YARRABILBA PRECINCT 5
STORMWATER MANAGEMENT PLAN

VERSION 2

DesignFlow

Prepared for Lendlease

September 2017

Document Control Sheet

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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 5 is the fourth major residential precinct within Yarrabilba and covers an area of approximately 247 hectares (ha) which includes just under 146 ha of development (lots, schools, parks), 13 ha of roads, 38 ha of environmental and conservation areas and around 50 ha of powerline easement and associated buffers.

This document presents the stormwater management strategy for Yarrabilba Precinct 5 to meet the requirements set out in the Context Planning Area Strategy. These are generally consistent with the State Planning Policy, *Yarrabilba Total Water Cycle Management Strategy* (DesignFlow, 2012) and *Yarrabilba Stormwater Infrastructure Master Plan* (DesignFlow, 2012). This report provides details of the proposed stormwater treatment measures including location and conceptual sizing across the total precinct. Verification of sizing and conceptual earthworks plans for each stormwater treatment system will be provided to support the relevant Reconfiguring a Lot applications for Precinct 5 as they occur.

This report focusses on the construction phase erosion/sediment control, stormwater quality and waterway stability elements specific to Precinct 5. 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.

2 FURTHER ISSUES RESPONSE

The further issues letter from EDQ (DEV2017/860) dated 1 September 2017 identified the following items relating to Stormwater and flooding based on the *Yarrabilba Precinct 5 Stormwater Management Plan - Version 1* (DesignFlow, July 2017). This updated version (Version 2) of the Stormwater Management Plan addresses the further issues as identified in the following sections of the report. Item numbers below are as per the EDQ further issues letter (DEV2017/860):

27. Provide an RPEQ certified copy of the Stormwater Management Plan.

This Stormwater Management Plan (Version 2) has been reissued with RPEQ certification details.

28. The location of treatment devices in buffer areas is supported in principle. Demonstrate that proposed device locations (including embankments) are located a sufficient distance from creek banks to ensure that bank failure or creek bed movement will not affect proposed treatment device locations.

Waterway corridors adjacent to stormwater treatment devices in Precinct 5 do not exhibit defined bed or banks and are characterised by broad, shallow, low gradient natural flow paths, more representative of overland flow paths. No evidence of meandering/migrating low flow channel has been observed. Cross-section profiles adjacent to the proposed stormwater devices (where measurable) have natural batter slopes in the order of 1:20 or flatter which, when combined with longitudinal grades of generally less than 1%, are not considered prone to failure or bed movement. These flat natural channel profiles transition into constructed batter slopes of 1:6 to 1:4 at stormwater treatment basins to manage waterway interface, safety and aesthetics.

Stormwater treatment earthworks are, in the majority of cases, outside the 15m minimum waterway setback from centreline due to existing vegetation constraints defining the works limit more than the nominal minimum buffer.

29. The supplied shear stress plots indicate a significant increase in shear stress as a result of development which in turn can be attributed to the increase in flow in each watercourse as a result of development without detention. Greater justification is required in relation to the ability for the existing watercourse to withstand increased flows without the inclusion of detention basins in upstream areas to reduce flow rates for frequent events.

Section 5 of this report has been updated and simplified with the bed shear stress mapping of the 1 year ARI pre- and post-development only (to compare against the discharges reported in Table 4) to focus the stability assessment on the more frequent minor discharge. Due to the minimal changes in bed shear stress within the northern and upper Quinzeh Creek tributaries, the discussion below concentrates on the Southern Tributary where the increases are most prevalent.

It should be noted that 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 5.3 in this report) which indicates that under pre-development conditions, the Southern Tributary shear stresses (in the order of 35-85 N/m^2) 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 (refer Section 5.3) 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.

Additional assessment of the shear stress values for the 1 year ARI event indicates that the increase in shear stress for frequent events is generally within permissible thresholds for erosion compared to various vegetation types in literature (refer to updated Section 5.2.2). 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/m^2 in Figure 7) and does not present risk of instability.

As noted in Section 5.2.2, the post development increase in flow in the tributaries of Precinct 5 is quite high however, due to the cross section profile of these waterways, the corresponding mean velocity remains low (velocities below 1.0 m/s) and below QUDM thresholds).

The inclusion of localised detention basins targeting waterway stability waterways adjoining Precinct 5 is therefore not warranted and the proposed waterway stability management strategy remains valid and appropriate for Precinct 5.

30. Update MUSIC analysis to be repeated using the standard rainfall stations listed in the Music Modelling Guidelines.

Shailer Park rainfall station (040715) is the closest station to Yarrabilba in the *MUSIC Modelling Guidelines* nominated for Logan City Council area. As part of the first stormwater management plan developed for Yarrabilba Precinct 1 in 2011, an analysis of the Shailer Park rainfall data was undertaken to ensure the data was relevant for Yarrabilba (using Logan Village rainfall data immediate north of site) based on common years of rainfall data recorded. This assessment found that while rainfall distributions were similar over time, the mean annual totals were not, with a factor of 0.849 derived to reduce the Shailer Park rainfalls down to better reflect Logan Village rainfall.

This approach is generally supported by the *MUSIC Modelling Guidelines* which notes that the closest rainfall station from the list provided for local authorities should be used providing the mean rainfall volume is consistent (within 10%) of that expected at the site.

To validate this variation in data, comparison MUSIC model assessments using both Shailer Park (Logan City east) and Greenbank (Logan City west) standard rainfall stations have been undertaken with the results compared to the adjusted rainfall (Logan Village) adopted for the Yarrabilba Precinct 5 stormwater management plan. This data remains consistent with all previous stormwater management plans approved for Yarrabilba and avoids over or under sizing treatment system as discussed in Section 6.3.1, 6.3.4 and 6.3.5 of this report. This data is therefore intended for continued use at Yarrabilba.

31. Provide concept details for the diversion device in the southern tributary and amend the MUSIC model to include the full catchment draining to the diversion structure.

Refer to Table 8 in updated Section 6.2.2 for conceptual details of diversion.

The MUSIC model has been updated to include the undeveloped portion of catchment draining to the southern tributary diversion structure. Refer to Section 6.3.2 item 3 for relevant assumptions and Section 6.3.4 for revised results.

32. Provide justification that the proposed treatment system for the southern tributary is preferable to a more distributed system with bio-retention systems located at the proposed sediment basin locations. Demonstrate that the increased nutrient loading in the southern tributary resulting from the proposed scheme will not lead to unacceptable watercourse impacts.

The proposed treatment strategy was adopted by Lendlease to provide for a more consistent and desirable urban design along the southern tributary (i.e. limiting the ‘indenting’ of the boulevard road fronting the waterway/vegetation corridor that would be required to accommodate more numerous bioretention basins). It also reduces the earthworks requirements in the mid and upper sections of the Southern Tributary as the level requirements of pipe drainage from the base of bioretention basins is not imposed on the design (and transferred down to the combine wetland/bioretention zone downstream where fill is required to accommodate sewer ad flood constraints). This further improves the urban design interface with the adjoining greenspace corridor by limiting fill where practical.

In terms of nutrient loading, the Southern Tributary is a broad open vegetated drained line that is ephemeral with no permanent aquatic habitat. Current and historical grazing livestock and wild animal access to this reach has resulted in localised vegetation damage, scour and animal waste, the source of which will be removed (followed by rehabilitation) as part of the development of Precinct 5 and future precincts adjoining. The modelled increase to nutrient inputs (noting that this is compared to a fully treated urban catchment, not existing agriculture) in this limited reach of vegetated ephemeral waterway are considered to be satisfactorily offset by the removal of animal inputs (while not directly quantifiable) and rehabilitation of the waterway. Further, nutrient loading to ephemeral waterways is not considered to pose the same risk as to perennial waterways where eutrophication and algal blooms can result with significant impacts on aquatic habitat.

33. Demonstrate that the flow (in terms of frequency and quantum) received by the bio-retention systems next to the wetland will be sufficient to maintain bioretention vegetation.

The inflows to the bioretention system (from wetland) occur whenever wetland water level rises 100mm from normal water level (equivalent to ~200m^3). An assessment in MUSIC of inflow days per year (based nominally on trickle flows than 1 L/s) over the 10 year modelling period indicates the wetland receives inflow 68 days per year while the bioretention basins received flow 62 days per year. This indicates that the differential between wetland and bioretention inflow is only around 4 days per year and therefore not 'starving' the bioretention of water. Further, the bioretention basins are to be saturated zone systems (as per all bioretention basins designed and constructed to date onsite) which involves ~400mm water storage zone below the growing (filter) media in a clay lined sump. This prolongs the availability of water to the plant root zones in extended periods of dry weather.

Bioretention basins in Precinct 1 with the same saturated zone arrangement are currently exhibiting healthy vegetation cover during this current dry period (Upper Quinzeh Creek rainfall gauge recorded only 1mm in last 2 months with 20mm in the month prior). The saturated zones therefore appear to be performing well in terms of sustaining plant health.

34. Confirm the flood immunity proposed for each treatment device.

Refer to Table 7 added to Section 6.2 for flood levels and immunity to each basin. All basins have bund levels above the 100 year ARI (driven mainly by local drainage rather than the requirement for flood immunity).

3 SITE CHARACTERISTICS

3.1 LOCATION

Development Precinct 5 lies in the central eastern portion of the Lendlease site bordering the southern edge of Precinct 3 and extending across to the eastern site boundary adjoining Plunkett Reserve as shown in Figure 1. The precinct covers a total area of 247 ha which includes a significant proportion of waterway and conservation open space as well as a major powerline easement and buffer defining the northern extent of the precinct.

3.2 TOPOGRAPHY, CATCHMENTS AND DRAINAGE

The existing topography across the precinct ranges from steep grades (up ~25% near Plunkett Conservation Park ridgeline) with broad flat zones along the main central drainage line feeding Quinzeh Creek (<0.5%), with much of the proposed development area below 10%. Elevations range from approximately 25 mAHD at the central northern boundary within the main waterway up to 90 mAHD at the north eastern portion of the precinct.

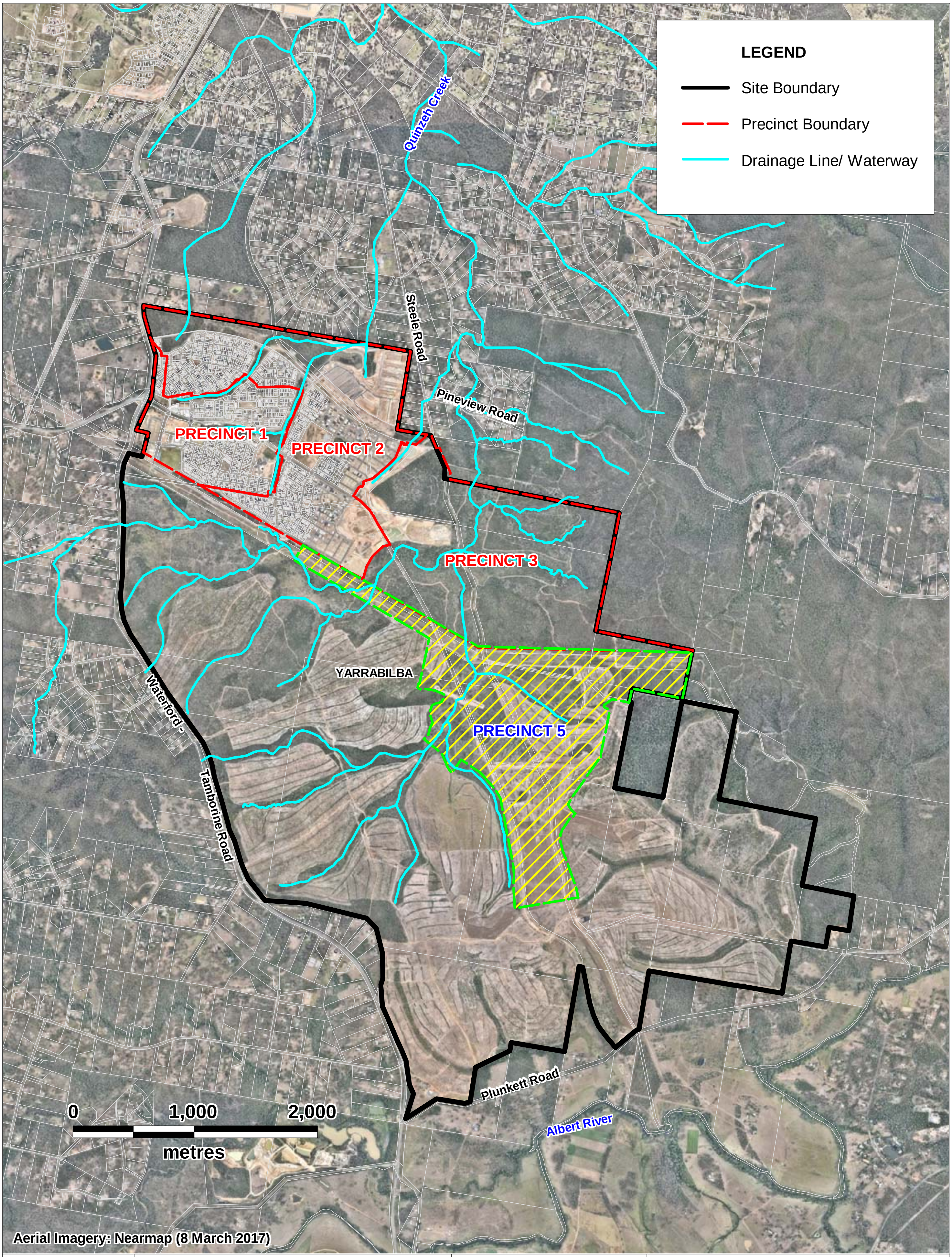
Precinct 5 sits within Catchment 4 of the broad Yarrabilba development site as defined in the *Yarrabilba (Quinzeh Creek) Flood Study - Version 1* (DesignFlow, 2017). As illustrated in Figure 2 the majority of Precinct 5 development drains toward Quinzeh Creek (upper limits of the declared watercourse defined by the powerline easement) via the main waterway in the north western portion of the precinct, which conveys upstream catchment flows through the site. Two tributaries off this waterway extend generally in a south east direction up into the Precinct 5 development area and provide the main conveyance paths for local runoff.

A small area (7.5 ha) on the ridgeline at the eastern edge of Precinct 5 drains eastward into a future development precinct (within the Albert River catchment). 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.

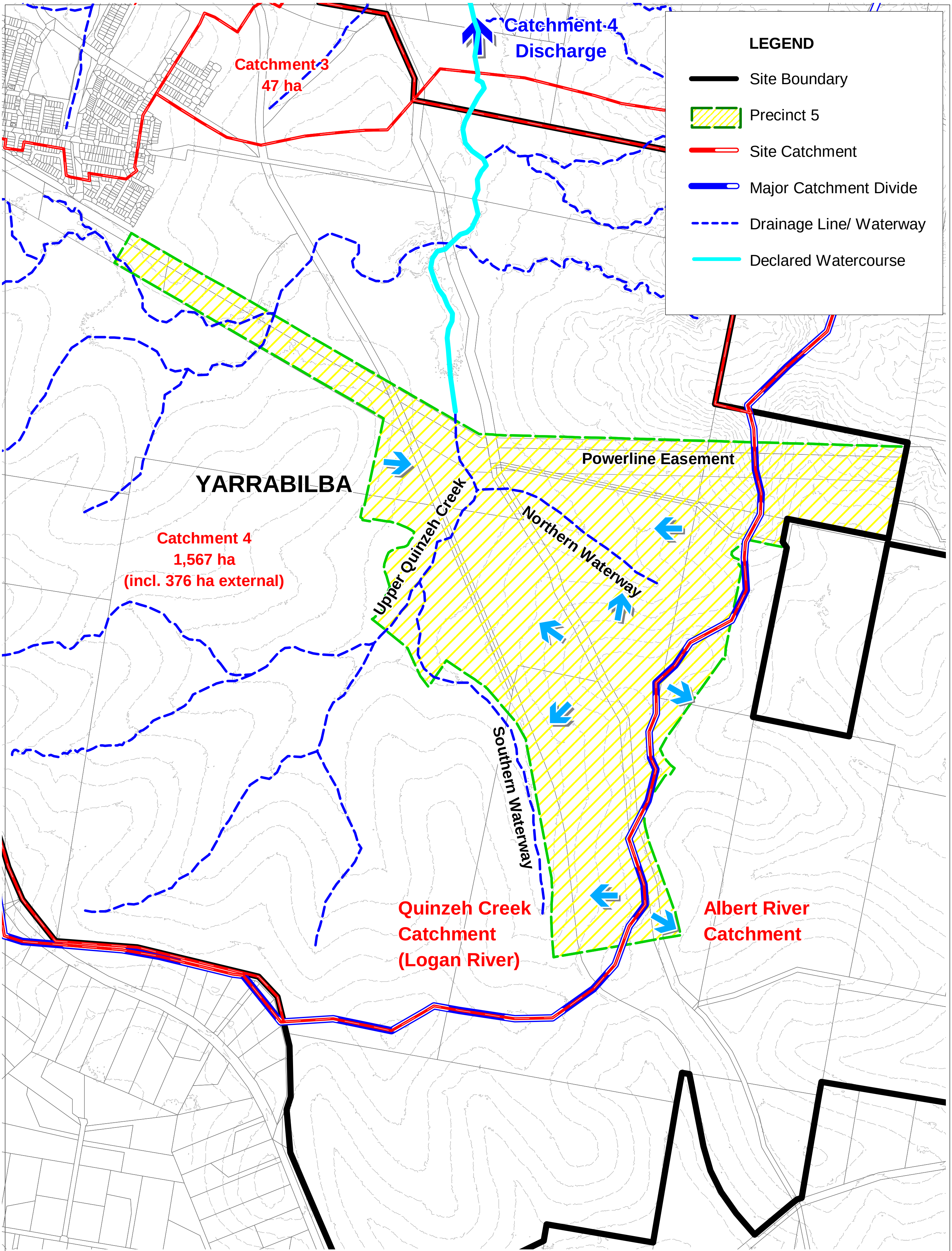
3.3 LAWFUL POINT OF DISCHARGE

The lawful point of discharge for stormwater from Precinct 5 is directly north into existing Precinct 3 and Quinzeh Creek as illustrated in Figure 2. Quinzeh Creek is a Declared Watercourse under the Water Act (2000) with the upstream limit defined as the Precinct 5 northern boundary. The lawful point of discharge from Precinct 3 downstream of Precinct 5 has been addressed previously in the *Precinct 3 Stormwater Quality Management Plan – Version 2* (DesignFlow. 2016).

Refer to *Yarrabilba Precinct 5 Flood Study* (DesignFlow, 2016) for further details regarding preserving peak flood flows at the site boundary at this point of discharge.



Prepared by: DesignFlow For: lendlease	Project: 4338 Yarrabilba Precinct 5 Stormwater Management Plan	N W E S Scale: 1 : 40,000 (A4)	FIGURE 1 Site Locality
	Client: Lend Lease	Date: 18 April 2017	



Prepared by: DesignFlow

For: lendlease

Project: 4338

Yarrabilba Precinct 5
Stormwater Management Plan

Client: Lend Lease

N W E S

Scale: 1 : 20,000 (A4)

Date: 18 April 2017

FIGURE 2

Topography, Catchments and Drainage

3.4 GEOLOGY AND SOILS

Geological mapping indicates Precinct 5 is located across three geological units:

- Woogaroo sub-group (RJbw)
- Ipswich Coal measure (Ri)
- Alluvium (Qa)

Broad scale geotechnical investigations completed across the site (Bowler, 2004) indicate subsurface soils are typically sands overlying silty clays and weathered sandstones. Recent geotechnical investigations just north in Precinct 3 found similar conditions locally with silty sands/sands to around 0.5m overlying sandy clays to a few metres depth. The soil conditions for much of Precinct 5 are not expected to vary significantly from those encountered in Precinct 3. Some variation may be expected in the north-eastern portion of the Precinct (Precinct 5A in Figure 4) where geology changes to Ipswich Coal measures. In this instance higher strength rock and more saturated deep sand profiles may occur, mainly along drainage lines. Further site specific geotechnical investigations will occur within Precinct 5 to confirm soil conditions for civil engineering design.

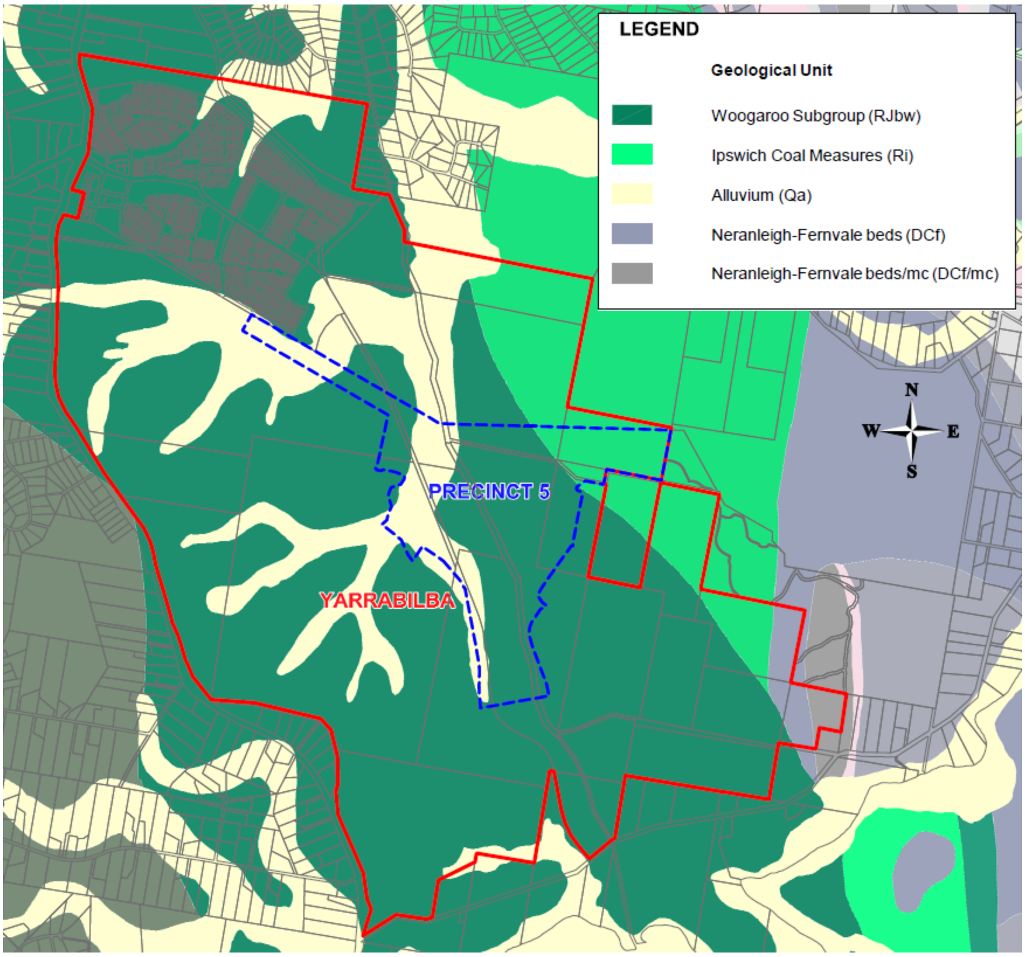


Figure 3: Geology and soils

3.5 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.

The fauna corridor and Plunkett Conservation Park represent the main ecological constraint for development within the Precinct 5 boundary. The *Natural Environment Site Strategy (NESS)* (Natura Consulting, 2012) provides an overarching strategy that pulls together the individual Infrastructure Master Plans, such as Fauna Corridor Master Plan (Natura Consulting, 2012). Strategy 14 in the CPAS provides the individual mapping for waterway, flora and fauna constraints as well as bushfire setbacks for the Precinct 5 development.

3.6 WATERWAYS

The ephemeral drainage lines and waterway corridors within Precinct 5 exhibit a range of physical and ecological conditions. For discussion purposes, the waterways within the precinct have been divided into 3 distinct areas (refer to Figure 2 previously):

- Upper Quinzeh Creek
- Northern Tributary
- Southern Tributary

While much of the southern tributary lies just outside the precinct boundary, it is included in its entirety for this assessment as it receives and conveys stormwater runoff from the majority of Precinct 5D and 5E (sub-precinct numbering as per Figure 4). The Upper Quinzeh Creek reach forms a minor part of the main waterway through the site which becomes a declared watercourse (under the Water Act 2000) at the northern boundary of the powerline easement.

With reference to the *Yarrabilba General Waterway Condition Assessment* (DesignFlow, 2013) and subsequent site inspections in Precinct 5, the Upper Quinzeh Creek waterway is generally in good condition with good to very good habitat and waterway stability scores. The lower portion of the northern and southern tributaries also exhibit stable geomorphic condition but somewhat poorer habitat due to greater vegetation disturbance from historical land use/clearing.

The mid and upper reaches of the northern and southern tributaries then show greater variation with localised pockets of better quality riparian and ephemeral aquatic habitat interspersed with minor scour pools, erosion and lower quality habitat. The generally low gradient of all waterways however means that there is very low risk of major or catastrophic instream erosion. Disturbance impacts from former land use (plantation and clearing) and livestock/wild animals were evident throughout the waterways.

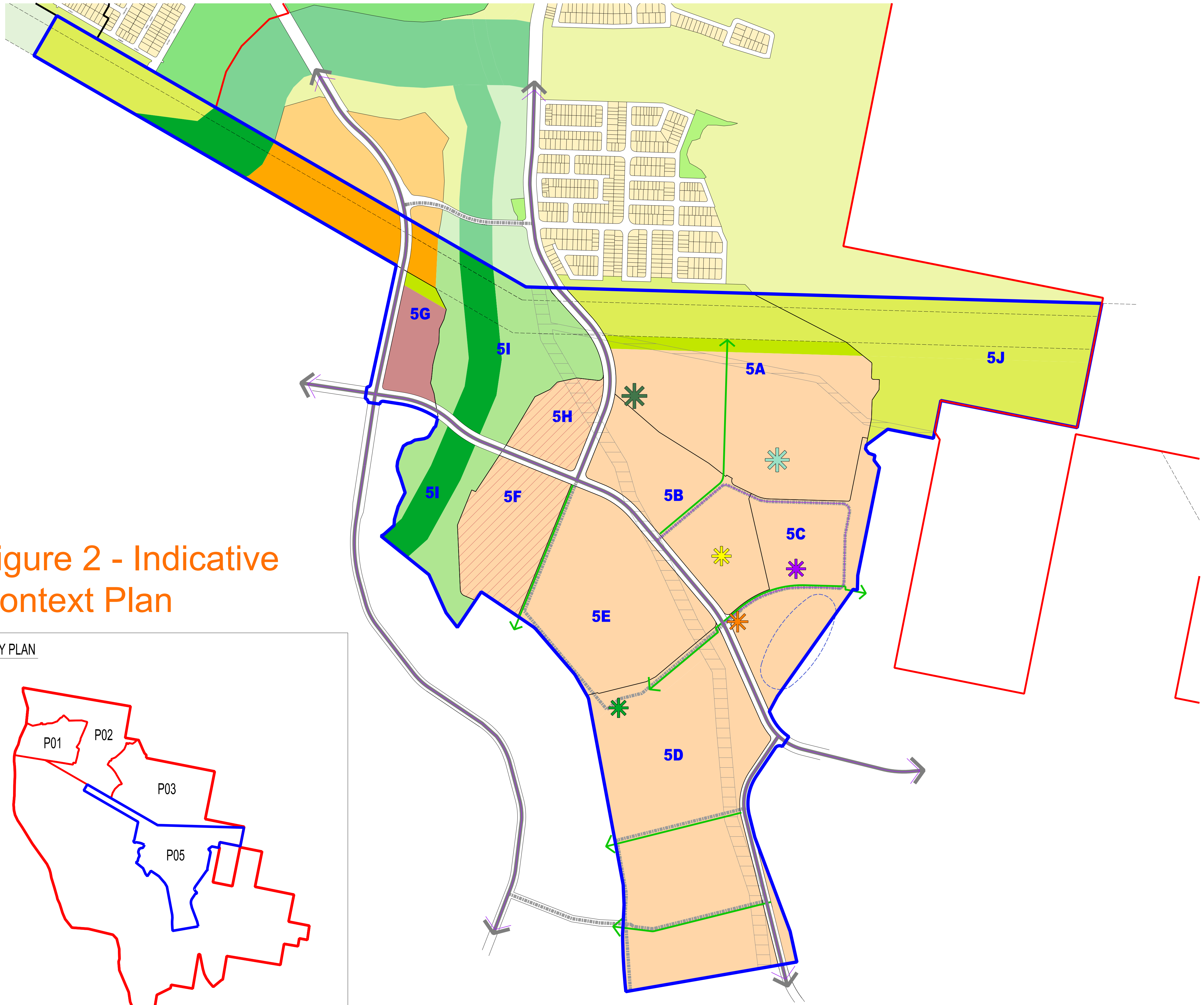
A detailed appraisal of waterways in Precinct 5 is provided in Section 5.2 with regards to the ultimate management and stabilisation strategy.

3.7 PROPOSED DEVELOPMENT

Proposed urban land uses are predominantly residential development with a school located within Precinct 5B. Precincts 5F and 5H are nominally urban residential with densities potentially higher than the balance of the precinct (subject to further investigation).

The total area of Precinct 5 development boundary is approximately 247 ha with a significant portion of Precinct 5 associated with fauna, waterway and conservation corridors as well as major infrastructure easements as illustrated in Figure 4.

Figure 2 - Indicative Context Plan



KEY PLAN

YARRABILBA

LEGEND

- YARRABILBA SITE BOUNDARY
- PRECINCT FIVE BOUNDARY
- PRECINCT FIVE SUB-PRECINCT BOUNDARY
- RESIDENTIAL
- URBAN RESIDENTIAL (min 20dw/ha)
- EDUCATIONAL ESTABLISHMENT - 7.0ha min
- INFRASTRUCTURE & EMPLOYMENT
- POTENTIAL COMMUNITY FACILITY
- FAUNA CORRIDOR (ENVIRONMENTAL PROTECTION)
- CONSERVATION PARK
- CONSERVATION OPEN SPACE
- INFRASTRUCTURE EASEMENT BUFFER
- NEIGHBOURHOOD PARK (0.5ha min)
- SOUTH ROCK LOCAL PARK
- DISTRICT SPORTS PARK - 7.5ha min
- DISTRICT RECREATION PARK - 5.0ha min
- INFRASTRUCTURE EASEMENT
- PRIMARY MOVEMENT NETWORK
- SECONDARY MOVEMENT NETWORK
- PROPOSED GREEN LINK
- PROPOSED BUS ROUTE
- FORMER ROAD RESERVE
- BALANCE LAND IN SEPERATE STORMWATER CATCHMENT
- RESIDENTIAL WITH POSSIBLE INVESTIGATION AREA FOR HIGHER DENSITIES (min 15dw/ha)

TOTAL PRECINCT AREA	246.76 ha
RESIDENTIAL (INCLUDES SPORT AND RECREATION PARKS AND SCHOOL)	145.92 ha
ELECTRICITY EASEMENT BUFFER	3.51 ha
ENVIRONMENTAL	37.93 ha
ROAD	12.50 ha
INFRASTUCTURE EASEMENT	46.90 ha

DISCLAIMER
The context plan is intended to guide development within the Yarrabilba Precinct Five area and show the preferred land use designations and structural elements. The context plan does not prescribe these designations and structural elements with complete accuracy and the final location will be determined through further detailed design and development applications.

NOTES
The contents of this plan are conceptual only. All areas are approximate only and subject to relevant studies, survey, engineering and relevant authority approvals.

PRECINCT FIVE
INDICATIVE CONTEXT PLAN

NOTE: This plan is indicative only, and specific uses, road alignment, boundaries, setbacks, and building layout shown may vary due to detailed design consideration.

0 125 250 325 400 625m
Scale 1:12,500 at A3

North

lendlease

File No. YAR-P05 Dgn No. P05-ICP-170428 Date 28 APR 2017

4 EROSION AND SEDIMENT CONTROL

4.1 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 5 are provided in Table 1 which are generally in accordance with the *Yarrabilba – Stormwater Infrastructure Master Plan* (DesignFlow, 2012) and updated to reflect the State Planning Policy (DSDIP, 2017).

Table 1: 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.

4.2 MANAGEMENT STRATEGY

4.2.1 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 5, 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 in Table 1.

4.2.2 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 5. 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 has 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. To date, HES basin designs have been implemented existing development areas in flood basins 6, 9 and Precinct 3A wetland.

4.3 MONITORING AND AUDITING

4.3.1 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

4.3.2 CPESC Compliance Audits

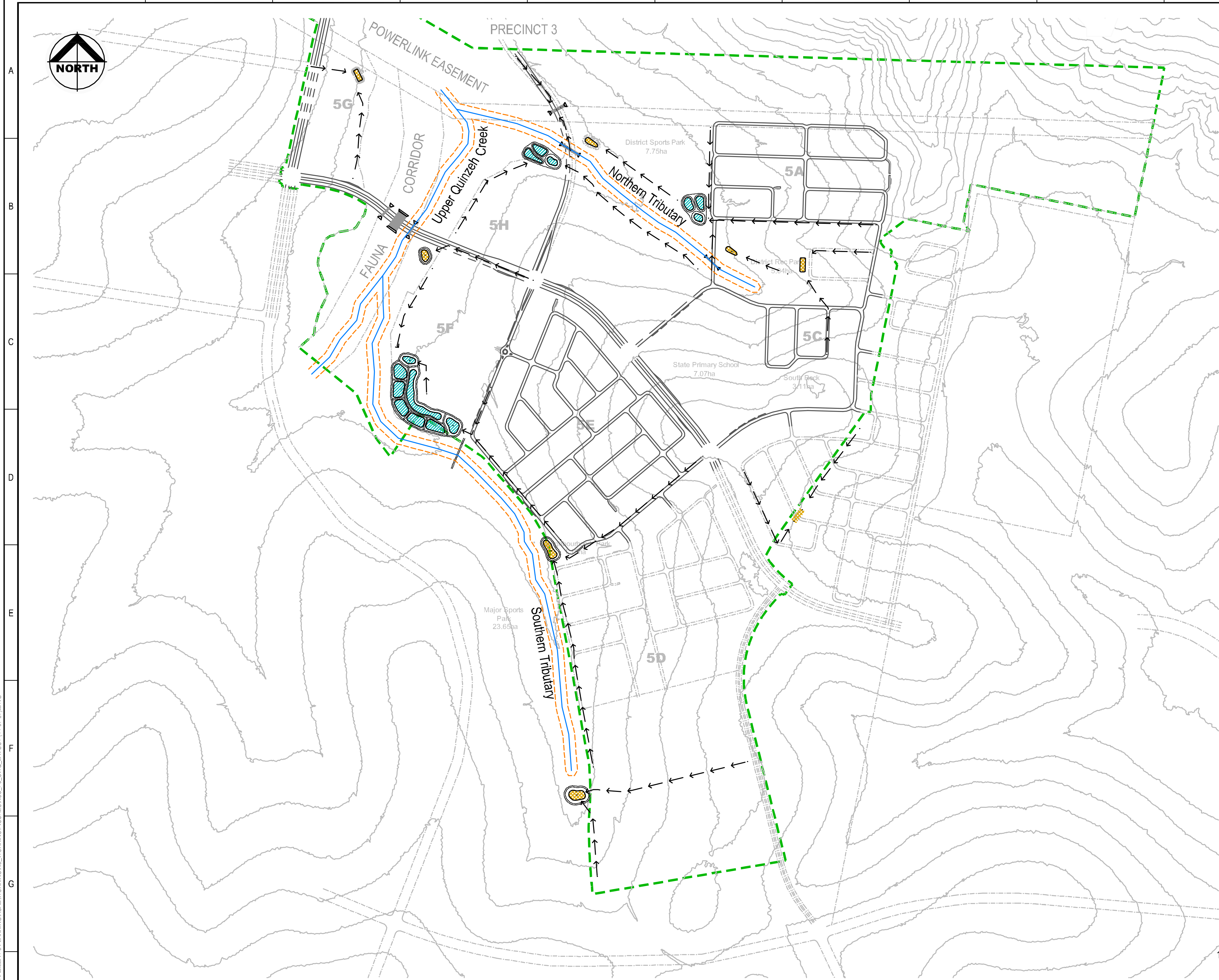
The ESC measures implemented at the site are to be inspected on a monthly basis by a CPESC (Certified Professional in Erosion and Sediment Control) who is independent of the principal contractor and an audit report kept on file. The purpose of the audits to is to ensure the developed and the contractors 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 *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).
- 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.



LEGEND

- Precinct Boundary
- 5m Contour (existing)
- Waterway and Buffer
- High Efficiency Sediment Basin
- Batch Sediment Basin
- Diversion Drain

Notes:

1. Construction phase sediment basins are presented to identify opportunities for co-locating these at permanent stormwater treatment infrastructure locations. However, these basin alone will not meet the ESC requirements for the site.
2. Additional sediment basins and flow diversions will be required within the development footprint and must be resolved as part of a detailed erosion and sediment control plan in conjunction with the proposed construction staging.
3. Basin sizing must be undertaken in accordance with IECA Guidelines and match construction staging.

5m CONTOUR INTERVAL

1:10,000 — 0 200 400 600m

REVISION	DESCRIPTION	INITS	DATE	INITS	DATE
D					
C					
B					
A	SMP ISSUE	NSS	14.07.17	NSS	14.07.17
		DRAFTED BY		CHECKED BY	

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CLIENT: LENDLEASE
DRAWN: NSS — DATE: 14.07.17
DESIGNED: NSS — DATE: 14.07.17
SCALE: 1:10,000 — A3

PROJECT: YARRABILBA PRECINCT 5
DRAWING TITLE: CONSTRUCTION PHASE SEDIMENT BASIN CONCEPT
PROJECT No: 4338 — DRAWING No: FIGURE 5 — REVISION: A

5 WATERWAY MANAGEMENT

5.1 WATERWAY OBJECTIVES

5.1.1 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 2. 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 2: 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 poor condition (i.e. poorly vegetated or active erosion)	As per above OR Rehabilitate waterway to convey the <u>post</u> 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 degraded 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.

5.1.2 Waterway and Wetland Buffers

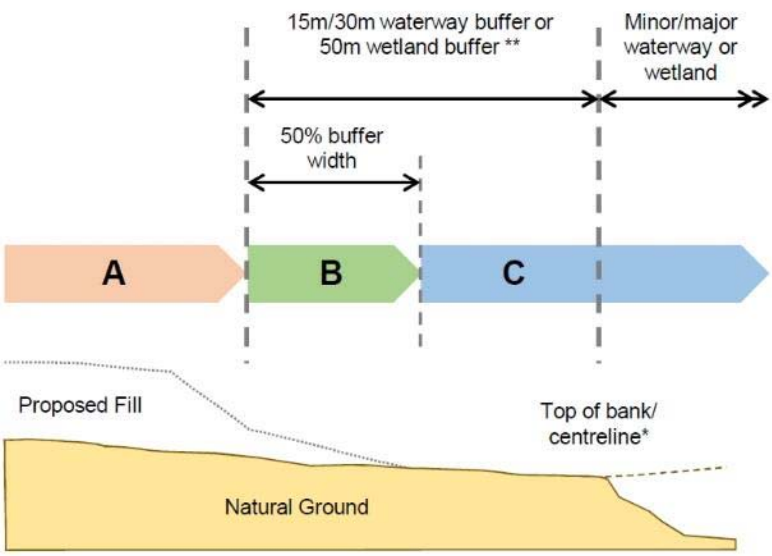
The waterways and associated buffer requirements outlined in the *Yarrabilba Stormwater Infrastructure Master Plan* (DesignFlow, 2012) and the *Yarrabilba Context Plan Area Strategy – Precinct 5* (Lendlease, 2016) have been considered in conjunction with the ecological constraints to inform the development layout. Where waterway buffer allowances are not constrained by other setbacks (i.e. vegetation protection) and are degraded, it may be practical to co-locate low impact uses such as vegetated stormwater treatment infrastructure or passive recreational infrastructure partly within the buffer in conjunction with rehabilitation. Applicable buffers in Precinct 5 are provided in Table 3.

Table 3: Waterway buffers

Waterway type	Minimum Buffer
Minor creeks/drainage lines	15m either side of centreline
Wetlands of local significance	50m to outer extent/bank

The limits of Quinzeh Creek as a declared watercourse have been previously defined by Queensland Department of Natural Resources and Mines (DNRM) as the northern boundary of the powerline easement in Precinct 3, above which is designated (by DNRM) as a drainage feature. For the purpose of this report, classification of the waterway upstream of this point has been assigned 'minor creek' while being referred to as Upper Quinzeh Creek refer Figure 2).

Permissible uses within the defined waterway and wetland buffers in Precinct 5 are shown in Figure 6.



** Where a waterway does not exhibit a defined channel and banks, the buffers will be applied to the approximate centreline such that the total riparian corridor achieved is a minimum of twice the buffer width prescribed for that waterway type.*

*** Where a more conservative setback to earthworks or infrastructure is required for vegetation, fauna corridor or bushfire buffers, these will override the minimum buffers identified here for waterway riparian corridors. Refer to Strategy 14 for details.*

Note: Buffers and permissible uses apply to land disturbing activities. Design must therefore allow for constructability to ensure encroachment/ disturbance beyond allowable zones does not occur during construction.

Permissible Uses within Waterway or Wetland Buffers:

Zone A

No restrictions to development or infrastructure from waterway/ wetland riparian buffers

Zone B

Permitted:

- Vegetated stormwater treatment systems with batters 1:4 max.
- Development batters 1:6 max. (vegetated)**
- Pathways
- Zone C allowances (see below)

Not Permitted:

- Clearing of native canopy vegetation
- Building allotments
- Road reserve (other than for waterway crossings)
- Retaining walls
- Scheduled maintenance areas of stormwater treatment systems (e.g. forebays)

Zone C

Permitted :

- Stormwater outlets/headwalls/diversions
- Waterway stabilisation works
- Riparian rehabilitation planting
- Road/water/sewer/stormwater/flood bund/pathway crossings of waterway

Not Permitted:

- All other general development earthworks, infrastructure and land disturbing activities

Figure 6: Waterway buffer permissible works

5.2 WATERWAY STABILITY ASSESSMENT

The stability assessment for the waterways in Precinct 5 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 5 boundary but receive discharge from precinct 5, these are included in the current assessment (southern tributary).

Details below are supported by the photographic log in Appendix B and waterway reference plan in Figure B1 (Appendix B)

5.2.1 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 5 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 northern tributary between Precinct 5A and 5B has an average slope of around 1.0% while the southern tributary is at 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 5 (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 5 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 5 since the original work undertaken in 2013. This inspection occurred around 3 weeks after the significant rainfall event of late March 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 8 in Section 5.3 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 5 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.

An existing interim flood detention bund (Flood 16-INT) is located approximately 300m 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 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.

Northern Tributary

The northern tributary extends from the eastern fringe of the wetland community in the Upper Quinzeh Creek waterway with a rapid transition from wetland undergrowth and canopy to open grassland and scattered immature regrowth trees. The lower 200m exhibits no defined channel profile (>100m wide, very flat) with very gradual narrowing of profile at around 500m chainage to a reduced but still comparatively broad 20m invert. No defined low flow channel is evident. Similar to Upper Quinzeh Creek, visual evidence of iron bacteria was observed in localise areas as well as on seepage/spring locations outside of the main waterway line (adjacent to the powerline easement).

The upper 500m of this tributary gradually transitions to a more defined low flow channel with localised erosion and scour, often associated with livestock tracks/disturbance and fallen trees. Vegetation is characterised by less dense grasses with more shrub undergrowth and mature canopy trees. Sediment bars were typically located downstream of localised eroded zones indicating higher energy erosion zones are very closely linked to the localised flow path feature (most predominantly seen as logs causing flow diversion/concentration) with rapid transition back to low energy deposition zones immediately downstream.

Southern Tributary

The southern tributary extends generally south-east to south off the main upper Quinzeh Creek floodway. The lower end (chainage 0-500m) 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 30 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).

5.2.2 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 5.3, 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 4 provides a broad scale analysis of the flow characteristics at the downstream end of the three 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 5 plus future adjoining and upstream precincts developed) and therefore Precinct 5 (in the short term) will show lower developed flows and velocities accordingly.

Table 4: 1 year ARI discharge in Precinct 5 tributaries (downstream ends)

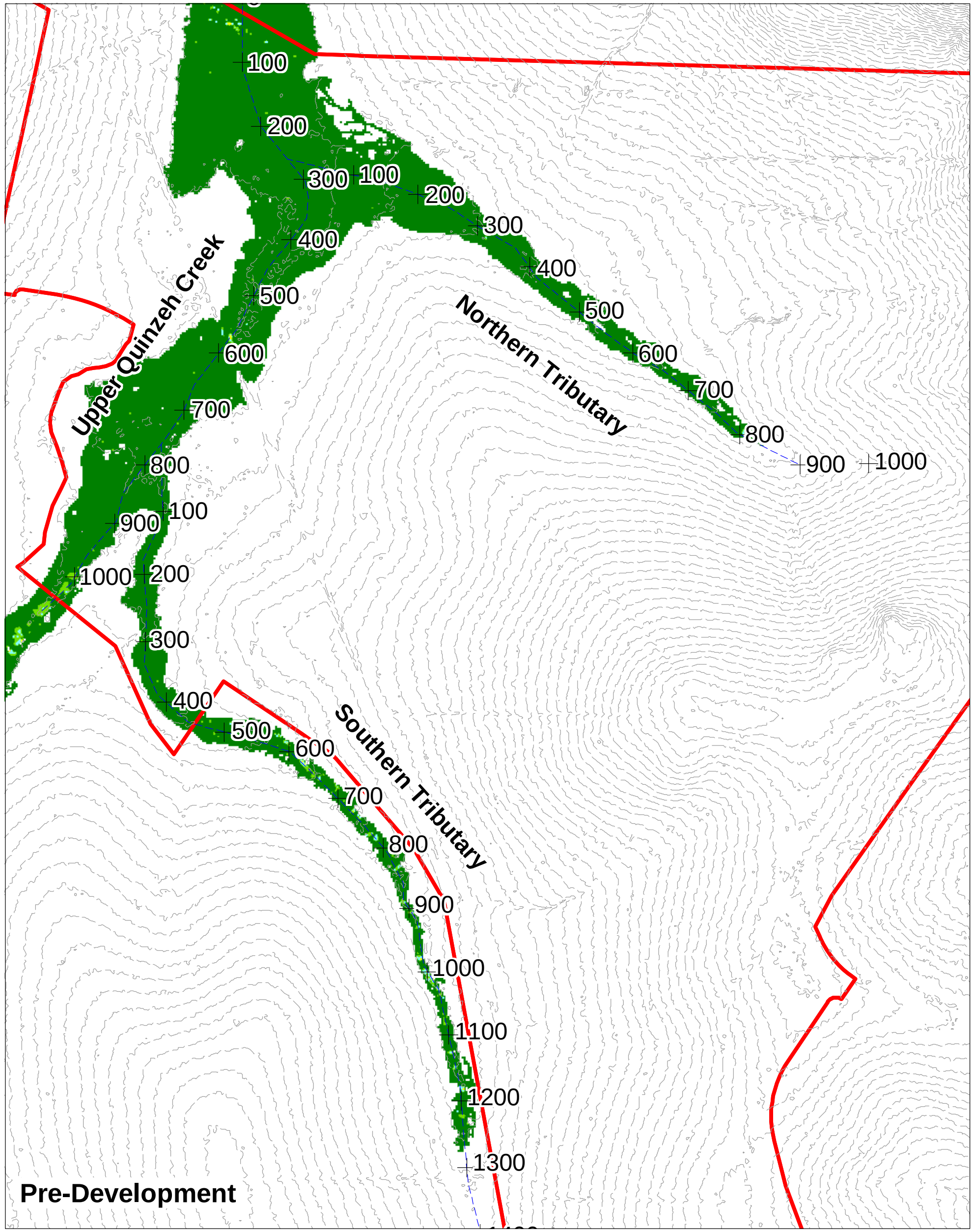
	Flow (m^3/s)		Velocity (m/s)	
	PRE	DEV	PRE	DEV
Upper Quinzeh Creek	20.9	24.8	0.57	0.66
North Tributary	3.8	8.0	0.47	0.62
South Tributary	3.9	13.9	0.53	0.80

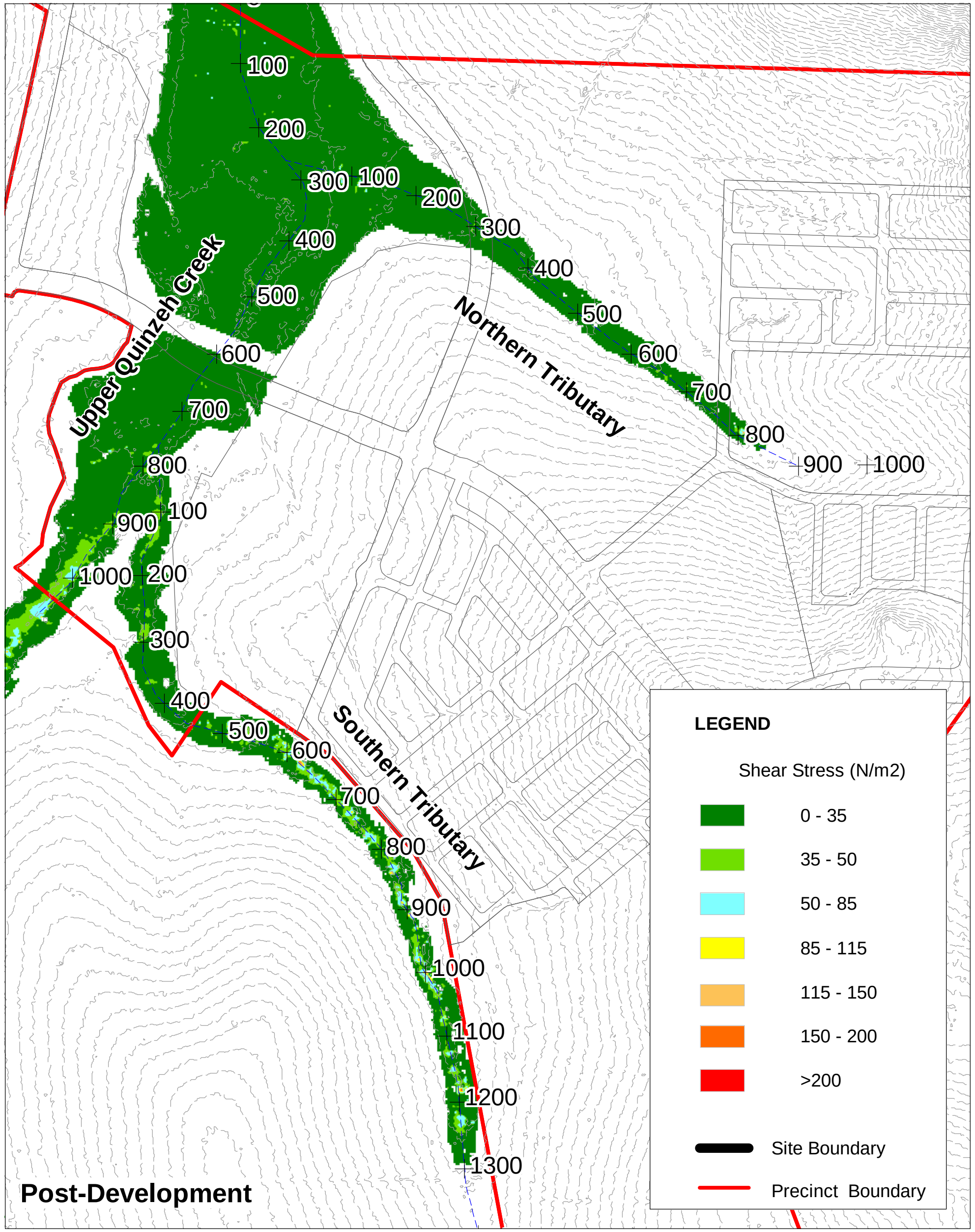
This data indicates that while the peak discharge (at bottom of each drainage line) increases as a result of urbanisation (particularly in tributaries), the actual velocity increases are comparatively small and very low in overall magnitude under both pre- and post-development scenarios. This is in most 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.

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 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.

Additional review of the minor (2 year ARI) and major (50 year ARI) bed shear stress results from the detailed hydraulic modelling undertaken as part of the *Yarrabilba (Quinzeh Creek) Flood Study – Version 1* (DesignFlow, 2017) was also undertaken to broadly identify any potential erosion locations for ongoing monitoring within Precinct 5. The results indicates that bed shear is very low to low across the majority of the Precinct 5 waterways for both the 2 and 50 year ARI. Under post development conditions, localised increases in the southern tributary are evident however these are still low (generally <85 N/m^2). In a number of these locations, targeted management of existing issues identified in Section 5.3 (such as scour pools and poor vegetation) will greatly enhance the capacity of the existing waterway to cope with minor increases in bed shear associated with increased flows.





Prepared by: DesignFlow

For: lendlease

Project: 4338

Yarrabilba Precinct 5
Stormwater Management Plan

Client: Lend Lease

Scale: 1 : 1,100 (A4)

Date: 12 September 2017

Figure 7

1 year ARI
Bed Shear Stress Comparison

5.3 WATERWAY STABILITY MANAGEMENT STRATEGY

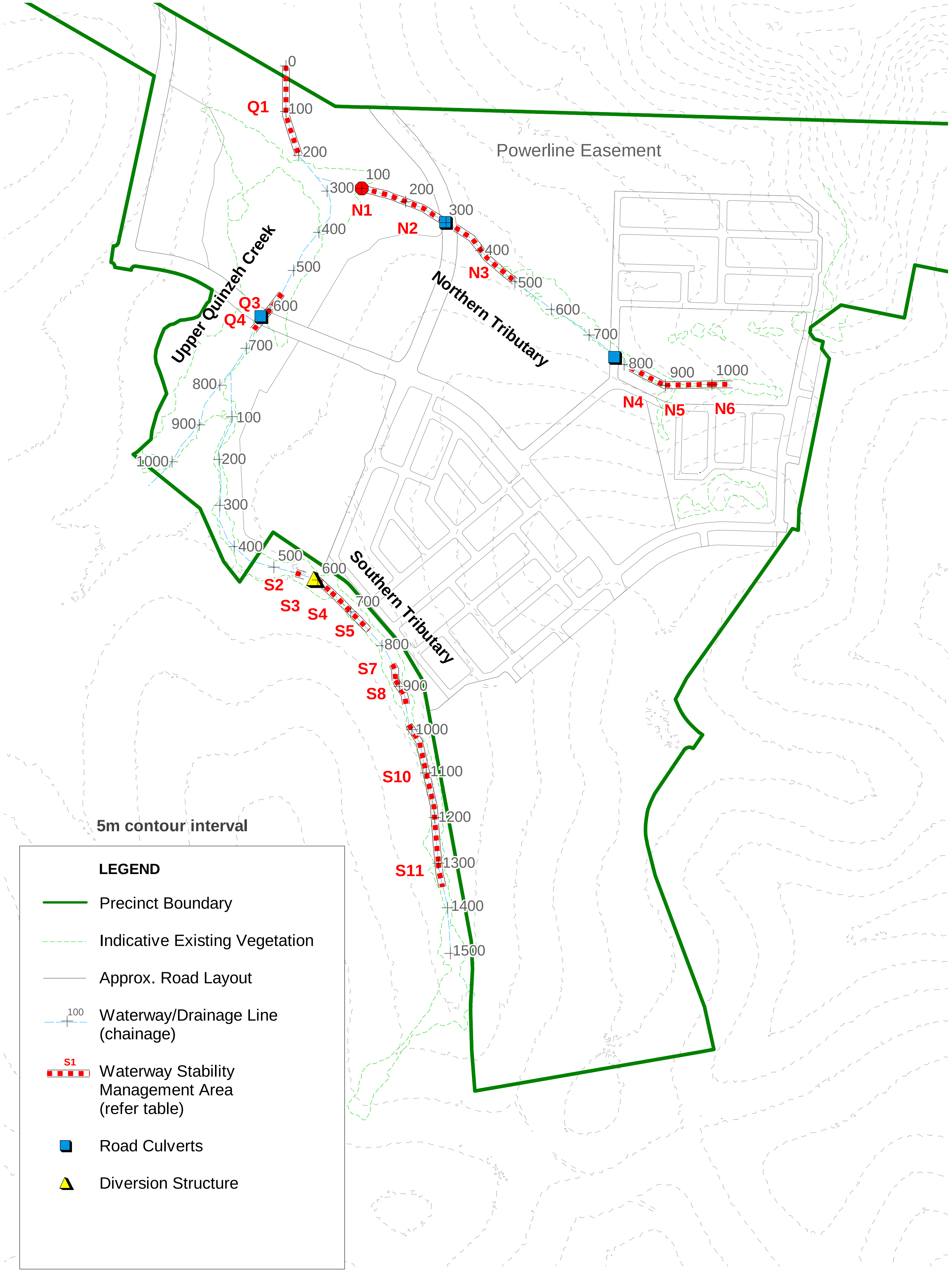
As described in Section 5.2.1, there are a number of waterway areas within Precinct 5 considered to be in average to good condition (ecologically) while being relatively stable owing largely to the very low gradients of these drainage lines. However, localised areas of instability combined with impacts of livestock 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, diversion structures 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, those adjacent to infrastructure (particularly instream infrastructure such as flood basins and crossings) and aggradation of the floodplain of Quinzeh Creek.

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 5 as both the longitudinal and cross sectional profile of the waterways are comparatively broad and flat, presenting minimal erosion and instability risk.

Figure 8 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 5.3.1.



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 conjunction with open space rehabilitation plans
N4	820-900	Historic sediment accumulation/smothering – monitor vegetation regrowth in sediments and ongoing stability. Re- plant if required.
N5	900-1000	Narrow low flow channel 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.
S3	600	Low flow diversion structure – to be designed to contribute to stabilisation of local waterway under both low and high flow conditions
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.

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.

Prepared by: DesignFlow For: lendlease	Project: 4338 Yarrabilba Precinct 5 Stormwater Management Plan Client: Lend Lease	Scale: 1 : 10,000 (A3) Date: 5 July2017	**Figure 9** **Waterway Stability Management Strategy**

5.3.1 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.

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 7 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 5 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.

6 STORMWATER QUALITY

6.1 DESIGN OBJECTIVES

The stormwater quality management objectives that apply to the operational phase of Yarrabilba Precinct 5 are listed in Table 5 as defined by the *Yarrabilba – Stormwater Infrastructure Master Plan* (DesignFlow, 2012), 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 5: 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%

6.2 STORMWATER QUALITY MANAGEMENT STRATEGY

A stormwater management strategy has been developed for Precinct 5 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.

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

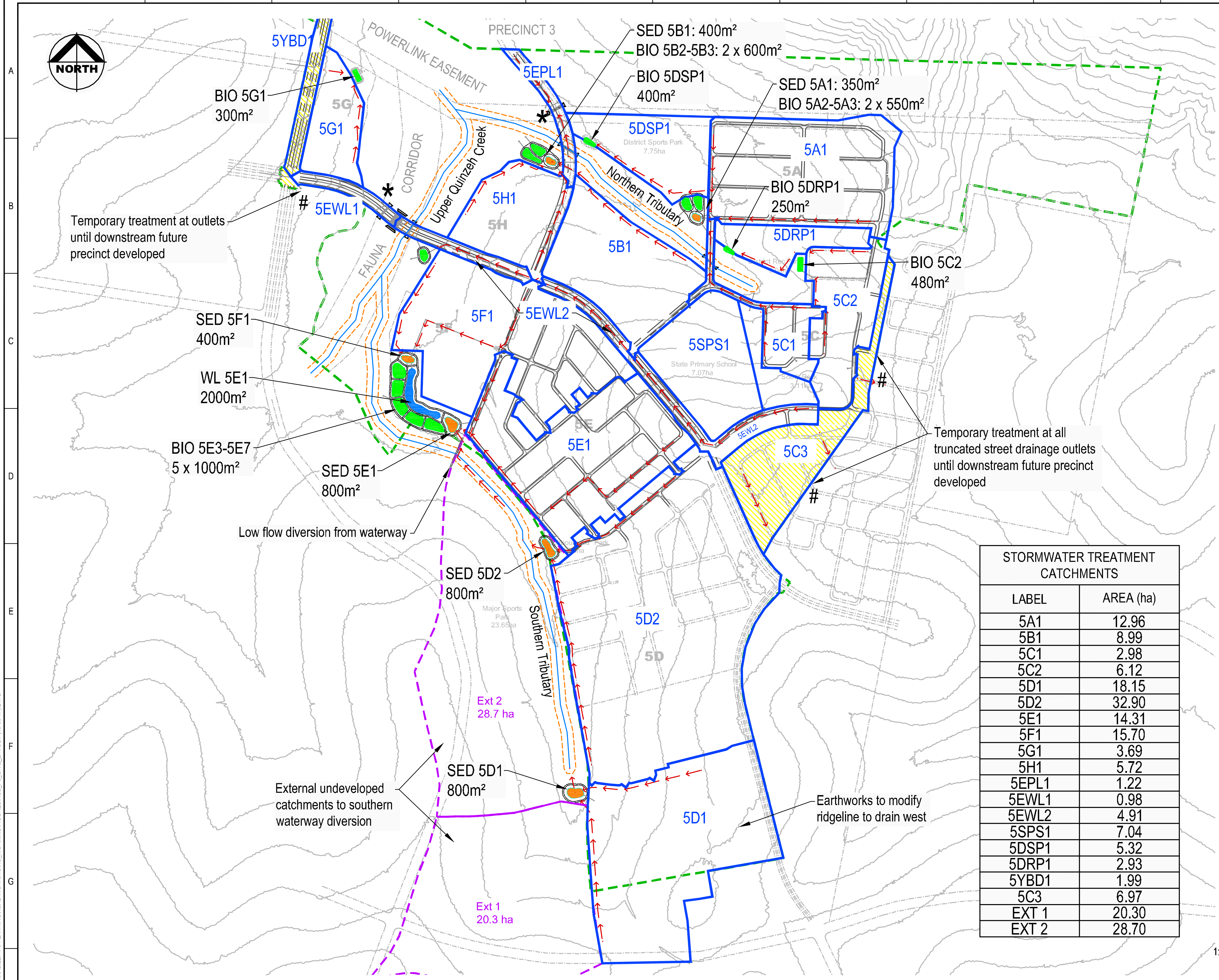
- Adopt multiple use open space principles where possible
- Locate treatments in waterway buffer zones, where applicable, as per *Yarrabilba – Stormwater Infrastructure Master Plan* (DesignFlow, 2012) and the *Yarrabilba Context Plan Area Strategy – Precinct 5* (Lendlease, 2017).
- Adopt similar treatment philosophy as per Precinct 1, 2 and 3 development to retain consistency across the development
- Apply at source treatment within school sites (by others)
- Integrate with landscape outcomes
- Minimise the impact on existing vegetation and adjacent aquatic ecosystems

The strategy is broadly divided into three areas defined by the strategy approach adopted and discharge location (note: precinct sub-stage numbering in accordance with endorsed Context Plan in Figure 4 previously):

1. Northern Tributary – Precinct 5A, 5B, 5C, 5H and Eastern Perimeter Link (EPL) road
2. Southern Tributary – Precinct 5D, 5E and 5F
3. Upper Quinzeh Creek – Precinct 5G and East West Link (EWL) road

Figure 9 shows the overall proposed treatment strategy for Precinct 5 with details of each location provided in Table 6 and the relevant flood immunity provided in Table 7. Further details of performance assessments of the proposed treatment strategy are presented in Section 6.3.

The precinct wide stormwater management strategy has been prepared to illustrate the precinct as a whole has the capacity to meet the require water quality and flow objectives. This strategy has been developed based on the current Precinct 5 Context Plan and available urban design at time of reporting. Further details of development stages will be resolved sequentially as part of each Reconfiguring a Lot (ROL) application and likewise, the locations, size and layout of stormwater treatment measures present herein will be revised and updated as required to match development. Strategy refinements (where required), certification of strategy compliance and functional earthworks of stormwater basins will be provided as part of subsequent ROL applications.



STORMWATER TREATMENT CATCHMENTS	
LABEL	AREA (ha)
5A1	12.96
5B1	8.99
5C1	2.98
5C2	6.12
5D1	18.15
5D2	32.90
5E1	14.31
5F1	15.70
5G1	3.69
5H1	5.72
5EPL1	1.22
5EWL1	0.98
5EWL2	4.91
5SPS1	7.04
5DSP1	5.32
5DRP1	2.93
5YBD1	1.99
5C3	6.97
EXT 1	20.30
EXT 2	28.70

LEGEND

- Precinct Boundary
- 5B1 Catchments (Stormwater Quality)
- Waterway and Buffer
- Sediment Pond (SED)
- Bioretention Basin (BIO)
- Constructed Wetland (WL)
- Catchment Drainage (Indicative)
- Urbanised catchment to be associated with future precinct drainage/treatment strategy
- * Vegetated swale at outlet to waterway
- # Future precinct treatment strategy integration

Notes:

1. Road layout shown is indicative only. Refer to plan of development for final urban layout.
2. Treatment sizing for park zones are indicative only and subject to detailed park design and layout.
3. School site stormwater quality treatment is undertaken onsite by others to meet the State Planning Policy water quality objectives.
4. Localised catchments draining to future precinct development areas to be provided with vegetated swale at temporary discharge until ultimate stormwater drainage/treatment strategy constructed.

REVISION	DESCRIPTION	DRAFTED BY INITS	DATE	CHECKED BY INITS	DATE
D					
C					
B	SMP-V2 ISSUE	NSS	18.08.17	NSS	17.09.17
A	SMP ISSUE	NSS	14.07.17	NSS	14.07.17

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CLIENT: LENDLEASE
DRAWN: NSS DATE: 17.09.17
DESIGNED: NSS DATE: 17.09.17
SCALE: 1:10,000 A3

PROJECT: YARRABILBA PRECINCT 5
DRAWING TITLE: STORMWATER QUALITY MANAGEMENT STRATEGY
PROJECT No: 4338
DRAWING No: FIGURE 10
REVISION: B

Table 6: Stormwater treatment elements

Treatment Type and ID	Treatment Size	Contributing Area and Catchments	Comment
Northern Tributary (Precinct 5A, 5B, 5C, 5H and EPL road)			
Sediment pond 5A1 Bioretention 5A2/5A3	Sed 350 m² Bio 2 x 550 m²	15.94 ha (5A1, 5C1)	Pre-treatment sediment pond into twin bioretention basins
Sediment pond 5B1 Bioretention 5B2/5B3	Sed 400 m² Bio 2 x 600 m²	14.71 ha (5B1, 5H1)	Pre-treatment sediment pond into twin bioretention basins
State Primary School	By others	7.07 ha (5SPS1)	Onsite treatment by school – design by others
Bioretention 5C2	Bio 480 m²	6.12 ha (5C2)	Treats balance of Precinct 5C
Bioretention DSP1	Bio 400 m²	5.32 ha (5DSP1)	Indicative based on assumed imperviousness and layout. Final park layout will dictate layout and size of single or multiple basins.
Bioretention DRP1	Bio 250 m²	2.93ha (5DRP1)	Indicative based on assumed imperviousness and layout. Final park layout will dictate layout and size of single or multiple basins.
Swale EPL1	Swale 20m	1.22 ha (5EPL1)	Clearance to powerlines limits implementation of bioretention basin. Offset treatment occurs in balance of northern waterway treatment measures.
Southern Tributary (Precinct 5D, 5E & 5F)			
Sediment pond 5D1	Sed 800 m²	18.15 ha (5D1)	Pre-treatment of southern portion of Precinct 5D plus potential for inflow from future precinct catchment west of 5D (indicative – future assessment)
Sediment pond 5D2	Sed 800 m²	32.90 ha (5D2)	Pre-treatment of northern part of Precinct 5D
Sediment pond 5E1	Sed 800 m²	16.14 ha (5E1)	Pre-treatment of southern part of Precinct 5E plus inflow from adjacent waterway low flow diversion. Distributes flow to major treatment area.
Sediment pond 5F1	Sed 400 m²	15.70 ha (5F1)	Pre-treatment of northern part of Precinct 5E and majority of 5F
Wetland 5E2 Bioretention 5E3-5E7	WL 2000 m² Bio 5 x 1000 m²	81.06 ha (5D1, 5D2, 5E1, 5F1)	Receives pre-treated flows from Sed ponds 5D1 and 5D2 via flow diversion from waterway plus direct inflow from Sed 5E1/5F1
Upper Quinzeh Creek (Precinct 5G and EWL Road)			
Swale EWL1	Swale 20m	0.98 ha (5EWL1)	Outlet pre-treatment for road catchment. Offset treatment occurs in balance of northern waterway treatment measures.
Bioretention 5EWL2	Bio 450 m²	4.91 ha (5EWL2)	End-of-pipe bioretention basin with option to allow discharge from small area of 5F1 or 5H1 discharge.
Bioretention 5G1	Bio 300 m²	3.69 ha (5G1)	Indicative based on assumed future development area.
Future Precinct Treatment Integration			
Future Precinct treatment	-	*1.99 ha (5YBD1)*	*Southern portion of Yarrabilba Drive to discharge to future precinct treatment from adjacent town centre.*
Future Precinct treatment	-	*6.97 ha (5C3)*	*Eastern fringe of Precinct 5C to discharge to adjacent future precinct (separate drainage catchment eastward).*

Table 7: Stormwater treatment basin flood immunity

Treatment Type and ID	Surface Level (mAHD)	Bund Level (mAHD)	Adjacent Flood Level (mAHD)	Flood ARI
Northern Tributary				
Sediment pond 5A1 Bioretention 5A2/5A3	34.0	35.0	31.9	100
Sediment pond 5B1 Bioretention 5B2/5B3	29.5	30.5	28.8	100
Bioretention 5C2	Outside flood model zone			
Bioretention DSP1	30.5	31.5	28.8	100
Bioretention DRP1	34.5	35.5	33.0	100
Southern Tributary				
Sediment pond 5D1	Outside flood model zone			
Sediment pond 5D2	35.5	36.5	34.5	100
Sediment pond 5E1	30.0	31.0	30.9	100
Sediment pond 5F1	30.0	31.0	28.9	100
Wetland 5E2 Bioretention 5E3-5E7	30.0	31.0	30.7	100
Upper Quinzeh Creek				
Bioretention 5EWL2	29.0	30.0	28.9	100
Bioretention 5G1	Outside flood model zone			

All stormwater treatment devices have top of bund levels above the 100 year ARI local flood level. While not required to achieve this level of immunity, level is most often driven by the requirements to get pipe drainage into and out of bioretention basins as well as earthworks batter setback from waterway or vegetation buffers.

6.2.1 Northern Tributary

Precincts 5A-5C and 5H discharging to the Northern Tributary generally proposed to adopt end-of-pipe bioretention basins integrated into the edge of waterway buffers and/or open space. Where bioretention treatment areas exceed approximately 500m², multiple basins are used in parallel with a sediment pond for pre-treatment and flow distribution. A portion of road extending south from Precinct 3 (Eastern Perimeter Link) passes under the major powerlines. Road levels are necessarily limited in elevation here to provide required clearance to overhead lines making the inclusion of a bioretention basin unfeasible. Allowance is made here for a vegetated swale at the drainage outlet with treatment offset in the adjacent urban area bioretention basins.

Future district sports and district recreation parks in this area have been assigned indicative bioretention basin treatment areas to manage runoff from developed areas of park. These area subject to further refinement as part of park planning to ensure surface drainage and location of basin(s) can be appropriately integrated into these spaces.

6.2.2 Southern Tributary

Precinct 5D drains in a generally westward direction towards two main sediment pond locations. These manage coarse to medium sediment from entering the natural drainage line defining the edge of the precinct.

A low flow diversion structure is proposed within the natural drainage line (just upstream of Sed 5E1) diverts minor flows (nominally up to 1.2 m^3/s) from the drainage line (i.e pre-treated flows from catchments 5D1 and 5D2) and directs them into Sediment Pond 5E1 and subsequently to the wetland/bioretention system for final treatment prior to discharge to the main waterway. It is proposed that this diversion structure will be utilised by the adjoining future development precinct stormwater strategy to the west of Precinct 5 via duplication of diversion outlet and equivalent treatment area constructed on the western side of the waterway. It also lies in the location of the greenway (pedestrian/cycleway) connection from Precinct 5 south to future precinct and therefore can have multiple functions.

Table 8: Diversion structure concept details

Element	Design parameter
Bund height	Variable to 1.0m max. at channel centreline
Top of bund width	3.0m min. (subject to greenway boardwalk connection concept design)
Batters	1:6
Bund/batter scour protection	Rock mattress
Diversion culvert (precinct 5)*	1200 x 450 RCBC 60m @0.8% (~1.2m^3/s capacity at 0.4m deep) Concrete invert to upstream intake (at channel invert) with sediment cleanout forebay.
Maintenance access	Min 3.0m maintenance access to invert/forebay from adjoining roadway/park

* Duplication of diversion culvert for future precinct to the west of Precinct 5 to be sized to divert flow rate proportioned to future contributing catchment

Runoff from Precinct 5E and 5F is directed towards two main sediment pond locations at the southern (Sed 5E1) and northern (Sed 5F1) end of the major wetland/bioretention treatment system identified previously. These ponds discharge into the central wetland element which distributes flow to the adjoining bioretention basins.

In order to optimise the treatment effectiveness for the Precinct 5D-5F urban area within the limited footprint available, the wetland has been configured to function as both a treatment and flow distribution measure. The treatment shortfall from the small wetland footprint is combined with a number of bioretention basins flanking the wetland that engages the top 0.3m of wetland extended detention (via weirs) to increase treatment capacity.

The bioretention basins will be constructed as saturated zone systems (as per all other bioretention basins in Yarrabilba) to retain water in a sub-surface reservoir for plant roots to access during extended dry periods. The design of the wetland outlet will also make provision for a connection to the bioretention basin saturated zone to ensure saturated zone water levels are maintained via trickle flows through the wetland.

6.2.3 Upper Quinzeh Creek

Both the northern and southern tributaries discharge to the upper Quinzeh Creek waterway however a number of sub-catchments also discharge directly to this waterway.

Future Precinct 5G has been assigned an indicative end of pipe bioretention basin while the adjoining major road link (Yarrabilba Drive) will integrate with the future stormwater management strategy for the adjacent major town centre catchment.

The major road link along the ridge of Precinct 5 (catchment 5EWL2) discharges to a dedicated bioretention basin on the western edge of the Upper Quinzeh Creek waterway between 5F and 5H. This basin may also provide local drainage discharge for the western portion of 5F1 and 5H1 that cannot be feasibly drained to the respective treatment zones assigned in Table 6 (subject to subsequent application and preliminary design). The western end of the EWL road within Precinct 5 cannot drain to Bio EWL1 due to level conflicts with the major fauna culverts so discharges via a separate outlet and vegetated swale to the open space corridor. Offset treatment is provided in Bio 5G and 5EWL1 to account for the partial treatment of this catchment.

6.3 STORMWATER QUALITY ASSESSMENT

MUSIC modelling was conducted to assess the stormwater treatment performance of the proposed treatment strategy. MUSIC Version 6.2 was used for the assessments.

6.3.1 Model Structure

The structure of the MUSIC model is shown in Figure 10 with the general data provided in Table 9. Attempts were made to achieve water quality objectives at both the tributary level (north and south) as well as the overall precinct discharge.

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 adaption 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.

A comparison of the modified dataset above to the two rainfall stations noted in the *MUSIC Modelling Guidelines* for use in Logan City (Shailer Park and Greenbank) is provided in Table 12.

6.3.2 Assumptions

1. Water quality management measures are sized only for the portion of each catchment undergoing development (i.e. excludes retained/rehabilitated conservation zones).
2. Future precinct treatment integration areas (See Table 6) excluded from Precinct 5 assessment (to be resolved with future development applications).
3. An allowance for interim external catchment inflows to the southern tributary diversion structure have been included based on current agricultural land use (cropping/grazing) in accordance with the *MUSIC Modelling Guidelines*, 2010). Pollutant load reductions from total catchment have been reported as % reductions compared to unmitigated Precinct 5 development catchment generation (in accordance with the *State Planning Policy*, July 2017).
4. A split catchment approach was adopted for urban areas.
5. Split land use percent imperviousness is generally in accordance with Table 3.5 in MUSIC Modelling Guidelines (Water by Design, 2010) with allowance for 70% for schools, 5% for natural park areas (discharging into urban drainage), 10% for recreation parks with embellishments/paths and 30% for sports parks.
6. Lot and park areas were measured from development layout (where available) and the balance of sub-catchment assigned to road reserve. Where layouts have not been resolved for future areas, typical splits were assigned based on MUSIC Modelling Guidelines Table 3.3 (Water by Design, 2010).
7. Roof area proportion for residential was assigned as 50% of lot areas to reflect what is being constructed onsite and to be more consistent with the *PDA Guideline no. 1: Residential 30* (EDQ, 2015) which allows up to 60% site coverage (MUSIC guidelines assumes 43% for 15 dw/ha).
8. Future urban areas 5F, 5G and 5H assume higher dwelling density from Table 3.3 MUSIC guidelines based on context plan allowance.
9. Bioretention default values for TN and OP content have been reduced to 400mg/kg and 30mg/kg respectively as per Water by Design advice (refer note below).
10. Wetland k and C* parameters for TN have been reduced to 200 m/yr and 0.75mg/L respectively. A sensitivity assessment is provided to compare to the original guideline values (refer note below).
11. The 0.4m wetland WL 5E1 extended detention depth (EDD) fills to 0.1m before spilling into the bioretention basins. The wetland area EDD was therefore set

to 0.1m while the bioretention EDD (0.3m) was set to the combined area of both systems.

12. Low flow diversion rate (via generic node) from Southern Tributary into Sed 5E1 is 1.2 m3/s.
13. Secondary links were applied to all sediment basins (upstream of bioretention basins) to bypass flow once the extended detention depth is exceeded via overflow weir.

Note: Water By Design have recently completed a review of important default values for wetlands and bioretention basins. The parameters in items 9 and 10 above are supported in principle by Water By Design and are intended to be incorporated in an updated version of the *MUSIC Modelling Guidelines* due for release in the coming months.

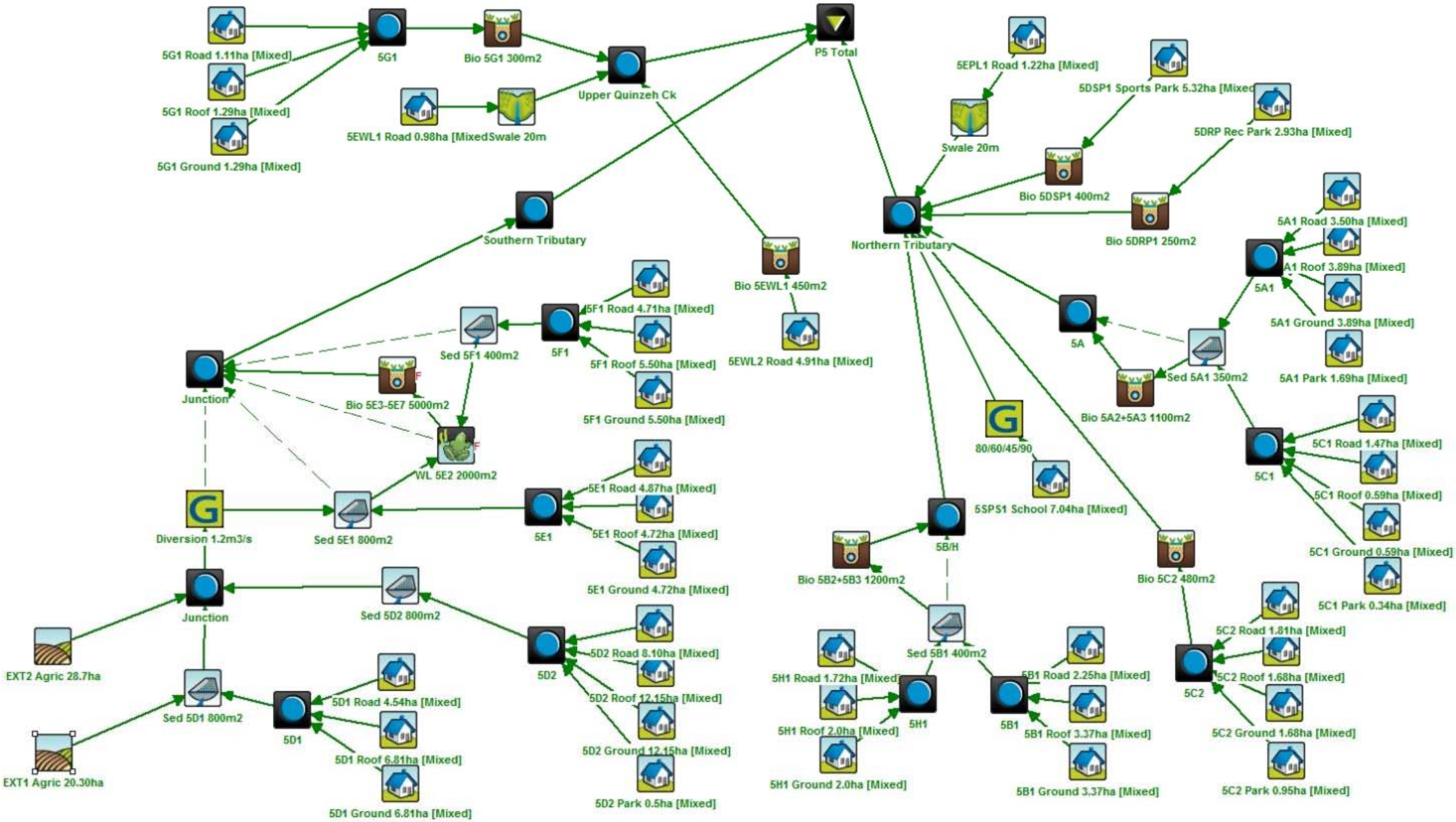


Figure 10: MUSIC model structure for Precinct 5

Table 9: 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 Seepage = 0 mm/hr TN content 400 mg/kg Orthophosphate content 30mg/kg
Constructed Wetland	Extended detention depth = 0.1m (refer assumption 10 in Section 6.3.2) 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 (Sensitivity undertaken on TN k = 150 m/yr, TN C*=1.0 mg/L)
Sediment Basins	Extended detention depth (EDD) = 0.3 m Evaporative loss 75% of PET Notional detention time = <0.1hr (upstream of bio) = 1.0 hr (stand-alone basins) Secondary link to bypass weir flow (at top of EDD)

6.3.3 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 6 previously identified catchments areas contributing to each treatment element. Table 10 below lists the catchment area, land use and percent impervious for each sub-catchment modelled with the detailed breakdown of surface types provided in Appendix A.

Table 10: MUSIC catchment data summary

Catchment ID	Area (ha)	Predominant Land Use [1]	Overall Impervious %
5A1	12.96	Residential	53%
5B1	8.99	Residential	60%
5C1	2.98	Residential	54%
5C2	6.12	Residential	51%
5D1	18.15	Residential	60%
5D2	32.9	Residential	59%
5E1	14.31	Residential	60%
5F1	15.7	Residential	67% [2]
5G1	3.69	Residential	67% [2]
5H1	5.72	Residential	67% [2]
5EPL1	1.22	Road	70%
5EWL1	0.98	Road	70%
5EWL2	4.91	Road/Residential	68%
5SPS1 [3]	*7.04*	*School*	*70%*
5DSP1	5.32	Open Space	30%
5DRP1	2.93	Open Space	20%
EXT1	20.3	Agriculture	0%
EXT2	28.7	Agriculture	0%

Notes:

1. Land use surface type split data provided in Appendix A.
2. Higher density assumed for catchment 5F, 5G and 5H based on Context Plan and subject to future development application.
3. School site subject to separate development application by others
4. External catchments EXT1 and EXT2 are existing land use areas subject to future development that discharge to the southern tributary

6.3.4 Results

The results of the MUSIC modelling for each treatment zone are presented in Table 11 based on the latest data associated with constructed wetland treatment performance (i.e. total nitrogen (TN) k and C* parameter variation). A sensitivity assessment was undertaken on the adoption of the default TN k and C* values in Constructed Wetland 5E2 to quantify the impact of these parameters. Results presented in Table 11 shown in *(italics)*. An additional assessment was undertaken to address a request for further information from EDQ regarding the selection of rainfall data for use in MUISC with the results provided in Table 12.

Table 11: MUSIC modelling results summary

Treatment ID	Pollutant	Generation (kg/yr)	Discharge (kg/yr)	Reduction achieved (%)^	Water quality objectives (reductions)
Northern Tributary	TSS	54600	10500	80.7	TSS: 80% TP: 60% TN: 45% GP: 90%
	TP	116	35.7	69.3	
	TN	656	339	48.3	
	GP	7430	126	98.3	
Southern Tributary ^ (P5 developed area inputs shown in brackets)	TSS	121000 (77000)	41400	103.4 ^	
	TP	208 (160.6)	81.1	79.0	
	TN	1260 (987)	746	52.1 *(51.9)**	
	GP	12400 (12400)	0	100	
Upper Quinzeh Creek	TSS	19300	3650	81.1	
	TP	32.5	8.7	73.1	
	TN	127	69.2	45.6	
	GP	1660	0	100	
TOTAL ^	TSS	195000	55600	92.3 ^ ✓	
	TP	357	126	74.6 ✓	
	TN	2050	1150	50.6 *(50.1)** ✓	
	GP	21500	126	99.4 ✓	

* Total nitrogen (TN) reduction achieved with default wetland TN k and C* values shown in *italics*

✓ Water quality objectives achieved

^ Southern Tributary (and total) 'reduction achieved' compares total loads removed from combined developed and undeveloped external catchment against only those loads generated as part of developed P5 portion.

Table 12: Rainfall station data comparison (total Precinct 5)

Pollutant	Overall Pollutant Reduction Achieved (%) (with current treatment sizing for Precinct 5)		
	Adj. Shailer Park (Logan Village) from Table 11	Shailer Park (ID: 40715)	Greenbank (ID: 40659)
TSS	92.3	88.7	94.6
TP	74.6	71.0	76.7
TN	50.6	47.3	52.2
GP	99.4	99.4	99.4

Results based on same treatment sizing as presented in overall modelling in Table 11

6.3.5 Discussion

The proposed stormwater quality management strategy provides the required pollutant removal from the urbanisation of Precinct 5 catchments. This is achieved at both the local tributary scale (north and south) as well as the overall precinct discharge north into Upper Quinzeh Creek. In the interim period until the adjoining precinct is developed to the west of Precinct 5, additional pollutant removal is occurring from the agricultural catchment that drains into the Southern Tributary (and therefore the downstream low flow diversion structure) that would otherwise not be required as part of an urban development. This therefore presents as a high pollutant removal efficiency in Table 11.

The wetland parameter sensitivity assessment indicates that the revised wetland k and C* values adopted in this report result in a 0.3% increase in the TN load removed from catchments in the Southern Tributary (Precinct 5D-5F) compared to the default values formerly adopted in MUSIC (52.1% compared to 51.9% in Table 11). The adopted value therefore does not impact the overall treatment strategy outcomes for the precinct which still achieve TN removal above 45% for both scenarios.

The current default wetland treatment parameters are being revised to more accurately represent the optimal treatment efficiency of constructed wetland. Oversizing treatment infrastructure for only very marginal benefit is not considered to represent best practice nor sustainable in the long term, both in capital cost and ongoing maintenance burden. In this instance, as the wetland is being used in conjunction with bioretention basins (as a flow distribution measure), the impact of this change is not as significant as it would if the wetland was the main component of the treatment train.

Finally, the comparison of overall treatment performance based on the selection of rainfall station from the *MUSIC Modelling Guidelines* (Table 12) shows that the current adoption of an adjusted Shailer Park rainfall data set (to more closely represent Logan Village rainfall) provides a reasonable and practical representation of the local conditions (and treatment requirements) that lies generally between the two stations proposed for Logan City. Based on the mean annual rainfall comparisons presented as part of the *Precinct 1 Stormwater Management Plan* (DesignFlow, 2011), adoption of Shailer Park data would have led to oversized treatment systems (shown as a reduced treatment efficiency in Table 12 . Conversely, defaulting to the Greenbank data would have resulted in undersized systems from Yarrabilba. The site adjusted rainfall data is therefore proposed for continued use at Yarrabilba.

6.4 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 (2017), *Draft Wetland Technical Design Guidelines (Version 1).* Healthy Land and Water Ltd, Brisbane.
- Water by Design (2009), C*onstruction 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.

7 FLOODING

A flood assessment for Precinct 5 has been undertaken as part of *the Yarrabilba (Quinzeh Creek) Flood Study – Version 1* (DesignFlow, 2017). This flood study was been submitted as part of previous Precinct 3 development applications and remains valid for Precinct 5.

In summary, Flood basin 15 proposed as part of Precinct 3B is a regional scale detention basin that captures and manages minor and major flows from the southern catchment of Yarrabilba draining to Quinzeh Creek and offsets (in conjunction with future flood basins to the west) the flood hydrograph timing occurring from the western catchments of Yarrabilba (future development precincts). This provides a reduction in peak flood flows leaving the site under minor and major flooding to meet the objectives set-out in the Precinct 5 Context Plan Area Strategy.

Reference to specific flood management infrastructure in the flood study applicable to Precinct 5 is limited to Flood (basin) 16. As stated in the flood study report, Flood 16 is defined as upper portion of Flood 15 and delineated by a future road embankment and culverts across the main waterway (now referred to as the East West Link road). Unless otherwise stated, the general discussion and interrogation of Flood 15 includes the Flood 16 zone as it is hydraulically linked (and backwatered) from the broader flood basin 15.

No further flood assessment is included in this Precinct 5 Stormwater Management Plan and reference should be made to the aforementioned flood study for all details.

8 RECONFIGURING A LOT (PRELIMINARY EARTHWORKS)

The stormwater management strategy present herein provides the required treatment areas to meet the water quality objectives based on MUSIC modelling. To ensure these areas can be appropriately configured and integrated into the development (i.e. levels, batters, bunds and maintenance access), preliminary earthwork will be required for each system as part of the relevant Reconfiguring a Lot application/stage.

The intent is that stormwater management will remain consistent with this *Precinct 5 Stormwater Management Plan*. However where the development detailed planning and design results in changes in catchment and/or the location and size of treatment systems, this will be described in a technical note and certified as part of the Reconfiguring a Lot application submission for each of the relevant Precinct 5 sub-stages.

9 CONCLUSION

A stormwater management strategy for Yarrabilba Precinct 5 development has been developed to meet the requirements of the *Yarrabilba Stormwater Infrastructure Master Plan (DesignFlow, 2012)* and Precinct 5 Context Plan Area Strategy which is generally consistent with the *State Planning Policy* (DSDIP, 2017).

The strategy includes a range of treatment measures including sediment ponds, wetlands and bioretention systems that 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.

Suitable space has been allowed in the development layout for the stormwater treatment measures which will be verified via preliminary earthworks plans to be submitted as part of the Reconfiguring a Lot applications for each sub-precinct.

Waterway stability has been addressed through the assessment of both existing and ultimate hydrologic and hydraulic conditions within the precinct and adoption of management approaches including localised remediation of scour, revegetation of waterways and riparian buffers and ongoing adaptive management through monitoring of changes overt time with appropriate remediation where required (as per precinct 1 and 2 to date).

Construction phase stormwater management objectives have been established for the site, in accordance with *State Planning Policy* (DSDIP, 2017). The preliminary locations of sediment basins has been provided with Erosion and Sediment Control Plans to be developed as part of detailed design. Audits will be completed during construction to ensure compliance with *State Planning Policy*.

10 REFERENCES

DesignFlow (2012) *Yarrabilba Total Water Cycle Management Strategy*

DesignFlow (2012) *Yarrabilba Stormwater Infrastructure Master Plan*

DesignFlow (2013) *Yarrabilba General Waterway Condition Assessment*

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

DSDIP (2017) *State Planning Policy*

Lendlease (2017) *Yarrabilba Context Plan Area Strategy – Precinct 5*

Natura Consulting (2012) *Yarrabilba Development: Natural Environment Site Strategy*

Natura Consulting (2012) *Natural Environment Site Strategy (NESS)*

Prosser, I.P. and Slade, C.J. (1994) *Gully formation and the role of valley-floor vegetation, southeastern Australia.* Geology v. 22, p. 1127-1130

Prosser, I.P., Dietrich, W.E. and Stevenson, J. (1995) *Flow resistance and sediment transport by concentrated overland flow in a grassland valley*. Geomorphology, v. 13, Issues 1–4, p. 71-86

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

APPENDIX A MUSIC MODEL DATA

Table A1: MUSIC model catchment split data

Catchment ID	Total Area (ha)	Surface Type	Sub-Area (ha)	Impervious %
5A1	12.96	Road	3.50	60%
		Roof	3.89	100%
		Ground	3.89	20%
		Park	1.69	5%
5B1	8.99	Road	2.25	60%
		Roof	3.37	100%
		Ground	3.37	20%
5C1	2.98	Road	1.47	60%
		Roof	0.59	100%
		Ground	0.59	20%
		Park	0.34	5%
5C2	6.12	Road	1.81	60%
		Roof	1.68	100%
		Ground	1.68	20%
		Park	0.95	5%
5D1	18.15	Road	4.54	60%
		Roof	6.81	100%
		Ground	6.81	10%
5D2	32.9	Road	8.10	60%
		Roof	12.15	100%
		Ground	12.15	20%
		Park	0.50	10%
5E1	14.31	Road	4.87	60%
		Roof	4.72	100%
		Ground	4.72	20%
5F1	15.7	Road	4.71	70%
		Roof	5.50	100%
		Ground	5.50	30%
5G1	3.69	Road	1.11	70%
		Roof	1.29	100%
		Ground	1.29	30%
5H1	5.72	Road	1.72	70%
		Roof	2.00	100%
		Ground	2.00	30%
5EPL1	1.22	Road	1.22	70%
5EWL1	0.98	Road	0.98	70%
5EWL2	4.91	Road	4.08	70%
		Roof	0.42	100%
		Ground	0.42	20%
*5SPS1**	*7.04*	*School*	*7.04*	*70%*
5DSP1	5.32	Park	5.32	30% #
5DRP1	2.93	Park	2.93	10% #
EXT1 ^	20.3	Agriculture	20.3	0%
EXT2 ^	28.7	Agriculture	28.7	0%
TOTAL	143.92		143.92	59%

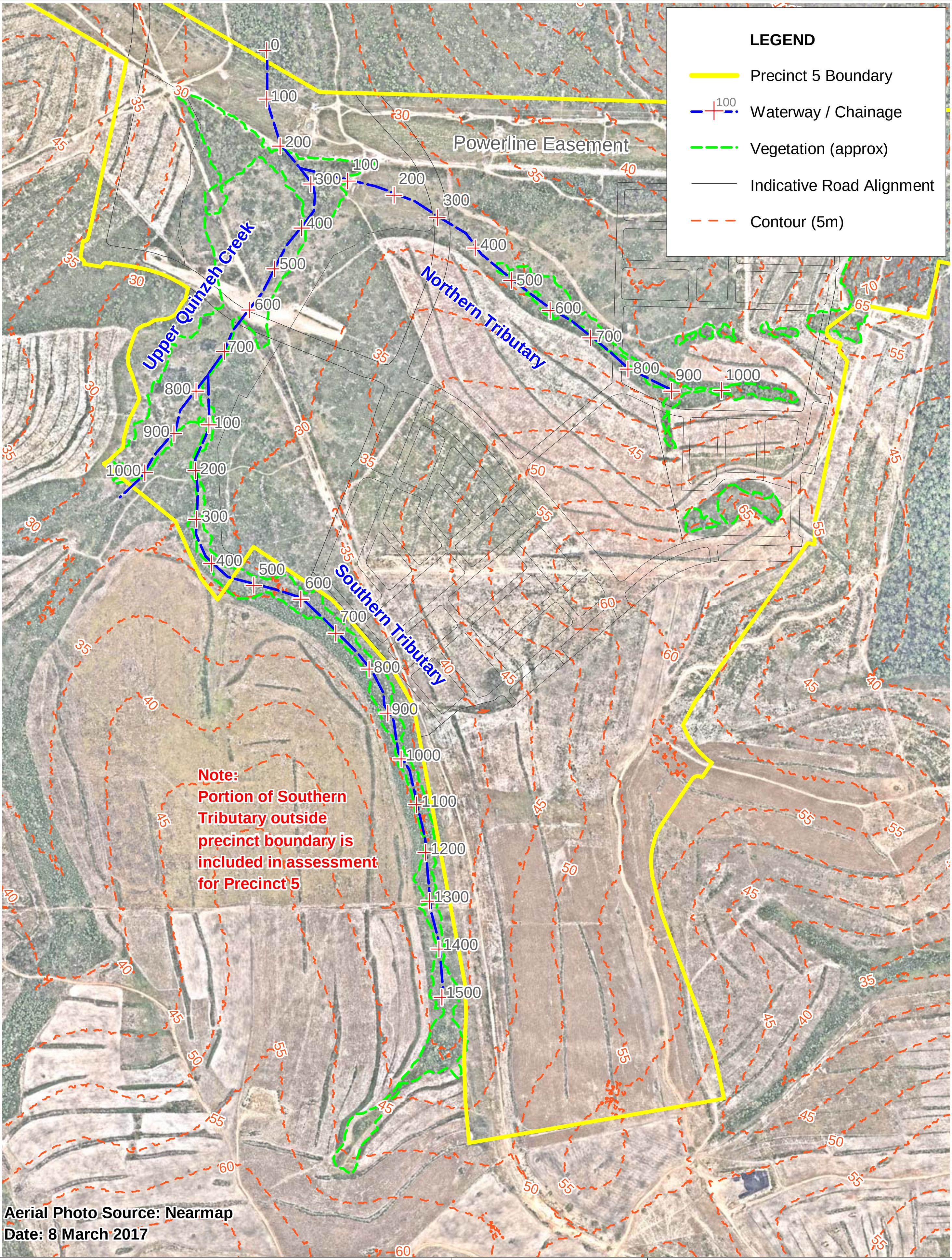
Table A1 Notes:
* Catchment 5SPS1 (school site) is not part of this stormwater management plan and will be addressed onsite by others.
# Parks impervious fractions have been based on the level of facilities and embellishments as follows:

- Conservation/natural parks: 5% imperviousness (only modelled where discharging into urban drainage)
- Local, neighbourhood and district recreation parks: 10% imperviousness
- District sports parks: 30% imperviousness

^ External undeveloped catchments included as they discharge into southern waterway low flow diversion structure

APPENDIX B PRECINCT 5 WATERWAY INSPECTION SUMMARY

Precinct 5 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.



Prepared by: DesignFlow For: lendlease	Project: 4338 Yarrabilba Precinct 5	Scale: 1 : 10,000 (A4)	FIGURE B1 Waterway Inspection Reference Plan
	Client: Lend Lease	Date: 5 July 2017	

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)