these areas where surrounded by very stable and/or well vegetated waterways zones. The potential impact of accessing these zones to undertake remedial activities (i.e. with earthmoving machinery) would likely create greater disturbance than benefit. Therefore, in the first instance, these areas will be monitored over the course of Precinct 4 development as well as into the adjoining precinct(s) development to review if these areas are degrading further. Reactive remediation can therefore be undertaken as required.

The adoption of this approach in Precinct 1 and 2 development indicates there is merit in limiting the intervention in degraded and disturbed waterways until development within the catchment has neared completion (unless major issues are evident prior). Allowing natural regeneration and succession of vegetation species within waterways (including weeds initially) has been shown to represent a beneficial and cost effective outcome for particular waterways. However, where overriding requirements for other fauna/flora management exist, these must be taken into consideration and adopted where necessary.

7 EROSION AND SEDIMENT CONTROL

7.1 DESIGN OBJECTIVES

The management of stormwater runoff during the construction phase is a critical part of protecting the Yarrabilba waterways and drainage lines. Construction phase design objectives for Precinct 4F are provided in Table 11 which are generally in accordance with the *Yarrabilba – Stormwater Infrastructure Master Plan* (DesignFlow, 2021) and the State Planning Policy (DSDIP, 2017).

Table 11: Construction phase stormwater quality

Issue	Desired outcomes
Drainage control	1. Manage stormwater flows around or through areas of exposed soil to avoid contamination. 2. Manage sheet flows in order to avoid or minimise the generation of rill or gully erosion. 3. Provide stable concentrated flow paths to achieve the construction phase stormwater management design objectives for temporary drainage works (part 2). 4. Provide emergency spillways for sediment basins to achieve the construction phase stormwater management design objectives for emergency spillways on temporary sediment basins (part 3).
Erosion control	1. Stage clearing and construction works to minimise the area of exposed soil at any one time. 2. Effectively cover or stabilise exposed soils prior to predicted rainfall. 3. Prior to completion of works for the development, and prior to removal of sediment controls, all site surfaces must be effectively stabilised* using methods which will achieve effective short-term stabilisation.
Sediment control	1. Direct runoff from exposed site soils to sediment controls that are appropriate to the extent of disturbance and level of erosion risk. 2. All exposed areas greater than 2500 metres2 must be provided with sediment controls which are designed, implemented and maintained to a standard which would achieve at least 80% of the average annual runoff volume of the contributing catchment treated (i.e. 80% hydrological effectiveness) to 50mg/L Total Suspended Solids (TSS) or less, and pH in the range (6.5–8.5).
Litter, hydrocarbons and other contaminants	1. Remove gross pollutants and litter. 2. Avoid the release of oil or visible sheen to released waters. 3. Dispose of waste containing contaminants at authorised facilities.
Waterway stability and flood flow management	1. Where measures are required to meet post-construction waterway stability objectives (specified in table B), these are either installed prior to land disturbance and are integrated with erosion and sediment controls, or equivalent alternative measures are implemented during construction. 2. Earthworks and the implementation of erosion and sediment controls are undertaken in ways which ensure flooding characteristics (including stormwater quantity characteristics) external to the development site are not worsened during construction for all events up to and including the 1 in 100 year ARI (1% AEP).

*Note: An effectively stabilised surface is defined as one that does not, or is not likely to result in visible evidence of soil loss caused by sheet, rill or gully erosion or lead to sedimentation water contamination.

7.2 MANAGEMENT STRATEGY

7.2.1 Local Erosion and Sediment Control

Erosion and sediment control (ESC) will occur on a development stage by stage basis in accordance with *Best Practice Erosion and Sediment Control* (IECA, 2008) to achieve the objectives listed in Table 1. This will involve a combination of:

- Erosion control - Ensuring that all exposed surfaces are stabilised as soon as possible and that erosion of un-stabilised areas of works are minimised
- Drainage control - Ensuring that provision is made to control all on site runoff to designated treatment areas and to enable appropriate bypass of external flows which do not require treatment
- Sediment capture - Ensuring that mobilised sediment is captured through a combination of source controls such as silt fences and appropriately designed sediment basins. Where possible sediment basins for construction will be located within the voids required for the future stormwater quality treatment systems (sediment basins, bioretention basins, wetlands etc.).

The details of the local erosion and sediment controls for each stage of development are not provided in this report given the high level nature of the document. However, prior to any works commencing on a particular development stage in Precinct 4F, a site specific Erosion and Sediment Control Plan (E&SCP) will be documented for the development stage in question prior to works starting. This will occur as part of the operational works application but can be adjusted by the contractor and site supervisor prior to commencement of construction provided the E&SCP complies with Best Practice Erosion and Sediment Control (IECA, 2008) and delivers the objectives listed previously in Table 11.

7.2.2 High Efficiency Sediment (HES) Basins

Given the importance of managing construction runoff into the waterways downstream of Yarrabilba and the potential impact on the ecology and residents, HES sediment basins are being strategically adopted (where practical) across Precinct 4F. HES basins offer an improved technology for construction sediment management which essentially converts batch sediment basins into continuous flow treatment systems that respond in real time to storm events. The design sought to be achieved by HES basins that ensures at least 80% of the average annual runoff volume treated to 50mg/L TSS or less

The HES basin essentially comprises:

- Flocculent dosing system
- Inlet zone for mixing, flow distribution and efficient removal of coarse sediment
- Settling basin
- Outlet(s)

Implementation of HES basins have the potential to significantly reduce the fine and dispersive sediment load discharge from the site by a further 50% compared to traditional batch sediment basins.

7.3 MONITORING AND AUDITING

7.3.1 Principal Contractor

Site inspections and monitoring are to be undertaken by the principal contractor in accordance with Sections 6.17 and 7.4 of *the Best Practice Erosion and Sediment Control Document* (IECA, 2008) as detailed below. Best practice site management requires all ESC measures to be inspected at the following frequencies and include the following checks as a minimum:

Daily site inspections (during rainfall):

- All drainage, erosion and sediment control measures
- Occurrences of excessive sediment deposition (whether on-site or off-site)
- All site discharge points (including dewatering activities as appropriate)

Weekly site inspections (even if work is not occurring on-site)

- All drainage, erosion and sediment control measures
- Occurrences of excessive sediment deposition (whether on-site or off-site)
- Occurrences of construction materials, litter or sediment placed, deposited, washed or blown from the site, including deposition by vehicular movements
- Litter and waste receptors
- Oil, fuel and chemical storage facilities

Prior to anticipated runoff producing rainfall (within 24 hours of expected rainfall)

- All drainage, erosion and sediment control measures
- All temporary flow diversion and drainage works

Following runoff producing rainfall (within 18 hours of rainfall event)

- All drainage, erosion and sediment control measures
- Occurrences of excessive sediment deposition (whether on-site or off-site)
- Occurrences of construction materials, litter or sediment placed, deposited, washed or blown from the site, including deposition by vehicular movements

7.3.2 CPESC Compliance Audits

The ESC measures implemented at the site are proposed to be inspected on a bi-monthly to quarterly basis by a CPESC (Certified Professional in Erosion and Sediment Control) who is independent of the principal contractor and an audit report kept on file. The purpose of the audits to is to ensure the developer and the contractors are meeting their obligations for ESC under the Environmental Protection Act (EP Act). The site will be assessed against these requirements in accordance with *Procedural Guideline: Standard work method for the assessment of the lawfulness of releases to waters from construction sites in South East Queensland EM1135* (DEHP, 2011).

The compliance audits will involve:

- Site inspection with the contractors to assess ESC actions on the site against the ESC plans and the requirements of EP Act and DEHP Procedural Guideline.
- Identifying non-compliances on the site, photographing and recording these for reporting.
- Where the rectification action is simple, these will be recorded and verbally communicated to the contractor for action.
- Review of any water quality and rainfall information for the site
- Compilation of a ESC Audit report which:
    - Identifies the ESC obligations
    - ESC issue and non-compliances
    - Actions (simple) to be taken to rectify the issues and non-compliances.

The triggers for inspections and reporting by the CPESC are as follows:

- Prior to the commencement of clearing works in each catchment
- Prior to the commencement of bulk earthworks;
- Prior to the commencement of civil works; and
- At regular monthly intervals during works.

8 CONCLUSION

A stormwater management strategy for Yarrabilba Precinct 4F development has been prepared to meet the requirements of the *Yarrabilba Stormwater Infrastructure Master Plan* (DesignFlow, 2021) and Context Plan Area Strategy.

The strategy includes a range of treatment measures including sediment ponds, bioretention systems and wetlands that manage both the existing Precinct 4D and 4E areas in conjunction with Precinct 4F. These treatment systems integrate with the local urban and natural environment to ensure the stormwater quality objectives are achieved for the overall precinct while providing protection or enhancement to the local waterways and amenity. Sufficient space has been allowed for in the development layout for the stormwater treatment measures which have been verified via preliminary earthworks plans. Site design has also ensured all development lots are above the local 1% AEP flood level and provided with adequate flow conveyance drains for external catchment discharge.

Setback to local waterway and vegetation corridors have guided the development layout with due consideration for future development expansion and waterway rehabilitation to the west of the subject site.

Construction phase stormwater management objectives have been established for the site, in accordance with State Planning Policy (DSDIP, 2017). Audits will be completed during construction to ensure compliance with State Planning Policy and Environment Protection Act.

9 REFERENCES

DesignFlow (2021) *Yarrabilba Stormwater Infrastructure Master Plan*

DesignFlow (2017) *Yarrabilba (Quinzeh Creek) Flood Study - Version 1*

DSDIP (2017) *State Planning Policy*

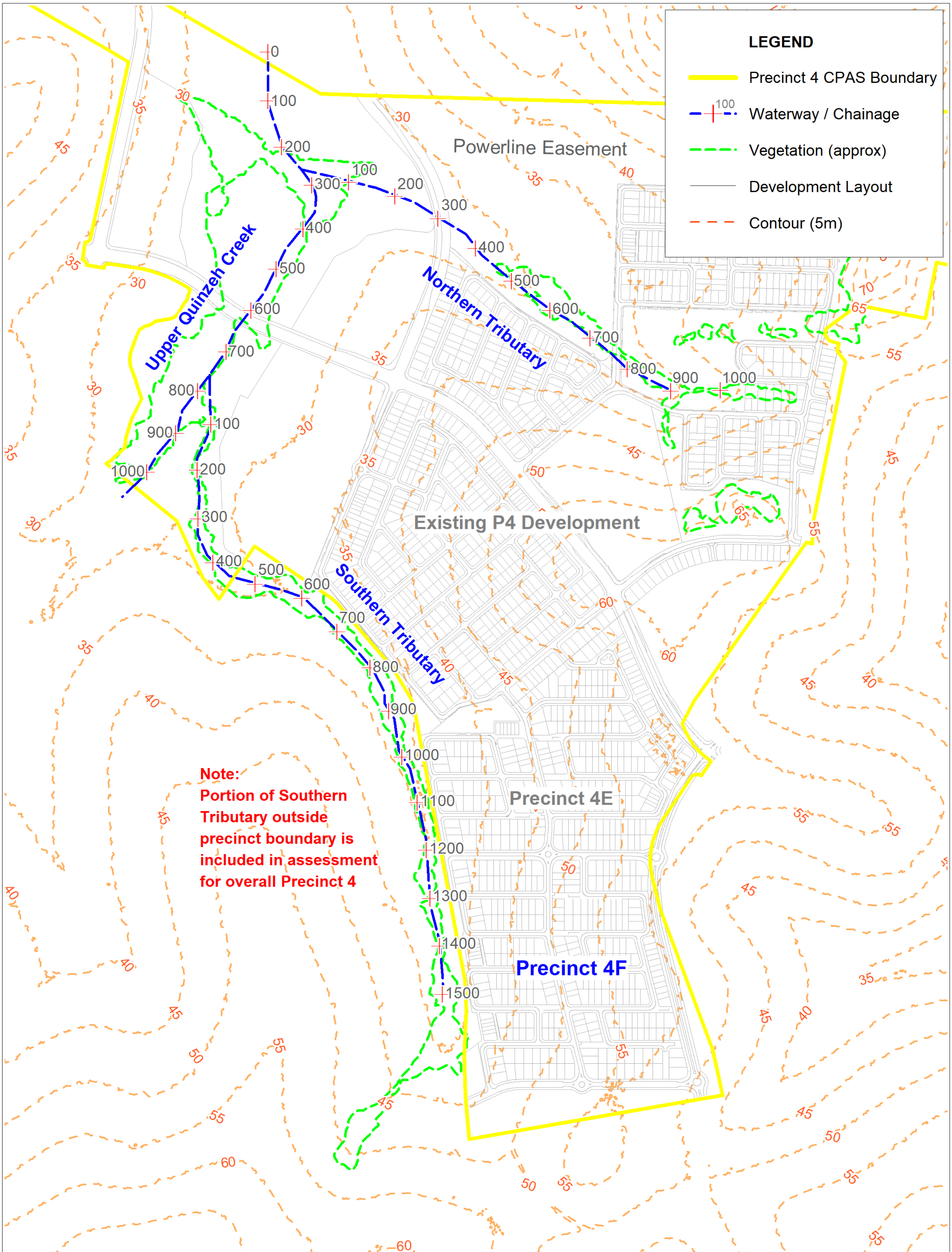
IECA (2008) *Best Practice Erosion and Sediment Control*

Water by Design (2010). *MUSIC Modelling Guidelines. SEQ Healthy Waterways Partnership.*

APPENDIX A FUNCTIONAL DESIGN PLANS

APPENDIX B PRECINCT 4 WATERWAY INSPECTION SUMMARY

Precinct 4 waterway inspection photo log summary is provided in the following sections with chainage references identified in Figure B1. All chainages commence at zero at the downstream extent/confluence of each tributary. Inspection was carried out 20 April 2017.



Prepared by: DesignFlow For: lendlease	Project: 4494 Yarrabilba Precinct 4F Stormwater Management Plan	N W E S Scale: 1 : 10,000 (A4)	**Waterway Inspection Reference Plan**
	Client: Lendlease	Date: 5 July 2017 (Revised 21/03/2023)	

UPPER QUINZEH CREEK

CH0-200 Powerline easement is fully cleared (grasses and some immature regrowth remain), broad flat scattered boggy zones.

CH200-400 mapped wetland - upstream extent with standing water, lower extent damp only. Excellent vegetation coverage.

CH400-600 Dense wetland understorey, moderate canopy, broad, flat, profile, no defined channel. Standing water throughout, no instability.

CH600 Interim flood bund 16-INT (downstream side). Post-civil works so minimal established vegetation evident.

CH600-800 broad flat wetland zone, moderate/dense vegetation within standing water. Vegetation (u/s of flood bund 16-INT).

CH600-800 broad flat wetland zone, moderate/dense vegetation within standing water. Vegetation (u/s of flood bund 16-INT).

NORTHERN TRIBUTARY	
 CH0-100 mapped wetland zone (background).	 CH100-500 very broad, flat gradient, open grassland, minimal trees, no channel definition.
 CH100-500 very broad, flat gradient, open grassland, minimal trees, no channel definition.	 CH500-800 open woodland with generally good grass cover, no flow channel present, minor livestock damage, very low gradient.
 CH800-900 reduced grass undergrowth, localised low flow channel (incised 20-50cm) with sediment deposition downstream of low flow channel formation, slight gradient.	 CH800-900 reduced grass undergrowth, localised low flow channel (incised 20-50cm) with sediment deposition downstream of low flow channel formation, slight gradient.

NORTHERN TRIBUTARY	
 CH800-900 reduced grass undergrowth, localised low flow channel (incised 20-50cm) with sediment deposition downstream of low flow channel formation, slight gradient	 CH900-1000 narrow incised low flow channel (1m wide to 0.75m deep) alternating with grassed broad sheet flow area, small pockets of scour pool, generally goof vegetation cover outside low flow channel.
 CH900-1000 narrow incised low flow channel (1m wide to 0.75m deep) alternating with grassed broad sheet flow area, small pockets of scour pool, generally goof vegetation cover outside low flow channel.	

SOUTHERN TRIBUTARY

CH0-500 open vegetation downstream transitioning into localised wooded zones, undefined low flow path within very broad flat waterway, scattered wet depressions throughout.

CH0-500 open vegetation downstream transitioning into localised wooded zones, undefined low flow path within very broad flat waterway, scattered wet depressions throughout.


CH500-600 moderate groundcover, clumps of trees, localised shallow pool and downstream sediment deposition area. Some livestock damage near pool.


CH500-600 moderate groundcover, clumps of trees, localised shallow pool and downstream sediment deposition area. Some livestock damage near pool.


CH600 stable pond, bare banks surrounded by mature and regrowth trees, some livestock damage to fringe.


CH600 stable pond, bare banks surrounded by mature and regrowth trees, some livestock damage to fringe.

SOUTHERN TRIBUTARY

CH600-800 iron bacteria coloured low flow shallow channel surrounded by dense groundcover and moderate tree canopy. No significant instability within low flow.

CH600-800 iron bacteria coloured low flow shallow channel surrounded by dense groundcover and moderate tree canopy. No significant instability within low flow.

CH800-850 well grassed broad flow path with localised sediment slug interspersed (material from upstream chain of ponds/scour pool)

CH800-850 well grassed broad flow path with localised sediment slug interspersed (material from upstream chain of ponds/scour pool)

CH850-950 Chain of ponds surrounded by dense vegetation. Local areas of instability and/or livestock damage.

CH850-950 Chain of ponds surrounded by dense vegetation. Local areas of instability and/or livestock damage.

SOUTHERN TRIBUTARY

CH950-1200 livestock disturbance, iron rich seepage within undefined low flow channel surrounded by dense ground and tree cover.

CH950-1200 livestock disturbance, iron rich seepage within undefined low flow channel surrounded by dense ground and tree cover.

CH1200-1300 dense grass surrounding iron rich low flow channel with pockets of livestock disturbance. Minimal instability issues.

CH1200-1300 dense grass surrounding iron rich low flow channel with pockets of livestock disturbance. Minimal instability issues.

CH1300-1350 moderate size pond ~30m x 50m (upstream of track crossing)

CH1300-1350 moderate size pond ~30m x 50m (upstream of track crossing)

SOUTHERN TRIBUTARY	
 CH1350-1500 dense grass, regrowth and very low seepage evident in localised pockets (no defined channel)	 CH1350-1500 dense grass, regrowth and very low seepage evident in localised pockets (no defined channel)