Henry & Hymas

Creek Realignment Design Report

Light Horse Interchange Business Hub, Eastern Creek State Significant Development Application (SSD 9667)

Project Number: 18652

Date: 24/01/2020

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PROJECT VERIFICATION

Project Name:	Light Horse Interchange Business Hub
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Report for:	Mr Luke Wilson, Western Sydney Parkland Trust

PREPARATION, REVIEW AND AUTHORISATION

Revision #	Date	Prepared by	Reviewed by	Approved for Issue by
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1.0 Introduction

Henry & Hymas has been engaged by Western Sydney Parklands Trust (WSPT) to prepare this Creek Realignment Design Report in satisfaction of commentary raised by Blacktown City Council during the State Significant Development Application for the Light Horse Interchange Business Hub.

This report aims to provide a summary of key engineering elements of the proposed realignment of Eskdale Creek in response to Council comment 19 under Drainage Matters of the submission schedule. Key engineering elements of the proposed realignment include:

- Background information on the existing Eskdale Creek and context of realignment with the proposed development.
- Proposed realignment methodology.
- Hydraulic assessment of the existing Eskdale Creek.
- Presentation of conceptual creek design:
    - General geometric design parameters.
    - Recommendations for vegetation and scour protection.
    - Recommendations for bedding and bank materials.
    - Recommendations for hydraulics structures.
    - Discussion on other considerations – Amenity, Flora and Fauna.
- Review of operation and maintenance requirements.
- Concluding remarks.

The report has been prepared in consideration with a number of key documents and should be reviewed in conjunction with:

- Civil Engineering Report prepared by Henry & Hymas
- Civil Engineering Drawings prepared by Henry & Hymas
- Ecology report prepared by Ecoplanning
- Flooding report prepared by BMT

The relevant documentation listed above, as well as industry standard documentation, will be referred to, or referenced, throughout the report as required.

In consideration of the current stage of the project submission the design of the proposed creek alignment has been prepared to be conceptual in nature with detail design occurring during later phases. A functional conceptual design that addresses key requirement for any development proposal containing a constructed waterway is detailed in the report. This includes waterway corridor alignment and sectional design, demonstrating suitability of the creek alignment in context to the proposed development, and review and analysis of the surrounding ecology.

2.0 Background information

Eskdale Creek is located in Western Sydney in the suburb of Eastern Creek, part of the local governing authority of Blacktown City Council, however it should be noted as the development is deemed a State Significant Development (SSD), the consenting authority is the NSW Department of Planning, Industry and Environment. Eskdale Creek ranges from the Creek's upper reaches of the Interchange Park Development running east beneath Wallgrove Road and the M7. Following the M7 the creek meanders through the Western Sydney Parklands bushland corridor to its confluence with Reedy Creek and shortly after Eastern Creek. A plan showing the location and extent of the Creek in relation to surrounding roadways and the proposed development is shown below in Figure 1. NSW Water management mapping indicates Eskdale Creek flows north east parallel to Reedy Creek and discharges into Eastern Creek without joining to Reedy Creek. It was determined by Ecoplanning during field ecological investigations Eskdale Creek discharges into Reedy Creek which later joins with Eastern Creek. The significance of the real confluence location is further discussed in subsequent chapters.

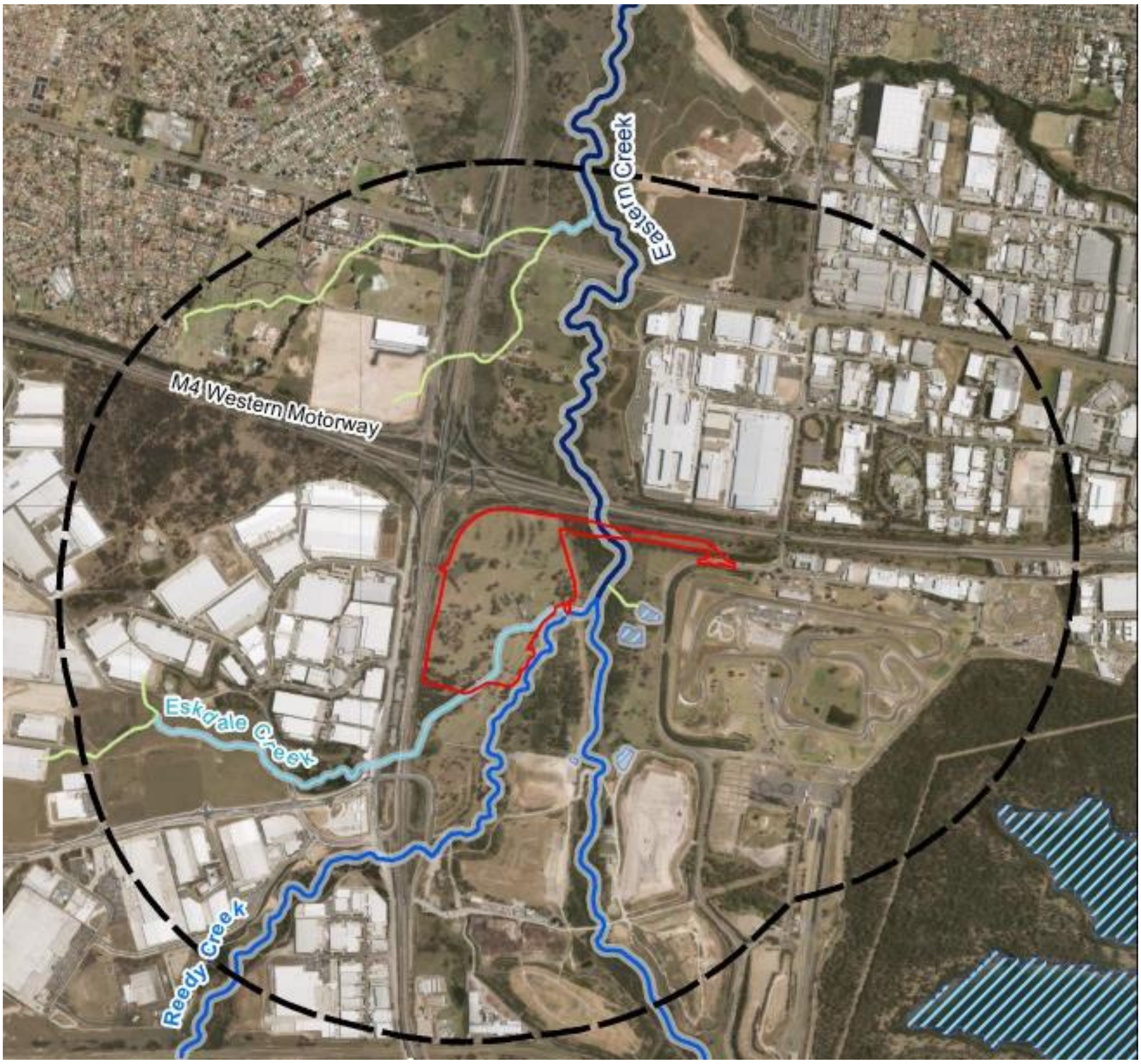


Figure 1: Locality map of proposed realignment and proposed development. (excerpt of image supplied by Ecoplanning 2019).

Considering the neighbouring developments of Interchange Park and M7 Business Hub, the Eskdale Creek catchment is predominantly comprised of developed commercial and Industrial areas, roads infrastructure, and low-medium dense vegetation along the riparian corridor and scattered within various developed areas. During detailed flood investigations the catchment area of the creek was determined to be approximately 208.5 hectares in area (BMT 2019). A plan showing the approximate extend of the catchment is shown below in Figure 2.

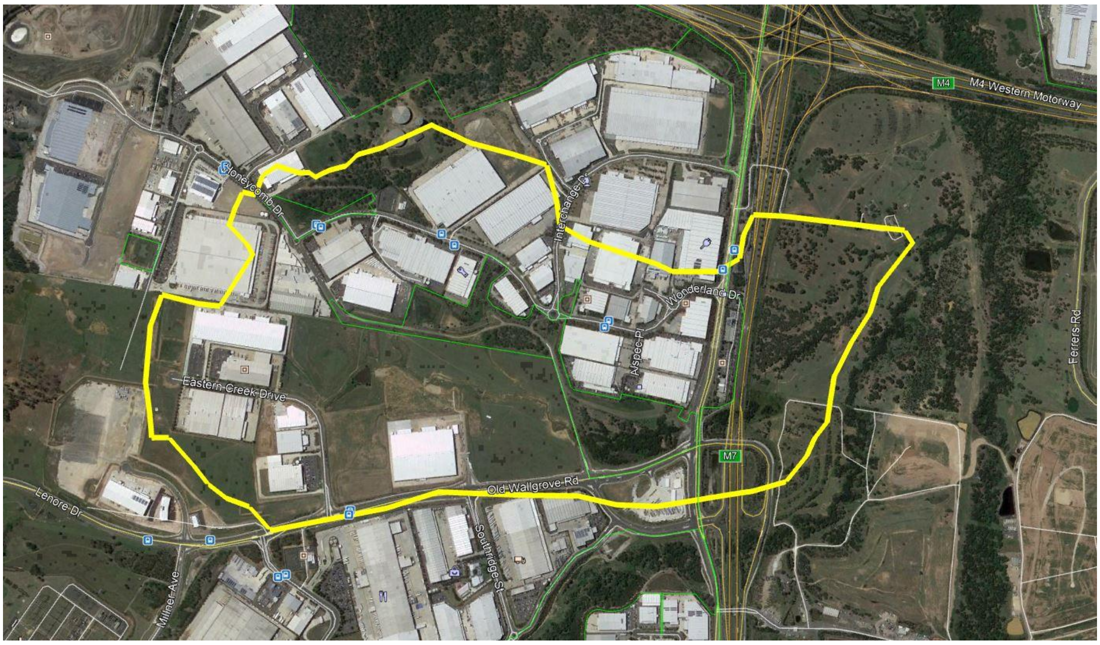


Figure 2: Catchment map of Eskdale Creek Catchment (supplied by BMT 2019)

Eskdale Creek has been classified as a 2nd order stream according to the Strahler system watercourse order, NSW Office of water, (2012), refer figure 3 Below. As such, the vegetated riparian zone (VRZ) is recommended to be 20 metres on either side of the creek for a second order stream. It should be noted the 40m offset (20 meters each side) can be skewed along the creek alignment due to the natural meanders of a given waterway system.

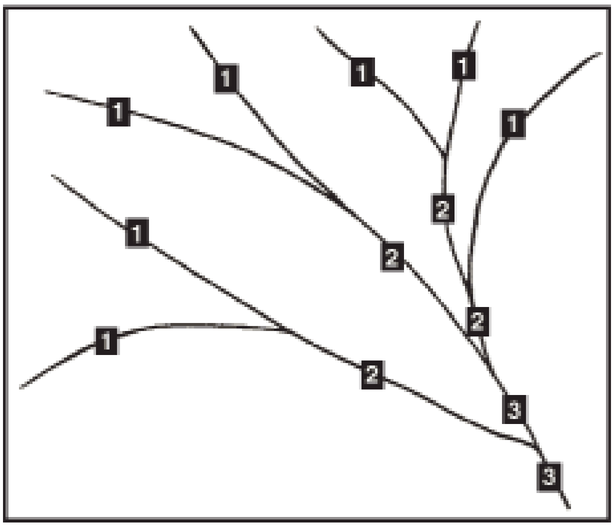


Figure 3: Strahler system watercourse order (NSW Office of Water, 2012)

The condition of the Creek within the Western Sydney Parkland Bush corridor can be described as a uniform drainage channel surrounded by areas of low-lying and shallow graded grassed banks. Photographs showing the existing condition of Eskdale Creek are shown below in Photograph 1 and 2.


Photograph 1 (left): Eskdale Creek at confluence with Reedy Creek facing West. Photograph 2 (right): Eskdale Creek at re-alignment point facing north.

The existing creek area is currently been used as a water source for livestock. Field investigations combined with review of historical data provides the following description by Ecoplanning:

> *Based upon the evidence of channelisation within the subject land and the surrounding vegetation, it is highly likely that historically, Eskdale Creek was not a waterway with a defined bed and bank, as it appears today, but rather a low lying, broad drainage depression that was covered in a woodland/forest vegetation matrix dominated by species that prefer 'wet feet' such E. amplifolia and E. tereticornis in the canopy, a midstorey dominated by Melaleuca spp. and ground layer of grass and sedge vegetation.*

Deep incision, scour and channel widening along the lower reaches of Reedy Creek were noted during Ecoplanning's field investigation. It was suggested that this was caused by significant changes in the hydrology of Reedy Creek, particularity flow metrics which include annual flow volume, flow velocities, shear stress, bank full flows and floodplain engagement. These changes of hydrology are likely attributable to the alteration of the Eskdale Creek channel alignment and discharge position from that documented in NSW Water management mapping to the current position noted from field investigations.

The Industrial Development proposed in the State Significant Development Application comprises seven (7) industrial lots that will be accessed via a sealed access road connecting through from Ferrers Road located to the east of the site. The access from Ferrers Road will require the construction of a new road and bridge crossing over Eastern Creek. For more information regarding the proposed development please refer to the Civil Engineering Report prepared by Henry & Hymas Engineers. A plan prepared by Ecoplanning showing the location of the Proposed Development in relation to the surrounding waterway network is shown below in Figure 4. As is evident in Figure 4 the proposed development encroaches into the existing Eskdale Creek alignment.

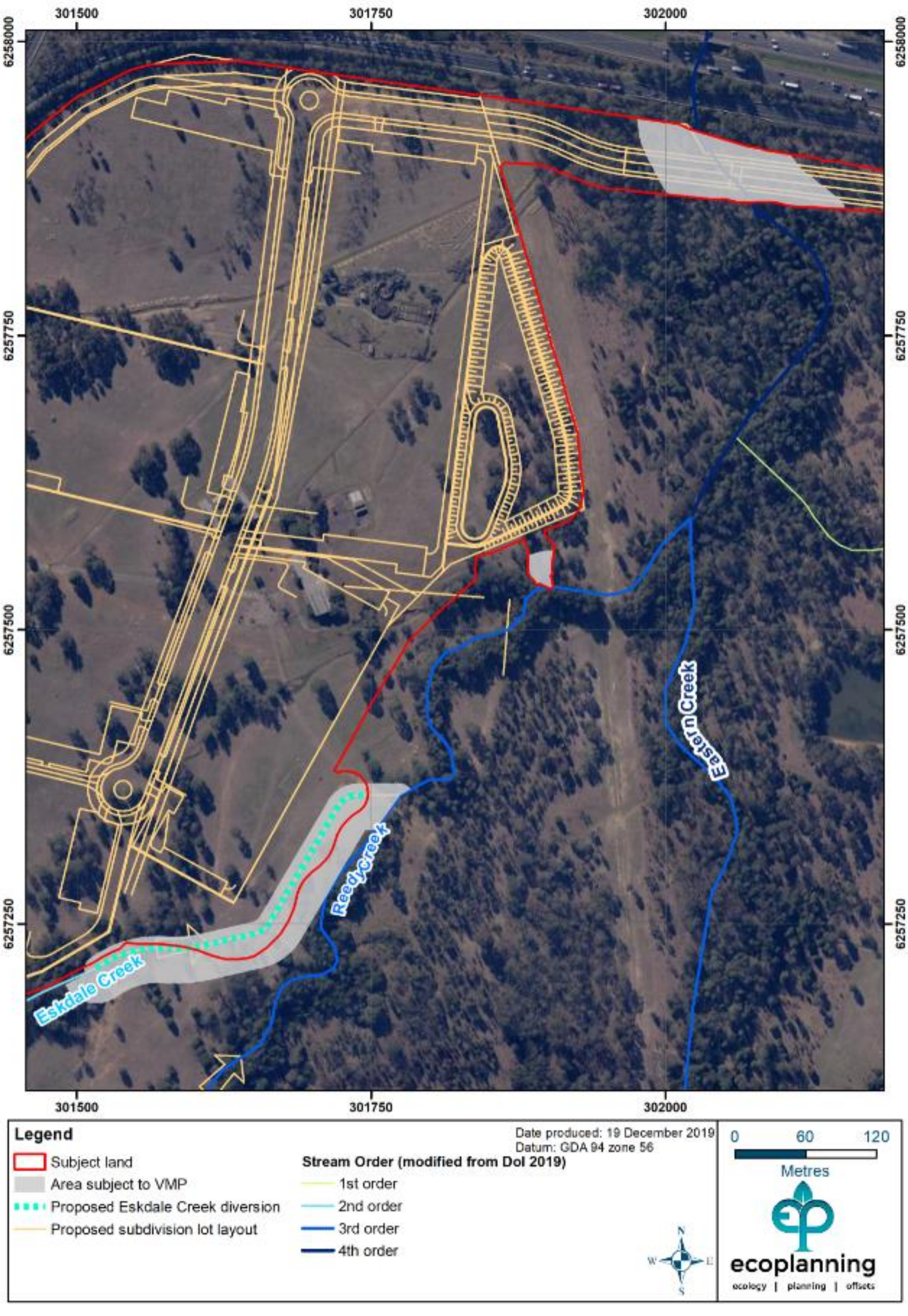


Figure 4: Plan of proposed realignment of Eskdale Creek (Figure provided by Ecoplanning 2019).

3.0 Proposed Realignment Methodology

To manage the encroachment of the development within the current Eskdale Creek alignment the applicant proposes to realign Eskdale Creek to achieve better stormwater, flooding and ecological outcomes. This plan aims to create a naturalised meadow akin to Eskdale Creek's state prior to the creek having been modified for anthropogenic purposes. The Meadow is proposed to be comprised of a wide low flow channel linking a series of interspersed pools surrounded by swampy meadows.

A key aspect of the proposed design is to minimise hydraulically variability upstream and downstream of the realignment to match or improve the existing flow conditions (flow rates, velocity and shear stress etc). To form a basis of the Proposed Design the existing Creek will be analysed to determine the exiting flow conditions and thus establish design criteria for the proposed realignment.

The proposed realignment is part of the subdivision works and proposed to be constructed during Stage 1 (infrastructure works). However, the realignment is not used for the conveyance of stormwater run-off induced by the proposed development and is not proposed to be accessible by pedestrians from the proposed development or traversing the parklands. On this basis the outcomes of the proposed creek alignment are different from those of a typical waterway. To aid in the understanding of the outcomes typical to creek design and applicable to the proposed creek design the following table was produced, a detailed discussion of key outcomes such as asset protection, flora and Fauna and asset management will be provided in subsequent sections of the report. The table has been populated using desired outcomes from the industry standard design manual, Constructed Waterways Design Manual by Melbourne Water 2019 (M.W.2019). In consideration of the approval stage of the development, the design of the proposed creek alignment will be a functional concept which addressed the specific design criteria listed in the Table 1 below.

Desired Outcome	Design Objective	Development specific design criteria.
Asset Protection	Flood Capacity and conveyance	• Creek is proposed to be designed to match the low flow capacity of the existing Eskdale Creek. • The high flow channel has been included in the detailed flooding assessment prepared by BMT. Refer to detail flood assessment for further explanation of interaction of proposed creek topography and major flooding.
	Drainage	• Creek geometry and outfall is to be designed to accommodate the low flow capacity of the existing Eskdale Creek. • Outfall is to be designed to minimise hydraulic and channel stability impacts on Reedy Creek.
	Channel Stability	• Creek geometry is to be designed to minimise shear/resistance on the creek boundary. • Recommendations are to be made regarding suitable bank protection and armouring. • Engineered stabilising structures are to be designed to minimise the instance of scouring and increase overall channel stability.
Amenity	Aesthetics	• The proposed creek realignment is proposed to not be assessable to the general public. As such amenity specific criteria has not been included in the report. • The creeks physical form and its features have been designed to promote the amenity in the form of water quality benefits. Although not a prime objective of the alignment the benefits should be noted.
	Accessibility	
Flora and Fauna	Habitat	• Design criteria for Flora and Fauna have been considered in the realignment design. The design will include habitat features that provide habitat, refuge, hydraulic variability and visual
	Connectivity	

		interest. These will be briefly surmised in subsequent sections. Refer to ecology report for detail response.
Asset Management	Maintenance	• Design is to ensure features supporting efficient maintenance. • Design is to ensure safe access to all function areas and hydraulic structures.
	Renewal	• Renewal design life of 25 years to be considered.
	Efficient Investment	• Design is to be cost effective from a construction and maintenance perspective.
Community Connection	Social Setting	• The proposed creek realignment is proposed to not be assessible to the general public. As such community connection specific criteria has not been included in the report.
	Pedestrian Access	

Table 1: Outcome & design criteria relationship table (adapted from M.W.2019 and updated for project specific criteria)

For the purpose of the providing a functional concept design in response to Council submissions the report will focus on civil engineering related outcomes, satisfying the asset protection and asset management outcomes listed above. Other outcomes not specifically related to civil engineering such as of amenity, community connection, and flora and fauna will be periodically referenced where required with detail supporting information provided in the ecology report by Ecoplanning.

The proposal to realign the creek qualifies as instream works by The Department of Primary Industries - Office of Water, and is regulated by the controlled activity provisions of the Water Management Act 2000. As such the future detailed design of the creek realignment is proposed to conducted and reviewed in accordance with relevant documentation for controlled activities on waterfront land, specifically The Department of Primary Industries - Office of Water's Guidelines for instream works on waterfront land.

As stipulated in The Department of Primary Industries - Office of Water's Guidelines for riparian corridors on waterfront land, a 40m Vegetated Riparian Zone (VRZ) is required for a second order creek such as Eskdale Creek. As the proposed realignment of Eskdale Creek, similar to the existing case, is an ephemeral creek that does not have a defined high flow bank the 40m VRZ will be consider as a clear 40m offset similar to that of the Riparian Corridor (RC). In line with the guidelines for controlled activities on waterfront land, the VRZ will be offset from the creek centreline whilst maintaining the average required width of the VRZ over the length of the realigned watercourse.

4.0 Hydraulic Assessment of Existing Creek

Initial review of the site topography during field investigations revealed the creek is currently acting as a low flow channel for minor storm events which rapidly inundates the creek banks and activates the surrounding eastern creek flood plain in moderate to major storm events. As with most constructed waterways the existing Eskdale Creek has two defined zones, a low flow channel and a high flow channel. The low flow channel conveys base flows and small flow events where as the high flow conveys larger flow events that exceed the capacity of the low flow channel. In this case the low flow channel is Eskdale Creek as a whole between the current banks and the high flow channel is represented by the surrounding Eastern Creek flood plain.

To determine the creek's capacity, and the point at which capacity of the low flow channel of Eskdale Creek is reached, the report aims to establish a hydraulic model of the existing creek. A HECRAS model was prepared to establish the existing flow conditions. HEC-RAS river analysis software was developed by the Hydrologic Engineering Center of the US Army Corps of Engineers and is ideal for one-dimensional steady and unsteady river simulations. In addition to the low flow channel capacity, the high flow channel capacity, or the creek's interaction with Eastern Creek floodplain will need to be assessed. A detailed flood impact assessment of the Eastern Creek floodplain was undertaken by BMT for the existing and proposed creek alignments. This will be further elaborated on with the introduction of the proposed creek design.

To confirm the hypothesis that the Eksdale Creek's current capacity is limited to the conveyance of minor storm events, estimated peak flow rates for minor storm events with the average recurrence intervals (ARI) of 6 months, 1 year and 2 year were simulated in the model. Refer Table 2 below. The peak flow rates were estimated by calibrating and extrapolating flow data obtained from hydrographs of Council's XP-RAFTS base model.

Storms Event (ARI)	Estimated Flow Rates (m^3/s)
6 month	3.5*
1 year	4.7
2 year	7.95

Table 2: Flow estimations for HEC-RAS modelling.
*flow rate for 6-month storm event is estimated as 0.75 x 1 Year Flow

HEC-RAS model - Parameters and Assumptions

The flows tabulated in Table 2 above were imported into the HEC-RAS software in order to model the flow conditions (depth, width and velocity etc.) for the existing Creek scenario.

Cross sectional data for the length of surveyed channel (1050m) around the existing creek was added at 10m spacings with the peak flows for the Eskdale Creek catchment (Table 2) inserted at the upper cross-section of the model. Based on an initial simulation it was found that using a mixed flow analysis was the ideal flow regime to simulate the existing creek due to the characteristics of the natural creek.

The following assumptions were used for the existing case model:

- A Manning's roughness coefficient of 0.06 was adopted for the main channel of the creek which is representative of small natural streams – moderate vegetation, sluggish weedy reaches with deep pools; ARR (1987).
- A Manning's roughness coefficient of 0.09 was adopted for the over bank of the creek which is representative of overbank flow areas – medium to dense brush; ARR (1987).

- Expansion and contraction coefficients were set to the default HEC-RAS manual coefficient as 0 for unsteady flow.
- The expansion and contraction coefficients were set to 0.1 and 0.3 respectively for steady flow.
- Boundary conditions upstream were set to the critical depth and downstream were set to the normal depth in the channel based on the average slope downstream.

Results from Existing Creek Hydraulic Modelling

The geometry (Figure 5) shows the modelled existing creek is 1,050m long flowing from south-west to north-east. Chainage 1050 represents the upstream section of the creek whereas chainage 280 represents the section immediately upstream of the confluence with Reedy Creek. Figure 6 below shows an overlay of the HEC-RAS cross section locations in relation to the surrounding area and proposed development.

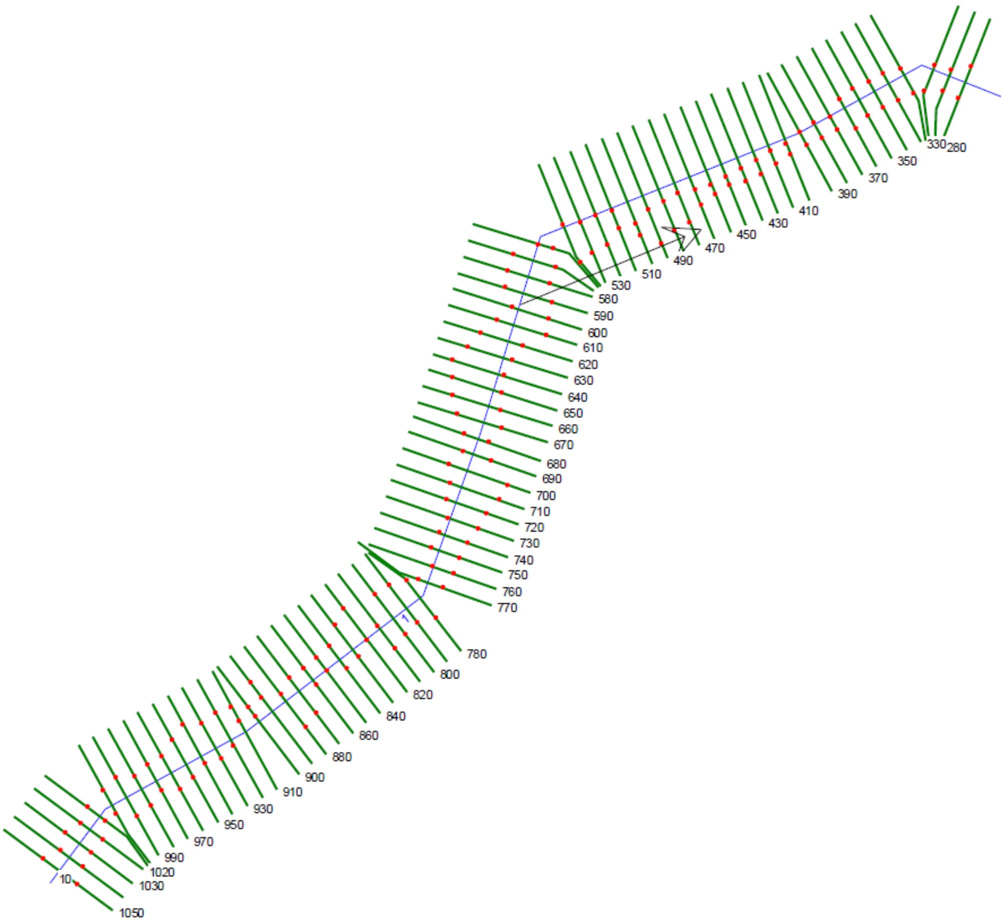


Figure 5: Geometric data from existing modelling case (HEC-RAS)

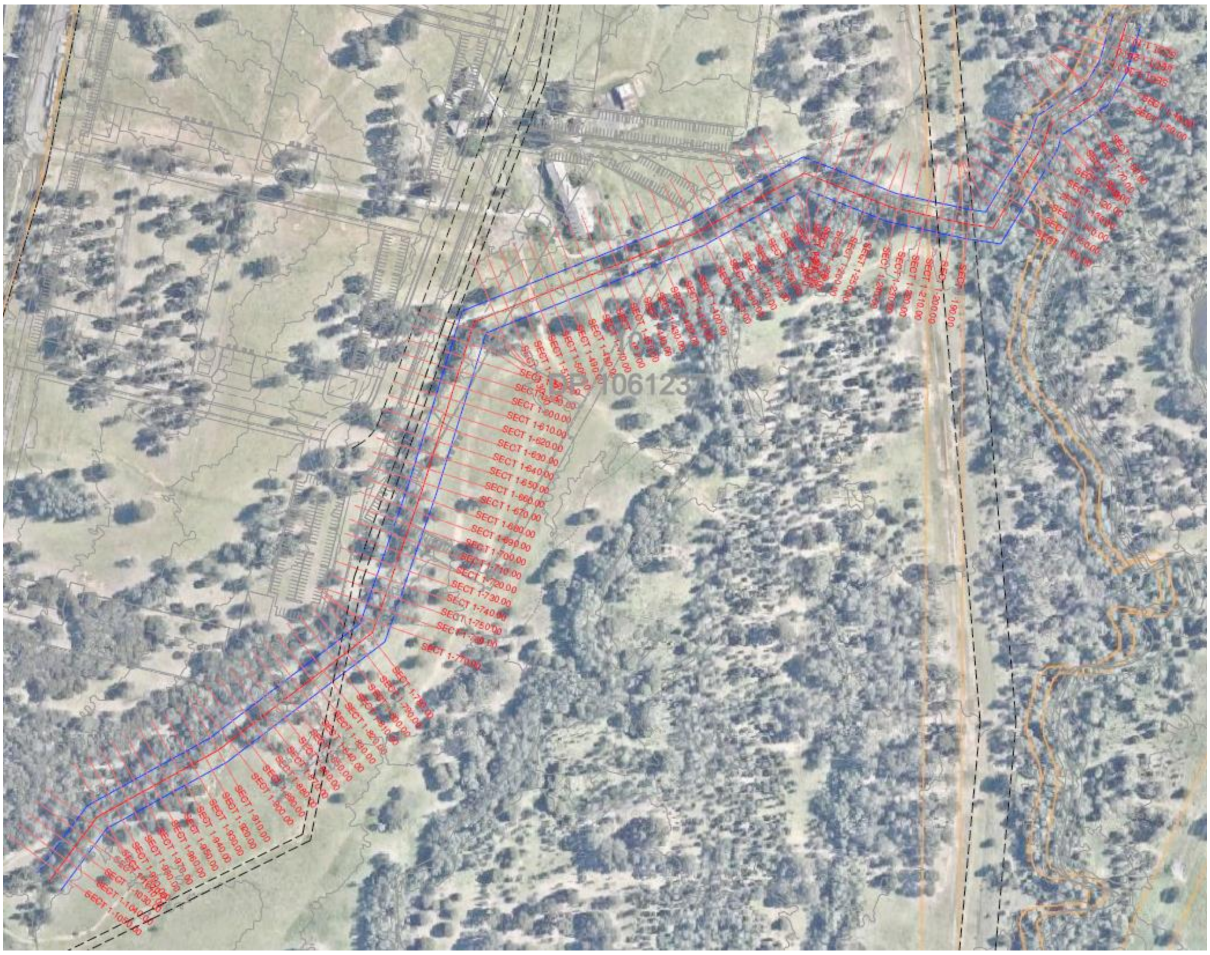


Figure 6: Geometric data from existing modelling case (HEC-RAS)

The long section of the existing creek (Figure 7) indicates the base invert of the low flow channel falling from approximately 47.5m AHD to 42.3m AHD. Considering the length of the existing creek an average gradient of 0.495% in the low flow channel was calculated. Figure 7 also indicates the nature of the creek with locations of minor and major pools and riffles as well as indicative water surface elevations for storm event present in preceding sections. From Figure 7 below it can be noted the 6-month water level exceeds the right and left banks exceeding the capacity of the low flow channel and inundating the overbank areas, in this case, representing the larger surrounding floodplain. This occurs throughout the existing creek line however is most prominent between chainages 380m to 620m. It should be noted these chainage locations are currently being used as locations for livestock watering and It is likely the natural creek system was either modified at this location to increase the agricultural efficiency of the water source or trafficking from livestock had increased the rate of erosion on the banks.

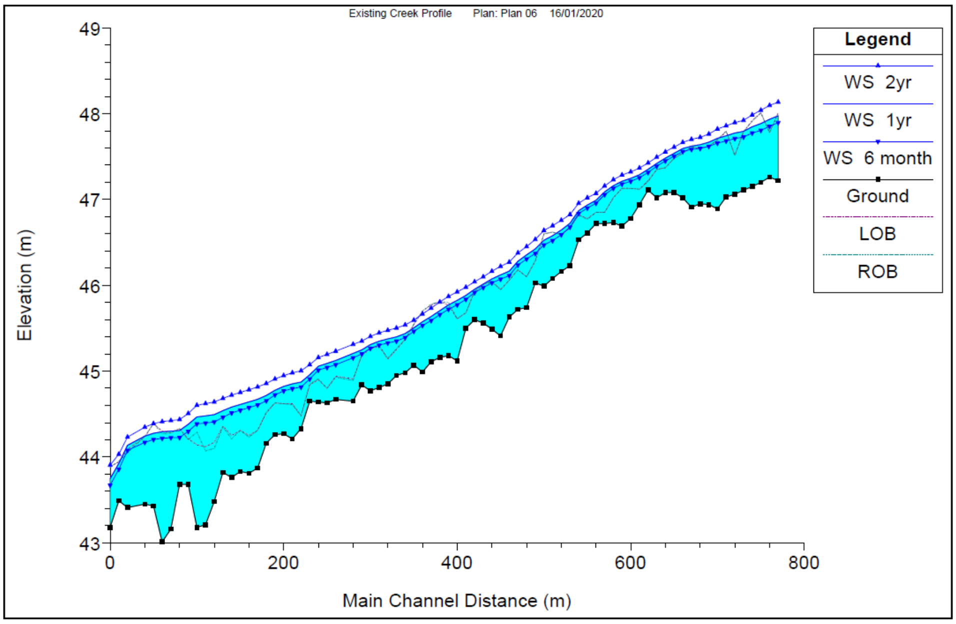


Figure 7: Longitudinal section of existing Eskdale Creek.
*Note to correspond main channel distance(m) with chainages on Fgiure 5 and 6, 280m should be added to the main channel distance listed on the x-axis.

The example cross section (Figure 8) of the existing creek is indicative of the general nature of the creek being approximately 14m in width and surrounded by a larger floodplain area. From reviewing the particular cross sections populated by HEC-RAS it is further evident the creek overbanks become inundated in storm events less frequent than the 6 month storm event. From a review of velocity plots the average velocity thoughout the low flow channel was calculated as 0.5m/s.

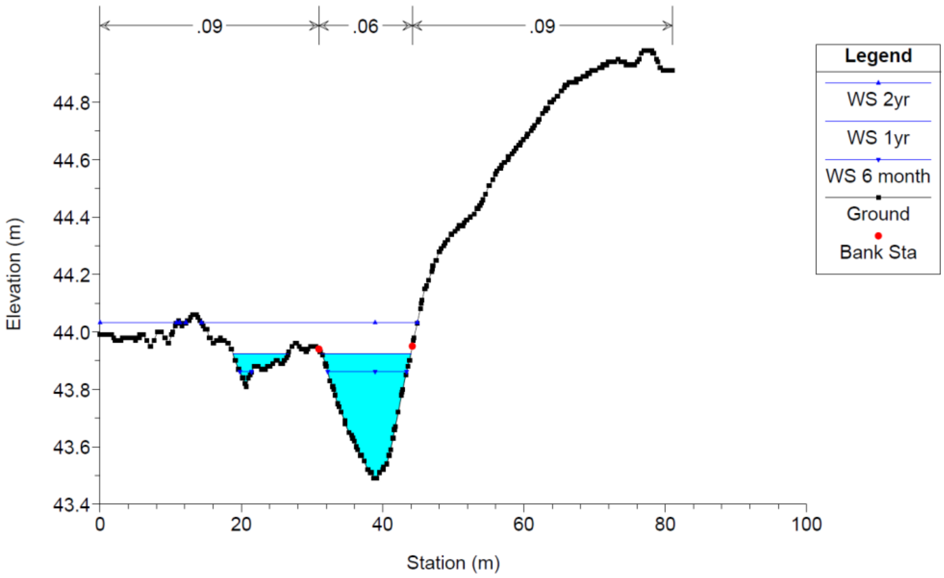


Figure 8: Typical existing Eskdale Creek cross section.

The hydraulic modelling shows the performance of the existing creek to be predominantly subcritical in nature and with frequent overtopping of the creek banks (even in smaller events such as the 6 month ARI). The results produced by the hydraulic modelling generally support the hypotheis that the existing creek is performing as anthropogenically modified agricultural landscape.

5.0 Conceptual Creek Design

The proposed design for the realignment of Eskdale Creek, including a swampy meadow/chain-of-ponds system, aims to recreate the geomorphology and to an extent the hydrology of the drainage system that is likely to have existed in this area prior to disturbance and channelisation associated with historical disturbances to this drainage system. A shallow marsh is proposed to dominate the realignment's flow path with areas of deeper marsh and submerged marshes confined to the margins of interspersed pools. A concept sketch of the proposed creek alignment is shown below, in addition to a concept plan of the realignment refer Figure 9 and 10 respectively. A full-size copy of the concept plan can be found in Appendix A. The concept plan showing the upstream and downstream interfaces with the waterway alignment and hydraulic structures have been designed to ensure the proposed matches the constraints and requirements.

Figure 9: Concept sketch for Proposed Creek Alignment (Ecoplanning 2019).

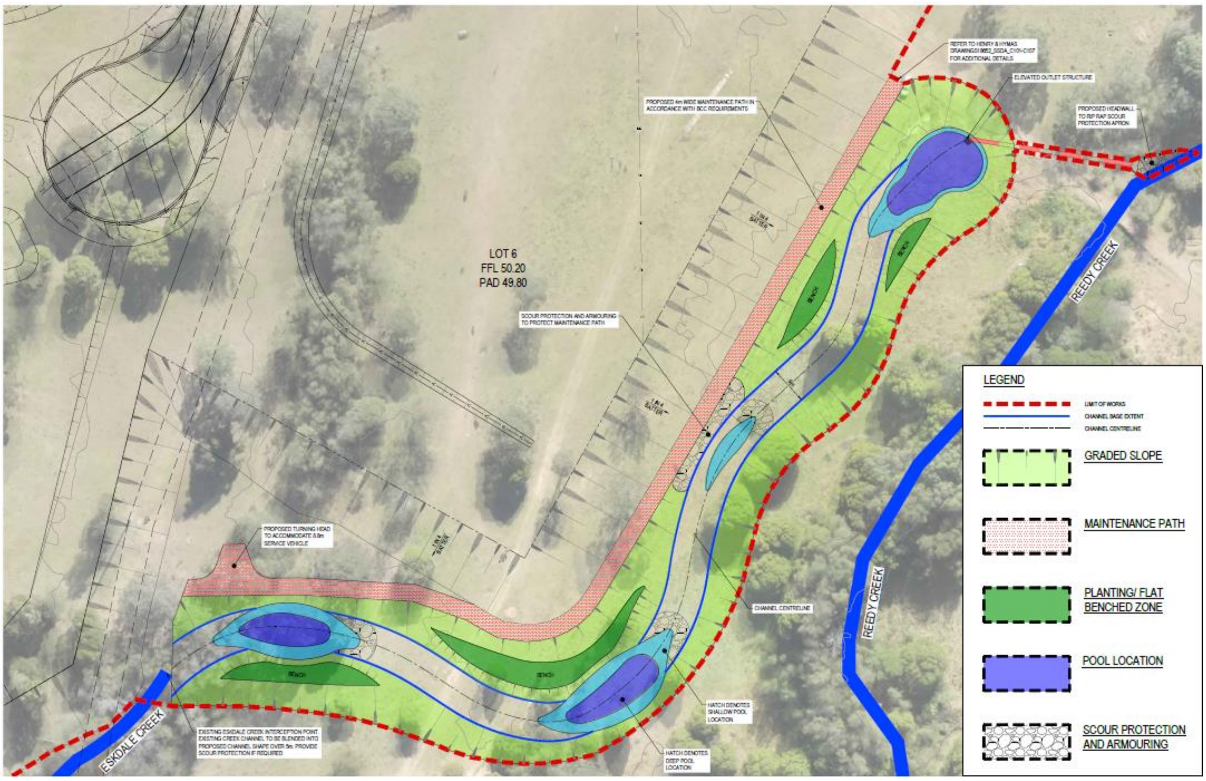


Figure 10: Concept Plan for Proposed Creek Alignment. Enlargement found in Appendix A.

The conceptual design of the creek realignment encompasses numerous design criteria relating to each of the specific outcomes of the proposed realignment. To simplify the presentation of the design the concept will be presented based on the specific design criteria relating to the relative outcome.

Flood capacity and conveyance, drainage and channel stability.

In parallel with the hydraulic assessment of the existing creek alignment the proposed creek realignment is proposed to have two defined conveyance zones, a low flow channel and a high flow channel. As previously discussed, the low flow channel is proposed to be designed to accommodate and convey the 6-month ARI flows. To achieve the proposed outcome of re -introducing a swampy meadow, the design aims to combine the principles of constructed water way design with the ecological expertise provided by Ecoplanning. On this background, in contrast to the existing uniform, deep, u-shape channel the design proposed to introduce a wide, shallow trapezoidal channel with undulating batter slopes and interspersed pools and riffles. The trapezoidal channel, similar to existing conditions will form the entirety of the low flow channel conveyance.

Key design parameters for the flood capacity and conveyance, drainage and channel stability of the low flow channel are the plan geometry, sectional geometry, hydraulic features (such as pools, rifles and benches) and the drainage outfall. For a typical constructed waterway these parameters are shown indicatively below in Figure 11 and for the project specific concept plan in Figure 10. The importance of each key parameter is highlighted below in addition to any recommendations necessary for the establishment of a detailed design in the future.

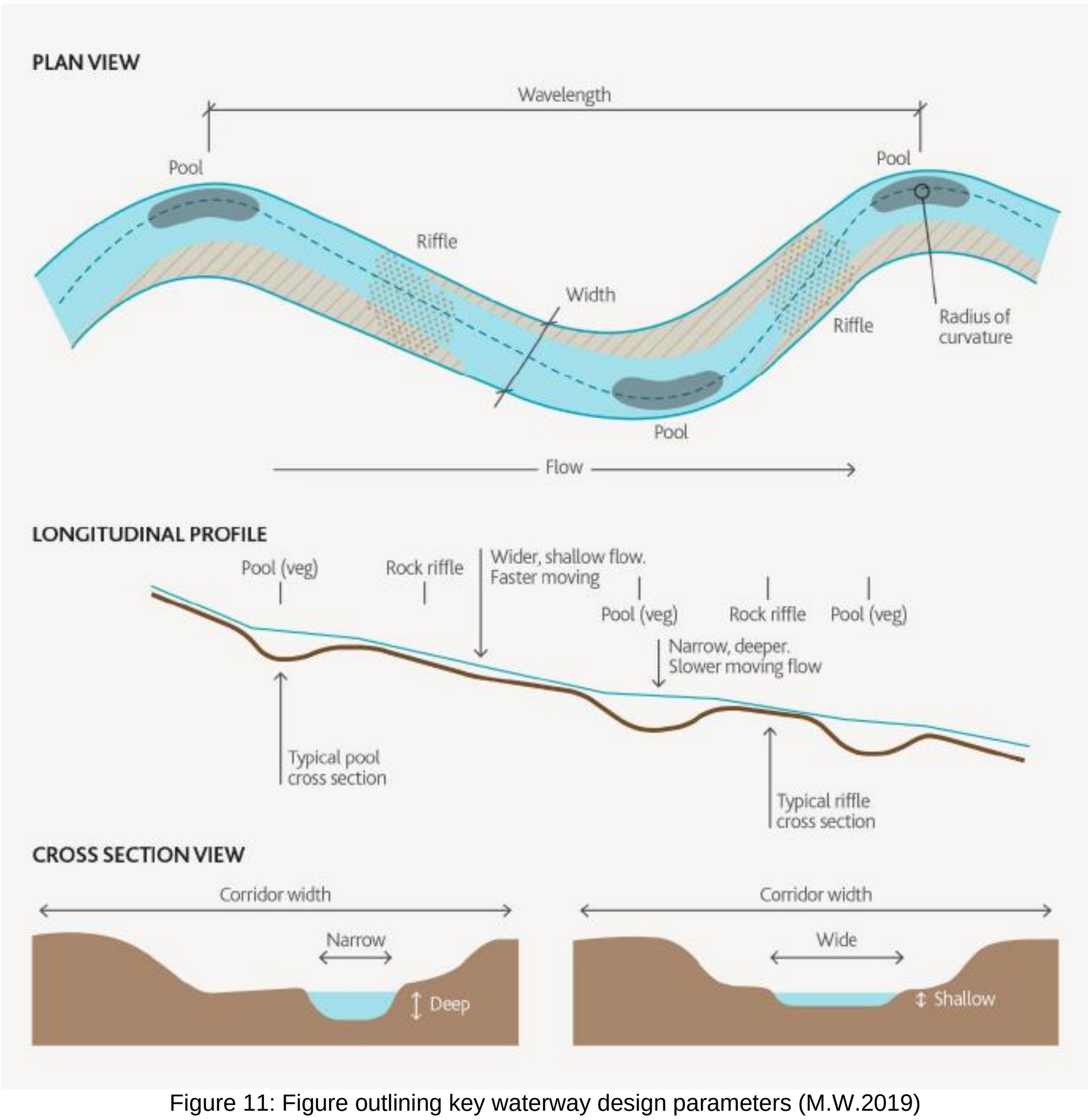


Figure 11: Figure outlining key waterway design parameters (M.W.2019)

Plan geometry

The plan geometry of the creek alignment is inherently inhibited by the constraints of the Developmental layout, ecological zones and the surrounding topography and landscape. In summary the realignment proposes to incorporate a naturalised meander from the existing upstream interface that continues through four (4) pools, riffles zones and low lying marsh areas to a control drainage outlet. The total length of the realignment is proposed to be approximately 300m in length. In contrast to typical constructed waterways through urban development the proposed realignment has the benefit of being able to efficiently convey low flows with the possibility of floodplain connectivity to the Eastern Creek floodplain south and east. This connection location of the proposed realignment also helps to minimise earthworks, match the sinuosity of existing meanders in Reedy Creek, and minimises disturbance to existing pockets of vegetation.

The design alignment was constructed to:

- Convey low flows originating from the Eskdale Creek Catchment in a relatively narrow, defined channel to maximise available habitat in features like pools and benches, (discussed in further detail in subsequent sections).
- To provide sufficient flow velocity to prevent stagnation in the relatively narrow low flow channel.
- Create hydrologic diversity across the width of the waterway corridor. The low flow channel will be significantly wetter than areas adjacent to it, hence supporting a different range of flora and fauna.
- Provide sufficient depth for stormwater pipes to drain freely to the waterway.

Resultant conceptually geometry is shown in Figure 10 (see appendix A for full size image).

Sectional geometry

As previously discussed, the plan geometry is inherently inhibited by a number of constraints. Additionally, it was determined through a hydraulic analysis that existing Eskdale Creek has the capacity of less than the 6-month ARI storm event. To match existing conditions the design flow rate for the channel is considered to be the 6-month ARI flow rate induced by run-off from the Eskdale Creek catchment. To ensure the low flow channel is designed to convey the design flow rate the flow depth of a typical trapezoidal channel was investigated.

The following parameters used to develop the concept design of the trapezoidal channel:

- A Manning's roughness coefficient of 0.06 was adopted for the main channel of the creek which is representative of small natural streams – moderate vegetation, sluggish weedy reaches with deep pools; ARR (1987).
- Slope was determined to be 0.5%
- Iterated for proposed velocity of 0.6-0.7m/s
- Flow depth of 0.5m corresponding to a wetted top of channel width of 15m.

The flow depth, corresponding flow rate and velocity is presented in Table 3 below, sectional geometry required to convey design flow shown in red. A schematic sketch of the coefficient used in the calculation of the trapezoidal channel flow depth and dimensions is presented in Figure 12 below.

Flow depth	Base width	side slope	W. surface width	Area	Slope	Rough co. n	W. Prim.	Hyd Rd.	Flow	Velocity
y	Bb		Bt	A	S	n	P	R	Q	V
m	m	deg	m	m^2			m	m	m^3/s	m/s
0	9	9.46	9.000	0.000	0.005	0.06	9.000	0.000	**0.000**	0.000
0.008	9	9.46	9.096	0.072	0.005	0.06	9.097	0.008	**0.003**	0.047
0.035	9	9.46	9.420	0.322	0.005	0.06	9.426	0.034	**0.040**	0.124
0.085	9	9.46	10.020	0.808	0.005	0.06	10.035	0.081	**0.178**	0.220
0.1	9	9.46	10.200	0.960	0.005	0.06	10.217	0.094	**0.234**	0.244
0.125	9	9.46	10.500	1.219	0.005	0.06	10.522	0.116	**0.341**	0.280
0.155	9	9.46	10.860	1.539	0.005	0.06	10.887	0.141	**0.492**	0.320
0.2	9	9.46	11.401	2.040	0.005	0.06	11.435	0.178	**0.762**	0.373
0.214	9	9.46	11.569	2.201	0.005	0.06	11.605	0.190	**0.856**	0.389
0.3	9	9.46	12.601	3.240	0.005	0.06	12.652	0.256	**1.540**	0.475
0.35	9	9.46	13.201	3.885	0.005	0.06	13.261	0.293	**2.020**	0.520
0.4	9	9.46	13.801	4.560	0.005	0.06	13.870	0.329	**2.560**	0.561
0.45	9	9.46	14.401	5.265	0.005	0.06	14.479	0.364	**3.161**	0.600
0.5	**9**	**9.46**	**15.001**	**6.000**	**0.005**	**0.06**	**15.087**	**0.398**	**3.824**	**0.637**

Table 3: Trapezoidal channel and calculated resultants. Proposed channel depth shown in red.

Where co-efficient shown in the top row of the Table 3 above are shown for an typical channel cross section below:

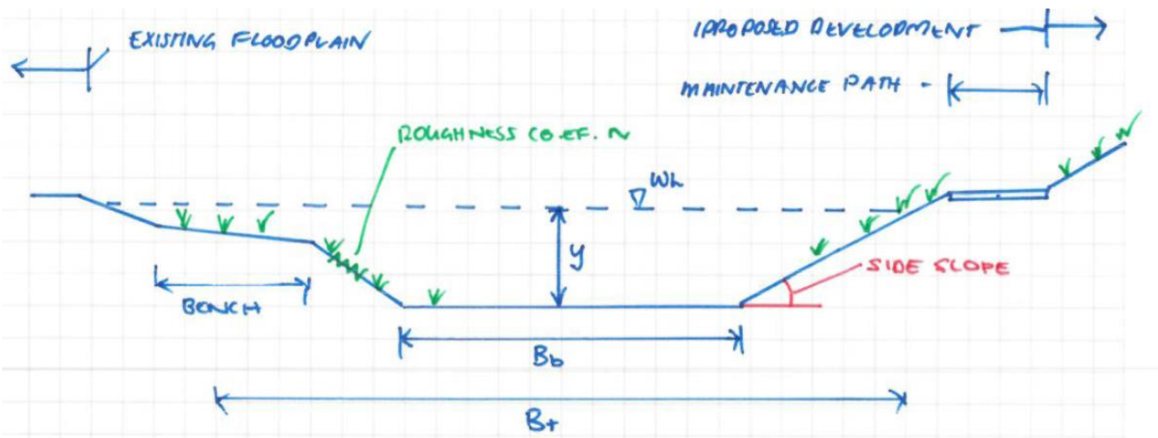


Figure 12: Typical channel cross section relating to Table 3.

<u>High Flow Channel – Interaction with Eastern Creek Flood Plain</u>

The Flood Impact assessment undertaken by BMT (2019) prior to submission, in addition to the proposed development and access infrastructure the flood assessment included conceptual level grading of the proposed creek realignment. In summary the modelling indicated that localised changes to peak flood levels and velocity distributions occur as a result of the proposed development and creek realignment. The investigation identified that these impacts are typically confined to within the site boundaries with no significant impacts on adjacent and upstream/downstream property. Pre and Post Development flood condition mapping for the 1% AEP event (100-year ARI) are shown in Figure 13 and 14 below. For further details please refer to Flood Impact Assessment prepared by BMT. Review of the Flood Impact Assessment by the ecology consultant, Ecoplanning, confirmed that both the change in duration and depth of flooding would not have a significant impact on the ecology in the Eastern Creek Floodplain and habitat for Fauna and Flora can be maintained in the floodplain following major flood events. For further details please refer to Biodiversity Development Assessment Report prepared by Ecoplanning.

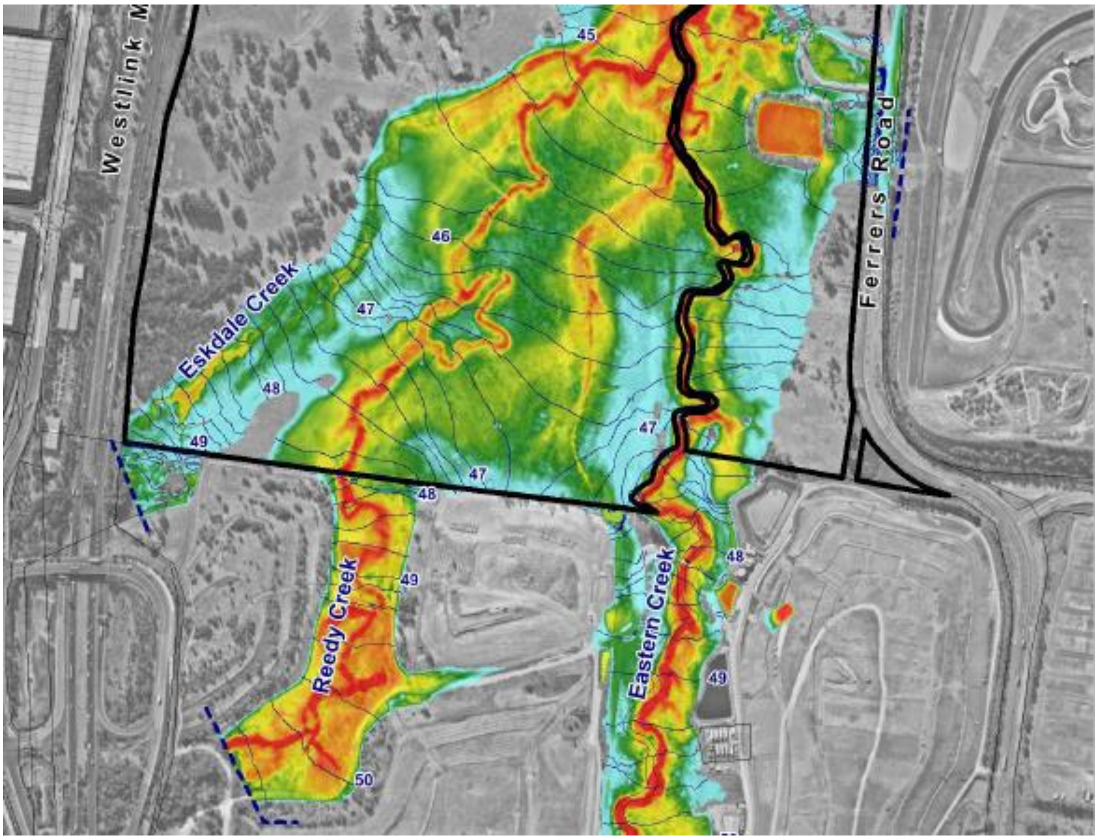


Figure 13: Pre-Developed Design Flood Conditions 1% AEP Event (BMT 2019)

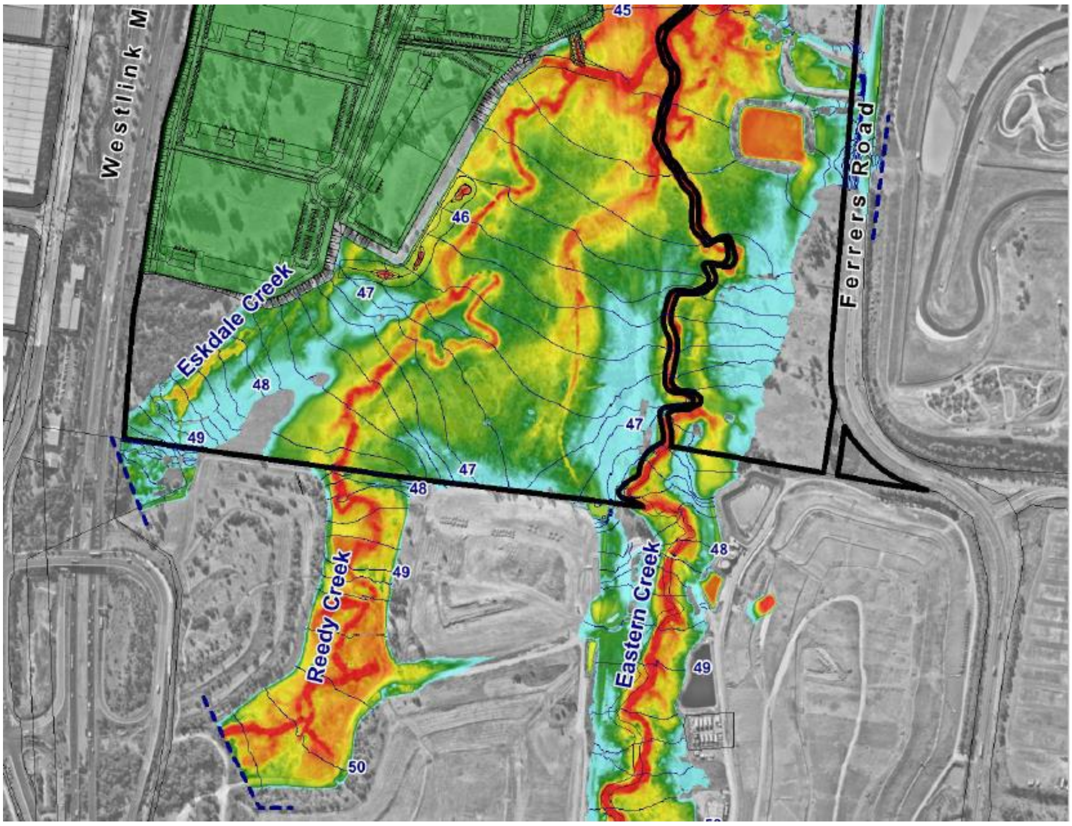


Figure 14: Post-Developed Design Flood Conditions 1% AEP Event (BMT 2019)

Hydraulic Features

Pools and riffles

In natural rivers longitudinal variations in depth and bed slope are often associated with periodic features called pools and riffles (M.W.2019). As previously discussed, the Eskdale Creek catchment is predominately urban development. Urban streams, such as the proposed realignment, are typically more ephemeral than their natural equivalent. The hydrology of developed urban areas often exhibits no base flow whatsoever. Pools therefore represent important habitat refuges for fish and other aquatic communities during a dry period. Pools are generally located on the outside bends of meanders between riffles. The pool has a flat-water surface slope and is deeper than the average channel depth. Riffles are bed features with larger bed material. Riffles are typically found between meanders and control the streambed elevation, ponding water into the pool upstream. Flow depth is relatively shallow over the riffles and the local bed slope is steeper than the average slope of the channel. The turbulence caused by water moving faster over riffles provides oxygen to the water (M.W.2019).

Where pools are required as critical drought refuge (flagged at the concept design stage) the pool geometry and configuration must demonstrate that critical habitat objectives can be achieved. For the proposed creek realignment, the following the design criteria for the pools and rifles is proposed:

- Pools located at approximately 10 times the low flow channel base width.
- Pools located at the meander apex, refer Figure 10.
- Length of pool to be approximately 3-4 times maximum pool width.
- Different pool zones to support variety of different habitats ranging from 1.5m to 0.15m below channel base.
- Riffles to be provided between pools/meanders.
- Riffles to be designed to initiate turbulence in the water.
- 4 pools to be founded in the low flow channel, refer to Figure 10 for locations.

Benches

Benches in natural waterways are horizontal geomorphic features formed by the deposition of sediment during flow events. Although true floodplains are not present in constructed waterways, such as the proposed Eskdale Creek realignment, some of their function can be provided by having small off-channel areas. These small off-channel areas are periodically inundated, and support plant species that are adapted to intermittent inundation. Benches are intermediate height features, and are typically located between the low flow channel and the batters of the high flow channel. (M.W.2019). To promote the objective of producing a swampy meadow, benches are proposed to be designed into the low flow channel lower than typical waterways in the cross section at different flow levels to create habitat niches for the establishment of different species of vegetation.

The following the design criteria for the inclusion of benches is proposed:

- Benches to be designed at roughly 3-month ARI water level with minor variation.
- Benches should have a 1:20 to 1:40 cross fall toward the waterway to facilitate drainage.
- Benches must not sit above the 6-month ARI storm event inundation level otherwise they will be too dry to perform the required habitat and ecological function.
- Benches are to be incorporate between meanders tapering from the inside edge adjacent to the pool and tapering in in width from the rifled section.

Drainage outfall

The low flow events are proposed to drain from the realignment via an elevated water level control structure located in the final pool. This aims to minimise erosion potential and foster a final permanent water body. The outlet structure will be connected to an underground stormwater line that discharges to the pre-determined point in Reedy Creek. The outlet structure will be sized to convey the 6-month ARI storm event run-off induced flow whilst assuming a blockage factor of 50%. Preliminary hydraulic grade line analysis determined the stormwater line would need to be at least 900mm in diameter. In line with industry standard practices the pipe is to designed to convey flows with an in-pipe velocity less than 1.5m/s measured at the outlet.

The drainage line is proposed to discharge into Reedy Creek tangentially with the apex of the natural meander of the creek. This alignment will reduce scouring and energy losses from perpendicular inflow. In addition to general alignment, the discharge outlet of the stormwater line is proposed to protected with rip rap rubble scour protection apron. A typical detail of the discharge connection to Reedy Creek is shown below.

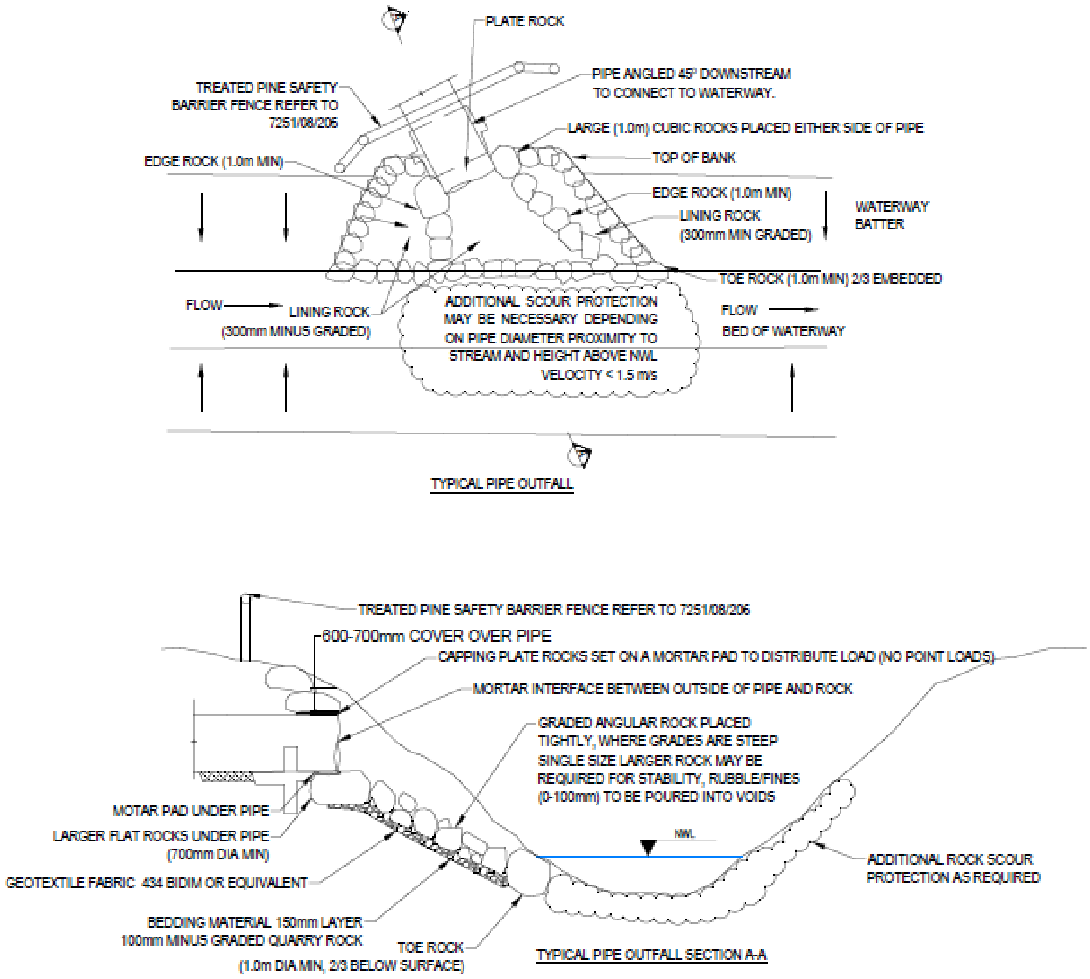


Figure 15: Typical rip rap scour protection apron detail (M.W.2019).

The rip rap scour protection is to be designed in consideration of the hydraulic conditions of the discharging stormwater line and in accordance with the requirements of the publication “Landcom – Managing Urban Stormwater - Soils and Construction, Volume 1, 4th Edition March 2004” and Blacktown City Council requirements.

Channel Stability

Channel stability is a key design parameter to provide an appropriate level of erosion protection to natural and anthropogenic assets in the vicinity of the waterway corridor. In the case of the realignment this represents neighbouring ecological zones and earthworks batters for the development.

Although erosion is a natural process, constructed waterways must be designed with a limited amount of potential channel adjustment via natural processes. Minimal change adjustment to provide a high level of protection to the natural surrounding whilst continuing to perform stormwater flow conveyance and flood protection functions.

To ensure channel stability the primary channel boundary material is proposed to be planted with native vegetation in preference over rock or other hard/man-made engineered materials. Native vegetation supports multiple social and ecological values in waterways and should be used throughout the waterway unless rock armouring is required to meet the design criteria. Once fully established, the root mass of vegetation strengthens the channel banks, and the above ground mass shields the bed and banks from erosion. Vegetation also accelerates recovery from floods by trapping sediment and 'repairing' areas of localised scour. In this way native vegetation provides long-term channel stability as well as visual amenity (M.W.2019).

Numerous key design criteria is proposed to satisfy outcomes related to channel stability; these include but are not limited to:

- Inclusion of natural meanders - Straight channels are inherently unstable and will usually adjust to reach a more stable form. The proposed realignment is to be design and constructed with an appropriate degree of sinuosity to the low flow channel form. Sinuosity is to be designed with appropriate meander wave lengths and eccentricity as site layout permits.
- During detail the shear stress (hydraulic force from flowing water), at the design flow rate is to be confirmed less than the shear resistance (hydraulic force needed to mobilise material). The cross-section average shear stress can be exported from HEC-RAS. The designer must consider the full range of shear stress values in the subject reach, not just at a single cross-section.
- Hydraulic features are to be included into the design to manipulate the channel hydraulics to minimise shear stress and velocity in the low flow channel. These features include: Pools, rifles, benches and localised rip rap scour protection, refer preceding sections.
- Satisfactory cross section design is to be finalised to ensure adequate levels of flow velocity and shear stress is not exceeded.
- Riparian trees are proposed to be retained where possible to strengthen bank substrate and tend to resist mass failure. The effect of the roots is to increase the effective cohesion of the sediments. In addition to larger riparian trees, dense vegetation is proposed to planted within the channel banks and benches to increases cohesion and bank strength through the root networks.
- Rock armouring is proposed in locations where an outward meander can potentially able to expand into the development. Proposed rock armouring locations are shown in Figure 10.

Asset management – Maintenance

Maintenance of the constructed waterway infrastructure is important to the ongoing operation (from a conveyance perspective) and stability of the creek. The following design criteria is to be considered during the detail design to ensure the realigned creek continues to hydraulically perform an maintain adherence with the proposed outcomes:

- Ensure sufficient access and space for all required maintenance activities.
- Appropriate forms of access to the waterway must be provided, as well as room for maintenance vehicles and machinery to manoeuvre along the waterway outside of the core riparian zone. The design is to provide an access ramp from Lot 6 down to the Eastern Creek flood plain. Refer engineering drawings by Henry and Hymas 18652_SSDA_C101-C107. The access ramp has been designed in accordance with recommendations for maintenance paths listed in BCC WSUD design drawings.
- Safe environments for inspectors and contractors to access and maintain the creek. This relates to proposed maximum grades for both channel stability and assess ability. The design is to limit max batter slope to 1V in 6H. The edge of any deep, open water should not be hidden or obscured by embankments or terrestrial planting, unless measures preventing access are provided
- Direct maintenance access is required along the length of the waterway (min 4m wide).
- The design is to incorporate the natural hydraulic features discussed in previous section of the report. These features are required to ensure the waterway is constructed with an appropriate degree of channel stability and resilience, and thus is less likely to undergo major channel adjustment. Reducing the likelihood of major channel adjustment will reduce the requirement for maintenance over the long-term (in the form of revegetation or ongoing bank stabilisation works).
- Access is to be provided to all hydraulic structures for removal of debris and general maintenance of outflow stormwater line.
- A detailed maintenance plan is to be submitted and approved to the maintaining body during the detail design phase. The maintenance plan is to cover maintenance activities relating solely to ensuring hydraulic conveyance structures such as the elevated drainage outlet and scour protection features are operating effectively.

Other Considerations – Amenity, Flora and Fauna

Amenity - Water quality benefits

This proposed design for the realignment of Eskdale Creek is not specifically designed as water quality treatment device, but rather is designed to mitigate flows by engaging a broad flood plain area, lose water via evapotranspiration and recharge groundwater via infiltration. These factors will improve both the quality and quantity of water flowing to Reedy Creek and increase local biodiversity by integrating deep wetland, shallow marshland and riparian ecosystems along a continuum of waterway.

Flora and Fauna

In addition to the importance of Flora and Fauna in keeping a healthy vegetation in the realignment to increase hydraulic roughness and bank stability the Flora and fauna promotes amenity and ecological benefits beyond that of engineering design. The Flora and Fauna aspects of the design are further elaborated on in the Biodiversity Development Assessment Report (BDAR) by Ecoplanning (2019), a short summary of key results is listed below:

- The vegetation corridor that surrounds the realignment provides a complex role of protecting the waterway by providing habitat support, facilitating connections to existing habitat and remnant vegetation, and strengthening habitat corridors between existing waterway systems.
- Specific to the proposed design the creek realignment will provide habitat for local threatened flora and fauna as identified within the BDAR by Ecoplanning (2019).
- BDAR by Ecoplanning (2019) further mentions through integrating deep wetland, shallow marshland and riparian ecosystems as detailed in the concept design along a continuum of waterway within the proposed realignment and design, it is expected the realignment will bring a increase local biodiversity.
- In addition to the re-introduction deep wetland, shallow marshland and riparian ecosystem, it is proposed, existing native vegetation where possible is retained and protected, especially mature remnant trees that provide substantial habitat and shading. Standing dead trees and large fallen trees must be retained as important habitat.

6.0 Conclusion

The report was prepared in satisfaction of commentary raised Blacktown City Council during the State Significant Development Application for the Light Horse Interchange Business Hub. It is noted the proposed development footprint submitted in the development encroaches on a portion of the existing Eskdale creek alignment.

It is generally understood through field investigations and historical evidence that Eskdale creek has been realigned in the past for the purpose of provided a watering source for local livestock. An in-depth ecological assessment of the existing creek line established that Eskdale Creek was not a waterway with a defined bed and bank, as it appears today, but rather a low lying, broad drainage depression dominated by marsh like conditions.

The report details a proposed design for the realignment of Eskdale Creek, including a swampy meadow/chain-of-ponds system, which aims to recreate the geomorphology and to an extent the hydrology of the drainage system that is likely to have existed in this area prior to disturbance and channelisation associated with historical disturbances to this drainage system. Using industry leading planning documentation, a set of outcomes applicable to the use of the realignment were developed, from which design criteria was established.

A hydraulic assessment of the existing creek was undertaken utilising HEC-RAS river modelling software by modelling minor stormwater flows generated by runoff from the Eskdale Creek Catchment. The assessment determined the existing creek's capacity is limited to less than and approximately equal to frequent and minor six-month storm event.

The report presents a functional concept design of the proposed realignment. The concept design outlines the necessary creek dimensions (plan and section) to ensure the low flow channel and high flow channels accommodate the necessary flow rates. The design outlines the required parameters for the low flow channel to accommodate the six-month storm event in parallel with the existing creek. The high flow channel was investigated as part of the detailed Food Impact Assessment of the Eastern Creek floodplain. The assessment found localised changes to peak flood levels and velocities, however no significant impacts on adjacent and upstream/downstream property was noted.

The report discusses the importance of other engineering aspects central to the effective operations of the proposed creek including:

- Hydraulic structures such as pools, rifles, drainage outfalls
- Channel stability and bedding materials
- Operation and maintenance.

Non civil engineering aspects of the creek realignment were also discussed including the increase in amenities i.e. improved water quality, as well as the complex role of the waterway plays in protecting ecology by providing habitat support. The Biodiversity Development Assessment Report prepared by Ecoplanning in summary endorsed the creek realignment with the proposed design anticipated to increase local biodiversity by integrating deep wetland, shallow marshland and riparian ecosystems.

7.0 References

BMT, Light Horse Interchange Business Hub [SSD 9667] - Flood Assessment, June 2019.

Ecoplanning, Biodiversity Development Assessment Report - Light Horse Interchange Business Hub (v 2.1). Prepared for Western Sydney Parklands Trust, August 2019.

Henry & Hymas, Civil Engineering Report Light Horse Interchange Business Hub, Eastern Creek State Significant Development Application (SSD 9667), June 2019.

NSW Office of Water, Controlled Activities on Waterfront Land, 2012.

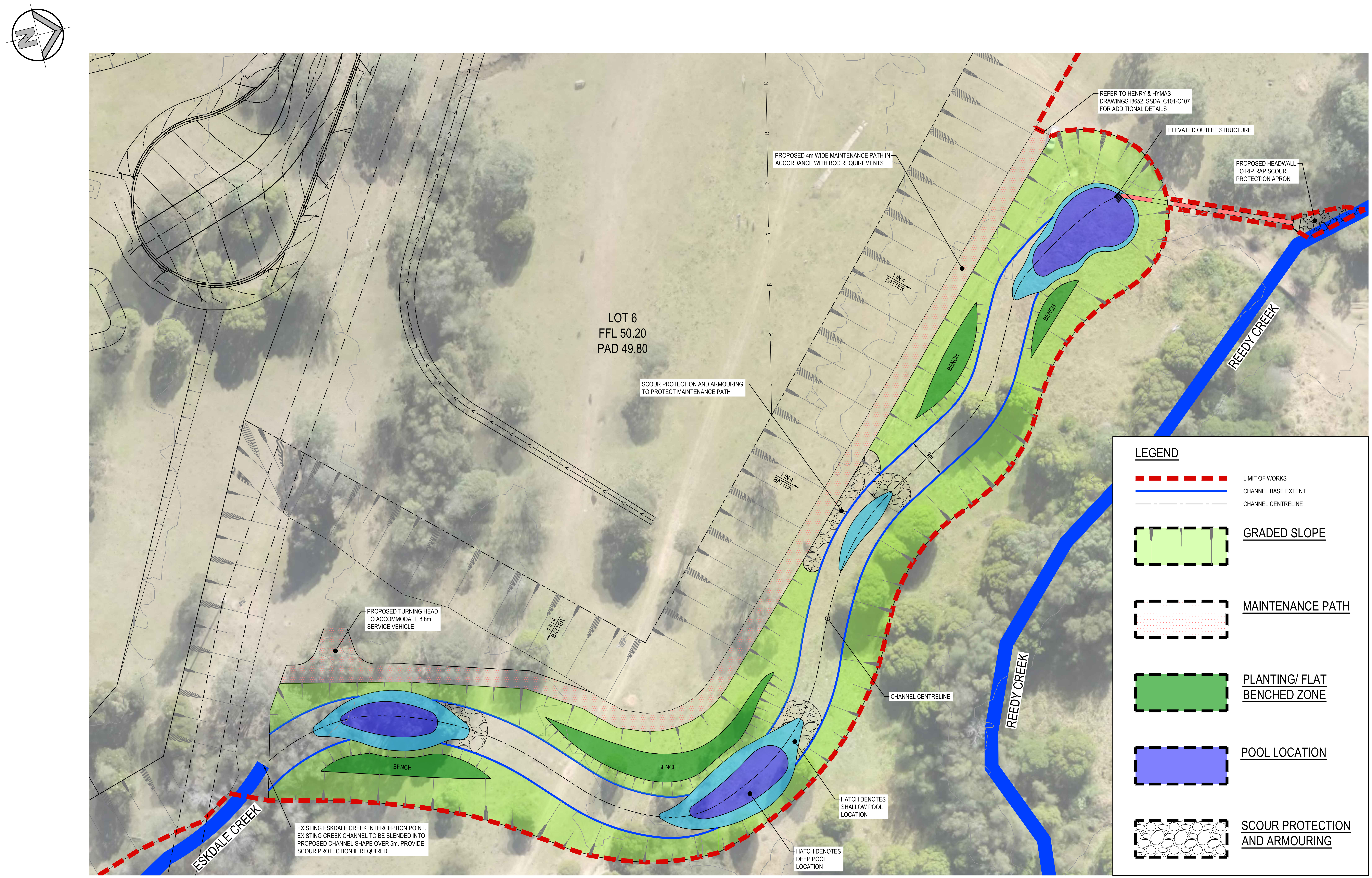
Urbis, Environmental Impact Statement Light Horse Interchange Business Hub, Eastern Creek SSD 9667, July 2019.

Melbourne Water, Constructed Waterway Design Manual, December 2019.

The Institution of Engineers Australia, Australian Rainfall and Runoff: A guide to Flood Estimation, Volume 1, revised edition 19867.

9.0 Appendices.

- Appendix A: Engineering drawing 18652_SK_14(01) - Eskdale Creek Design Concept



ESKDALE CREEK DESIGN

SCALE: 1:400

0 8 16 24 32 40m
8 6 4 2

SCALE 1:400

CONCEPT

REVISION	AMENDMENT	DRAWN	DESIGNED	DATE	REVISION	AMENDMENT	DRAWN	DESIGNED	DATE
01	ISSUED AS CONCEPT SKETCH	IK	NW	21.01.2020					

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Project
LIGHT HORSE INTERCHANGE BUSINESS HUB
EASTERN CREEK, NSW (SSD9667)

Title
ESKDALE CREEK DESIGN

Drawn	Designed	Date
M.Stimova	L.Caha	FEB 2019
Checked	Approved	Scale @A1
N.Wetzlar	A.Francis	1:400

Drawing number: 18652_SK_14

Revision: 01