CTENVIRONMENTAL
ECOSYSTEM MANAGEMENT AND MONITORING

Stephen O'Connor

Project Director

Altis Property Partners and Frasers Property Australia

Level 14, 60 Castlereagh Street

Sydney, NSW 2000

July 30, 2020

Dear Stephen,

RE: Changes to "Mamre Road South Precinct – Assessment of Riparian and Groundwater Dependent Ecosystem" as a result of proposed footprint modification and change to State Significant Development (SSD)

This letter has been prepared to provide a summary of changes that have occurred to the report post exhibition period due to the revision of the proposed development footprint.

Changes are as follows;

- Changed proposed development footprint on report mapset which include Figures 1, 2, 3, 5, 8 and 10.
- Omission of reference to Development Application (DA) where required.
- Inclusion of reference to State Significant Development (SSD) where required.
- Inclusion of reference to State Environmental Planning Policy (Western Sydney Employment Area) 2009 where required.

If you have any questions, please do not hesitate to get in contact.

Kind regards,

Carl Tippler

Director – Principal Ecologist

CTENVIRONMENTAL
ECOSYSTEM MANAGEMENT AND MONITORING

Mamre Road Precinct – Assessment of Riparian and Groundwater Dependent Ecosystems.

Proposed Warehouse, Logistics and Industrial Facilities Hub
657-769 Mamre Road, Kemps Creek

Prepared for Frasers Property Australia and ALTIS Property Partners Pty Ltd

July 2020

Project	**Mamre Road Precinct – Proposed Warehouse, Logistics and Industrial Facilities Hub. Assessment of Riparian and Groundwater Dependent Ecosystems**
Prepared For	Frasers Property Australia and ALTIS Property Group
Author/s	Carl Tippler, Ben Green (CTENVIRONMENTAL)
Reviewed by	Stephen O'Conner (Altis Property Partners)
Approved by	Stephen O'Connor (Altis Property Partners)
Version	FINAL

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CTECS PTY LTD Trading as CTENVIRONMENTAL
23 Marns Street, Wagga Wagga, NSW, 2650
M: 0400 216 206
www.ctenvironmental.com.au

Table of Contents

Figures

Tables

Executive Summary

This assessment of stream order, key fish habitat, groundwater dependent ecoystems and riparian vegetation and creek channel condition of South Creek has been undertaken to accompany a State Significant Development (SSD) Application for sub-division and proposed industrial buildings, located on Lot 34 // DP 1118173, Lot 1 // DP 1018318, Lot X // DP 421633, Lot Y // DP 421633 and Lot 22 // 258414, Mamre Road, Kemps Creek, and to address issues raised by the Secretary's Environmental Assessment Requirements (SEARs) for a State Significant Development (SSD) which include:

- Define and map appropriate vegetated riparian zone (VRZ) as required by *NSW Water Management Act 2000* – page 17.

- Assessment of Key Fish Habitat by application of the framework outlined in Department of Primary Industries – Fisheries (NSWDPI) (2013). Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (2013 update). See Results section – pages 6 and 11.

- Establishing an adequate riparian buffer zone to the creek. This buffer zone should be revegetated with native riparian species. The width of this riparian buffer zone is to comply with Crown Lands and Water buffer zone width requirements. See Results and Conclusion and Recommendations sections – pages 16-19 and Figure 9.

- Mapping and assessment of Ground Water Dependent Ecosystems. See Results and Discussion sections – pages 6,11 and 17.

- Satisfy the conditions of the *State Environmental Planning Policy (Western Sydney Employment Area) 2009* that relate to Riparian and Groundwater Dependent Ecosystems.

To determine stream order, the presence and extent of groundwater dependent ecosytems, assess the type and class of key fish habitat and current condition of riparian vegetation and creek channel, a combination of desktop review and field assessment were undertaken.

To determine the risk to stream ecology (ie fish habitat) the modelled Stream Erosion Index was compared to guidelines presented by Penrith Councils Water Sensitive Urban Desing (WSUD) Policy and Growth Centre

Results from this study indicate that;

1. South Creek is classified as a 5th Order stream under the Strahler stream ordering system and therefore a 40 m vegetated riparian zone is required as per the *NSW Water Management Act* 2000.

2. Terrestrial and aquatic groundwater dependent ecoystems are present in the subject land, however their distribution across the subject land is confined to South Creek and adjacent riparian zone which lies outside the development footprint.

   As a result, these ecosystem will unlikely be impacted during the construction phase if an appropriate Construction Environmental Management Plan (CEMP) is developed (see recommedation 3)

3. South Creek is mapped as key fish habitat and was assessed as Type 1 – highly sensitive fish habitat, Class 2 – moderate key fish habitat due to the habitat attributes observed within the creek and the intermittent flow regime. At the time of assessment, the Sydney region was declared as experiencing intense drought conditions which resulted in the upper reaches of South Creek to cease flowing and therefore a Class 2 – moderate key fish habitat was assigned. However, this condition should be regarded as stochastic and during years of "normal" rainfall South Creek has permanent flow and therefore should be considered as Class 1 – Major Key Fish Habitat.

   As a result, Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (NSW Department of Primary Industries 2013) recommends that where possible a 100 m VRZ is the desired outcome. However, this is not regulated by the *Fisheries Management ACT* 1994 and therefore the 40 m VRZ as regulated by the *NSW Water Management Act* 2000 is the required outcome.

4. The reach of South Creek adjacent to the subject land is considered High Ecological Value and Water Dependent Ecosystem (DPIE 2019). Therefore, disturbance of and impacts to these areas should be considered.

5. The condition of the riparian vegetation and creek channel along this reach of South Creek is considered to range between poor and fair. Historical and current land use practices at the subject land and within the upper catchment have resulted in significant degradation to the waterway and surrounding vegetation community.

It is unlikely the proposed development will have significant impact on groundwater dependent, aquatic and/or riparian ecosystems and improvement to these ecosytems will occur if the following

recommendations are implemented. These recommedations will ensure the biodiversity and environmental conservation values outlined by *State Environmental Planning Policy (Western Sydney Employment Area)* will minimise the potential impacts the aquatic and ground water dependent ecosystems of South Creek.

1. Establish and appropriately buffered Vegetated Riparian Zone (VRZ).

2. Develop an appropriate Vegetation Management Plan if associated stormwater infrastructure encroaches in to the VRZ.

3. Develop and appropriate Construction Environmental Management Plan (CEMP).

Introduction

This assessment of riparian vegetation and creek channel condition, groundwater dependent ecosystems (GDE) and key fish habitat (KFH) has been undertaken to accompany a SSDA relating to the proposed Warehouse, Logistics and Industrial Facilities Hub located at Lot 34 // DP 1118173, Lot 1 // DP 1018318, Lot X // DP 421633, Lot Y // DP 421633 and Lot 22 // 258414, Mamre Road, Kemps Creek, NSW (the 'subject land') (Figure 1).

The subject land covers approximately 118 ha and is proposed to be developed into a logistics and warehousing industrial precinct (Ecoplanning 2019).

This report has been prepared to accompany the State Significant Development Application for sub-division and to address issues raised by the Secretary's Environmental Assessment Requirements (SEARs) for a State Significant Development (SSD).

This study has been undertaken to determine the presence and extent of groundwater dependent ecosystems (GDE), determine key fish habitat (KFH) class and type and assess the current condition of riparian vegetation and creek channel, within a stretch of South Creek which forms the western boundary of the subject land.

To achieve this a combination of desktop review and field assessment was conducted which included review of vegetation, KFH and GDE mapping and field assessment to validate the condition of the riparian vegetation and creek channel, the extent of terrestrial and aquatic GDE's and class of type of KFH.

This study recommends mitigation actions which will minimise potential impacts to these ecosystems from the proposed development.

Figure 1: Aerial photograph location of subject land (yellow border), proposed development footprint (white border) and significant waterways.

Methods

Desktop study and literature review

A site-specific literature and database review was undertaken prior to undertaking field survey and the preparation of this report. This included desktop analysis of aerial photography and regional scale mapping from the following sources:

- Western Sydney native vegetation mapping (NPWS 2002 and OEH 2015).
- Freshwater threatened species distribution maps (NSW Department of Primary Industries 2016).
- NSW Key Fish Habitat Mapping (NSW Department of Primary Industries 2007).
- Atlas of Groundwater Dependent Ecosystems (Australian Bureau of Meteorology 2018a).
- High Ecological Value and Water Dependent Ecosystems (DPIE 2019).
- NSW statewide topographic mapping (SIX maps 2018).
- Local climate data (Australian Bureau of Meteorology 2018b).

Previous reports of relevance to the subject site reviewed include:

- Ecoplanning (2019). Biodiversity Development Assessment Report – Mamre South Precinct, Kemps Creek, Western Sydney Employment Area. Prepared for ALTIS Property Partners Pty Ltd.
- Costin Roe (2020). Civil Engineering Report Incorporating Water Cycle Management Strategy.
- Penrith City Council (2013) Water Sensitive Urban Design (WSUD) Policy.

Policies and guidelines relating to the proposed development include:

- Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (2013 update) (NSW Department of Primary Industries 2013).
- Fisheries Management Act 1994.
- Office of Water Controlled Activities on Waterfront Land – Guidelines for Riparian Corridors on Waterfront Land (NSW Department of Primary Industries NSW 2012).

- Office of Water Controlled activities on Waterfront Land – Guidelines for Vegetation Management Plans on Waterfront Land.

- State Environmental Planning Policy (Western Sydney Employment Area) 2009.

Ground Water Dependent Ecosystems

A desktop review of the Atlas of Groundwater Dependent Ecosystems (Australian Bureau of Meteorology 2018a) was undertaken to determine if aquatic and/or terrestrial GDE's were mapped across the study land.

Key Fish Habitat, threatened fish and Strahler stream order

A desktop review of Key Fish Habitat (KFH) mapping for Sydney Local Government Areas was reviewed (NSW DPI 2007) to determine if reach of South Creek in the subject land is considered as KFH.

A desktop review of freshwater threatened species distribution maps (NSW Department of Primary Industries 2016) was undertaken to determine if any threatened fish species had been recorded in or adjacent to the reach of South Creek that lies within the subject land.

New South Wales statewide topographic mapping (SIX maps 2018) was consulted to determine the Strahler stream order of South Creek in the subject land.

High Ecological Value and Water Dependent Ecosystem

A desktop review of High Ecological Value and Water Dependent Ecosystems (HEV) (DPIE 2019) mapping for Penrith Local Government Area (LGA) was undertaken to determine whether land within or adjacent to the subject site is considered as High Ecological Value or contain Water Dependent Ecosystems.

The map shows areas within the Penrith LGA where waterways and water dependent ecosystems are defined as high ecological value, based on definitions, guidelines and policies under the *Environment Protection and Biodiversity Conservation Act 1999*, *Biodiversity Conservation Act 2016*, *Fisheries Management Act 1994* and *Water Management Act 2000*. Water dependent ecosystems are defined as wetlands, and flora and fauna that rely on water sources (including groundwater). The map represents an overlay of a potential 39 indicators being used by the State Government to define high value, 17 of which make up the map for the Penrith LGA.

Field survey

Field surveys were undertaken on April 30, 2018 by Carl Tippler (Principal Ecologist) and Ben Green (Ecologist). Riparian vegetation and creek channel condition and KFH was assessed at five locations

along South Creek. A site walkover was undertaken to validate the extent of aquatic and terrestrial GDE's (Table 1, Figure 2).

Table 1: Location of riparian vegetation, creek channel and key fish habitat assessment sites.

Site	latitude	Longitude
Site 1	-33.829667	150.766525
Site 2	-33.832225	150.766647
Site 3	-33.833928	150.765778
Site 4	-33.835595	150.766175
Site 5	-33.835720	150.767595

Ground Water Dependent Ecosystems

Field validation was undertaken to validate the presence and extent of the mapped GDE's across the subject land. This consisted of a site walkover and inspection of areas which were mapped as containing GDE's.

Key Fish Habitat

Assessment was undertaken following the framework set out in Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (NSW Department of Primary Industries 2013). Assessment of KFH was undertaken at the same location of each riparian vegetation and creek condition assessment (Table 1).

Riparian vegetation and creek channel condition

Riparian vegetation is a significant factor in maintaining waterway 'health'. Vegetated riparian buffers along creeks filter nutrients and sediment from overland flow, provide habitat and food resources to native fauna, regulate creek water temperature and stabilise creek banks (Paul and Meyer 2001).

To assess the relative condition of riparian vegetation and creek channel, the Rapid Riparian Assessment (RRA) developed by Findlay et al (2011) and later refined by Dean and Tippler (2016) was applied. This method combines the assessment of both instream and riparian habitat metrics and was developed in the Sydney region for visual assessment of streams.

Assessment includes qualitative and quantitative data for site area based on percentage of nine types of land use and six additional observations on the left and right creek banks; 14 metrics of channel deposition and erosion features; key fish habitat metrics; riparian vegetation based on 14 vegetation structural classes plus measure of vegetated buffer width, weeds and overhanging vegetation.

Assessment of these metrics combine to rank sites from severely degraded to excellent which reflects a gradient of disturbance and corresponding riparian and creek channel condition. Sites assessed as severely degraded reflect a significant departure to reference conditions found in minimally disturbed naturally forested catchments. Severely degraded condition is typical of creeks in highly urbanized areas that have undergone severe channel alteration, possibly concrete lined, with very restricted to no vegetated buffer or riparian vegetation. In contrast, a site with excellent condition is indicative of a minimally disturbed catchment with intact channel geomorphology, an expansive and complex riparian vegetation community with minimal weeds and unaffected by human induced impacts such as stormwater and sewage.

Sites assessed as degraded, poor, fair or good reflect the gradient of disturbance between the two extremes with riparian vegetation and creek channel condition progressively improving as disturbance is reduced.

Assessments were undertaken at five assessment sites along South Creek which forms the western boundary of the subject land (Table 1, Figure 5). Prior to field assessment a desktop review of Western Sydney native vegetation mapping (NPWS 2002 and OEH 2015) and Ecoplanning (2019) was undertaken to determine the type and extent of native vegetation across the study land.

Results

Desktop study and literature review

Groundwater dependent ecosystems

Review of the Atlas of Groundwater Dependent Ecosystems (BOM 2018) showed that aquatic and terrestrial GDE's are mapped across the subject land. Figure 2 shows South Creek is considered an aquatic GDE which is flanked by terrestrial GDE for an approximately 50% of its length within the subject land. An additional small isolated patch of terrestrial GDE is present in the southern development footprint.

The location of terrestrial GDE's correspond with the location of some vegetation patches within the subject land the majority of which are located within the riparian corridor of South Creek and contain PCT 835 - Forest Red Gum – Rough -barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (Figure 2).

The small and isolated patch of terrestrial GDE mapped in the southern part of development footprint contains PCT 849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (Figure 2).

Further interrogation of the Atlas of Groundwater Dependent Ecosystems (BOM 2018a) shows the potential (i.e. confidence) of South Creek (mapped as an aquatic GDE) as being groundwater dependent is high. Similarly, the potential of the mapped terrestrial GDE within the South Creek corridor (primarily PCT 835) as being groundwater dependent is high. In contrast, the potential of the mapped terrestrial GDE on the southern boundary of the development footprint (an isolated patch of PCT 849) to be groundwater dependent is low.

Native vegetation

Review of field validated vegetation mapping by Ecoplanning (2019) shows patches of native vegetation were present across the study area, the majority of which were located in the northern portion of the proposed development footprint and within the riparian corridor of South Creek.

Native vegetation across the subject lands was a mix of plant community type (PCT) 835 - Forest Red Gum – Rough -barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion and PCT 849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (Figure 2).

Strahler stream order

Review of NSW topographic mapping (SIX maps 2018) showed South Creek as being fifth order under the Strahler stream ordering system (Figure 2).

Key fish habitat and threatened fish

Review of KFH mapping for Sydney (DPI Fisheries 2007) shows South Creek is mapped as KFH (see Appendix 1 for map). Review of Freshwater Threatened Species Distribution Maps (DPI Fisheries 2016) showed no threatened fish species were recorded in South Creek or in proximity of the subject land.

High Ecological Value and Water Dependent Ecosystems

Review of HEV mapping for Penrith LGA (DPIE 2019) shows the South Creek corridor and the patch of PCT 835 within the subject site is considered as High Ecological Value and Water Dependent Ecosystems (Figure 3).

Figure 2: Subject land, waterways, mapped native vegetation and groundwater dependent ecosystems (GDE).

Figure 3: High Ecological Value and Water Dependent Ecosystem (DPIE 2019) within and adjacent to the Subject Land

Field survey

Field survey was undertaken on April 30, 2018. A site walkover was undertaken which included assessment of KFH and field validation of mapped GDE's and native vegetation. An assessment of riparian vegetation and creek channel condition was undertaken at five sites along South Creek within the subject land (Figure 5).

Weather conditions at the time of survey were mild and fine. 4.4 mm of rainfall was recorded in the 48 hours prior to the survey and 15.2 mm was recorded on the day of the survey however this fell after the field work was completed (Table 2).

Table 2: Daily weather observation at Prospect Dam (nearest weather station) (BOM 2018).

Date	Temp (°C)		Rainfall (mm)	Wind	
	Min	Max		Direction	Max (km/h)
28/04/2018	13.0	20.1	4.0	Calm	
29/04/2018	11.5	22.2	0.4	W	13
30/04/2018	11.9	22.9	15.2	W	2

At the time of survey, flow in South Creek was not flowing around/under a historic weir/crossing point on South Creek. Under these flow conditions this structure provides a barrier to fish passage and is maintaining a deep weir pool on its upstream side (Figure 4).

Figure 4: South Creek at the subject land. Historical weir/crossing can be seen mid-image with upstream weir pool.

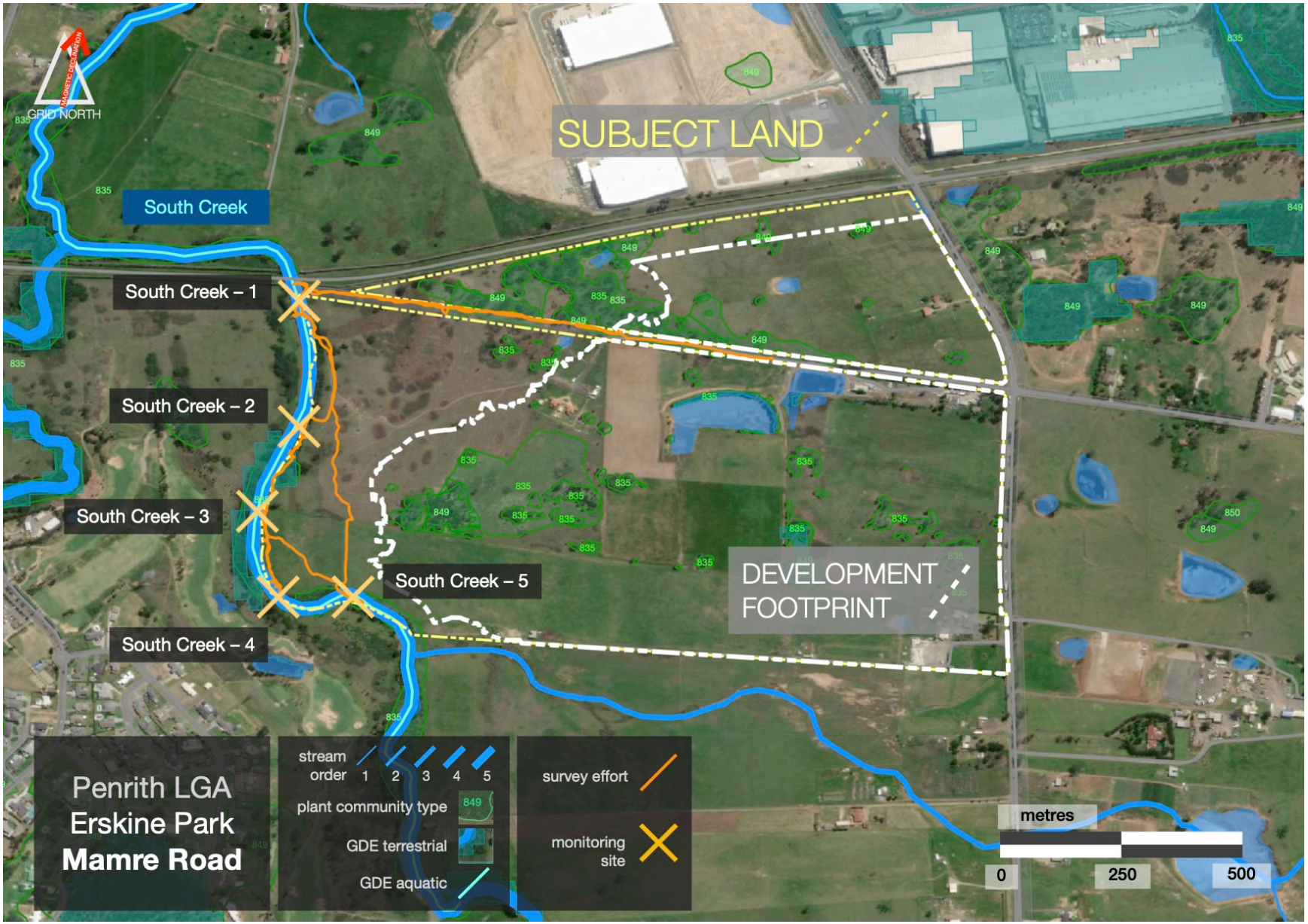

Figure 5: Field survey effort and location of riparian vegetation and creek channel condition assessment sites.

Groundwater dependent ecosystems

The site-walk over to validate the presence of GDE's and native vegetation confirmed that remnant patches of native vegetation mapped throughout the study area were also mapped as terrestrial GDE's. South Creek is mapped as an aquatic GDE, and at the time of assessment was not flowing and was reduced to a series of long pools of > 1 m in depth (Figure 6).

Figure 6: Photograph of aquatic GDE (left) and terrestrial GDE (right) in subject land.

Key fish habitat

Assessment of KFH type and class following the framework set out by DPI Fisheries (2013) shows at the time of assessment the reach of South Creek within the subject land were classified as Type 1 – highly sensitive fish habitat, Class 2 – moderate key fish habitat.

Classification as Type 1 – highly sensitive fish habitat is due to the presence of instream large woody debris > 300 mm diameter and > 3 m in length and presence of native macrophytes in some areas. The determination of Class 2 – moderate key fish habitat is due to the intermittent flow observed at the time of survey and the presence of a clearly defined creek bed and banks with semi-permanent to permanent waters in pools (Figure 7).

Figure 7: Photographs showing Type 1, Class 2 KFH attributes for South Creek (right) within the subject land.

Riparian vegetation and creek channel condition

Results of the assessment of riparian vegetation and creek channel condition using the Rapid Riparian Appraisal (Findlay et al 2011) show the condition of assessment sites within the reach of South Creek in the subject land ranged from 'poor' to 'fair' (Table 3, Figure 8).

Site 1 was found to be in poor condition (Table 3, Figure 8), a result which reflects the surrounding landuse which is primarily pasture/grazing. The vegetation community within the 50 m assessment radius is dominated by exotic species with only a thin and scattered band of native vegetation present. A high degree of litter was recorded at the site and a significant bank slump was observed on the western bank which, if left unmanaged will increase in size and potentially threaten future infrastructure.

Sites 2 – 5 were found to be in fair condition (Table 3, Figure 8) which when compared to Site 1 reflects a more complex riparian vegetation matrix and a lesser degree of bank erosion Although pasture/grazing land use was typical along the entire assessment reach, the percentage of the assessment area covered by this land use varied and contained a greater percentage of remnant native vegetation, less litter and less erosion.

Overhanging vegetation and key fish habitat attributes of large woody debris were common to all assessment sites.

The bed and bank of all assessment reaches appeared to be stable with only one significant erosion feature observed which was the bank slump recorded at Site 1. The historical weir/crossing located at Site 1 is likely to provide protection by regulating flow velocity and therefore mitigating against bed and bank erosion.

The results of this assessment indicate the current condition of South Creek along this reach is a significant departure from what would be considered an undisturbed waterway in a natural state. In the context of Western Sydney and the Cumberland Plain this would be represented by a contiguous vegetated riparian zone which transitions to a floodplain vegetated with a complex matrix of woodland plant communities, with low weed density, minimal erosion and no litter.

See Appendix 1 for detailed summary reports for each assessment reach.

Table 3: Results summary of riparian vegetation and creek channel condition assessment using Rapid Appraisal of Riparian Condition (Findlay et al 2011).

	Riparian Buffer		Land Use	Weed Cover		% Bank Slump	% Bank Undercut	Litter (pieces)	Woody Debris (pieces)	Overall Condition
	Left Bank	**Right Bank**		**Left Bank**	**Right Bank**					
Site 1	over 40m	over 40m	Left bank land use is 20% bushland, 80% pasture. Right bank land use is 100% pasture	Severe. over 70%	Severe. over 70%	Severe >30% bank	Minor <10% bank	High >20	High >10	Poor
Site 2	over 40m	over 40m	Left bank land use is 5% bushland, 95% pasture. Right bank land use is 30% bushland, 70% pasture.	Moderate. 40-70%	Moderate. 40-70%	Absent	Minor <10% bank	Low 1-5	High >10	Fair
Site 3	over 40m	over 40m	left bank land use is 60% bushland, 40% pasture. Right bank land use is 10% bushland, 90% pasture.	Moderate. 40-70%	Moderate. 40-70%	Minor <10% bank	Moderate 10-30%	Low 1-5	Moderate 4-10	Fair
Site 4	over 40m	over 40m	Left bank land use is 50% bushland, 50% pasture. Right bank land use is 30% bushland, 60% pasture.	Moderate 40-70%	Moderate 40-70%	Minor <10% bank	Moderate 10-30%	Low 1-5	Low 1-3	Fair
Site 5	over 40m	over 40m	Left bank land use is 10% bushland, 90% pasture. Right bank land use is 20% bushland, 80% pasture.	Light. Up to 40%	Light. Up to 40%	Minor <10% bank	Minor <10% bank	Moderate 6-20	Moderate 4-10	Fair

Figure 8: Results of riparian vegetation and creek channel assessment using Rapid Riparian Appraisal (Findlay et al 2011).

Discussion

Groundwater dependent ecosystems

This study shows that groundwater dependent ecosystems are mapped across the subject land however their distribution is primarily limited to the South Creek corridor. South Creek is mapped as an aquatic GDE and is considered as having a high likelihood of groundwater dependence (as per BOM 2018a). It is likely groundwater does play a part at maintaining baseflow however the upstream urban and agricultural land use will significantly increase run-off and is likely to be the major contributor of flow in South Creek. If this is not the case now it will most certainly be in the future given the rapid conversion of agricultural land to housing developments.

Terrestrial GDE is mapped within the South Creek corridor which is also considered as having a high likelihood of groundwater dependence (as per BOM 2018a). The extent of this GDE corresponds with the distribution of PCT 835 - Forest Red Gum – Rough -barked Apple grassy woodland on alluvial flats as validated by Ecoplanning (2019). Most of this GDE and the associated PCT are located outside the development footprint and therefore is unlikely to be affected by the proposed development. However, a small portion appears to lie within the south west corner of the development footprint as discussed by Ecoplanning (2019).

An additional patch of terrestrial GDE is mapped in the southern portion of the development footprint however this is considered to have low potential of being groundwater dependant. This patch of GDE corresponds with a small isolated and underscrubbed patch of PCT 849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain as validated by Ecoplanning (2019).

Although mapped as a terrestrial GDE it is likely this vegetation patch derives its primary source of water from shallow subsurface ground water which recharges after rain events and although western Sydney is in a prolonged dry spell, rain events are still a regular occurrence and therefore it is considered this patch has a low reliance on groundwater which corresponds with the BOM (2018a) assessment of having a low likelihood of groundwater dependence.

Strahler stream order

Review of NSW topographic maps and calculation of Strahler Stream Order shows South Creek is classed as a 5th Order stream. The proposed development is considered as a Controlled Activity under the *NSW Water Management Act (WMA*) 2000 which regulates the width of vegetated riparian zones on waterfront land and, therefore, a 40 m vegetated riparian zone (VRZ) measured from top of bank is required for South Creek.

The proposed development footprint will not encroach in to the VRZ and therefore the construction of the development is not considered as a threat to the riparian ecosystem.

However, the proposed development will require stormwater treatment and at the time of assessment it was proposed stormwater infrastructure may be required to connect the development site to a discharge point on South Creek. This construction of stormwater infrastructure will disturb the riparian zone and is considered a Controlled Activity under the *Water Management Act 2000* and therefore consent will be required from DPI Water.

For example, the required VRZ for South Creek is 40 m from top of bank, however, development may encroach into the VRZ by up to 20 m so long as the area consumed by the encroachment is offset in another section of the VRZ. However, the area of encroachment must already be cleared land. See Figure 9 for interpretation.

Application of the averaging rule can potentially be applied to the proposed development footprint by permitting up to 20 m encroachment into the VRZ of the south-west corner and offsetting this in the north-west corner where there is an existing 150 m of vegetated riparian corridor however this will require liaison with and consent by the NSW Office of Water

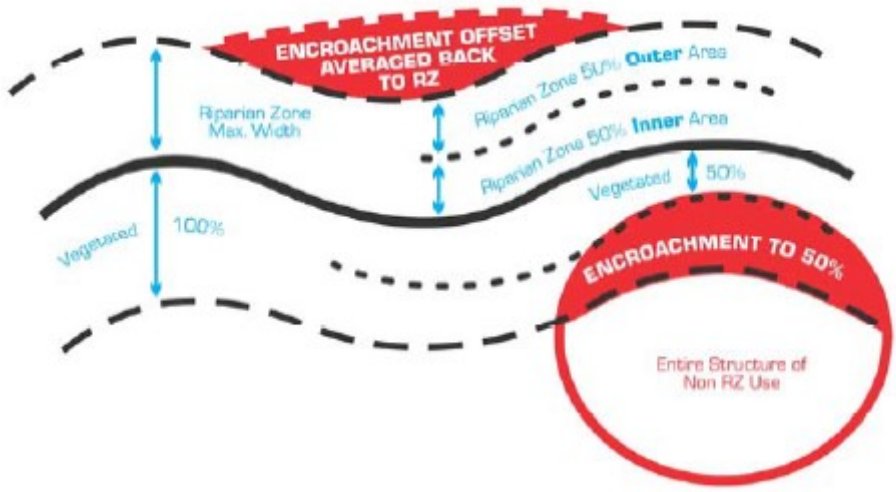

Figure 9: Image interpreting the WMA 2000 averaging rule for vegetated riparian zones (RZ).

Key Fish Habitat

Assessment of KFH shows at the time of assessment South Creek was mapped as KFH and field assessment classified the reach of the creek within the subject land as Type 1 – highly sensitive fish habitat, Class 2 – moderate key fish habitat. Type 1 – sensitive fish habitat was assigned due to the high degree of woody debris in the channel, presence of large rocks and emergent native macrophytes along creek sections. Class 2 – moderate key fish habitat was assigned as at the time of survey there

was no flow and the creek was reduced to a long weir pool due to the presence of a historical weir/crossing.

At the time of assessment, the Sydney region was declared as experiencing intense drought conditions (NSW DPI 2018) which resulted in the upper reaches of South Creek to cease flowing and therefore a Class 2 – moderate key fish habitat was assigned. However, this condition should be regarded as stochastic and during years of "normal" rainfall South Creek has permanent flow and therefore should be considered as Class 1 – Major Key Fish Habitat.

NSW DPI recommend vegetated riparian zones (VRZ's) are maintained/established along waterways classed as KFH. NSW DPI will assess the width of the recommended VRZ based on habitat Type and waterway Class (see Tables 3 and 4), the possible extent of the development disturbance and the susceptibility of the bank to erosion. As a guide the following are recommended (NSW DPI 2013):

- Type 1, Class 1: 100 m VRZ
- Type 2-3: 50 m VRZ
- TYPE 3, CLASS 3-4: 10-50 m VRZ

Due to South Creek being assessed as Type 1 – highly sensitive fish habitat, a 100 m VRZ is recommended to protect aquatic habitats in South Creek (Figure 10). It is unlikely the construction and operational phases of the proposed development will directly impact fish habitat as the development footprint does not encroach into the recommended 100 m VRZ. Therefore, no direct impacts to Key Fish habitat is expected.

However appropriate sediment and erosion control and stormwater management will be required during both construction and operational phases to mitigate potential indirect impacts to fish habitat that may arise due to run-off generated from the site.

Table 4 and Table 5 show extracts from Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (NSW Department of Primary Industries 2013) used to justify the assess KFH type and class of South Creek.

Table 4: Extract from Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (NSW Department of Primary Industries 2013) showing KFH type classification. Habitat attributes present in South Creek highlighted.

Table 1 – Key fish habitat and associated sensitivity classification scheme
(for assessing potential impacts of certain activities and developments on key fish habitat types)

TYPE 1 - Highly sensitive key fish habitat:

- *Posidonia australis* (strapweed)
- *Zostera, Heterozostera, Halophila and Ruppia* species of seagrass beds >5m^2 in area
- Coastal saltmarsh >5m^2 in area
- Coral communities
- Coastal lakes and lagoons that have a natural opening and closing regime (i.e. are not permanently open or artificially opened or are subject to one off unauthorised openings)
- Marine park, an aquatic reserve or intertidal protected area
- SEPP 14 coastal wetlands, wetlands recognised under international agreements (e.g. Ramsar, JAMBA, CAMBA, ROKAMBA wetlands), wetlands listed in the Directory of Important Wetlands of Australia[2]
- Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 metres in length, or native aquatic plants
- Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act
- Mound springs

TYPE 2 – Moderately sensitive key fish habitat:

- *Zostera, Heterozostera, Halophila* and *Ruppia* species of seagrass beds <5m^2 in area
- Mangroves
- Coastal saltmarsh <5m^2 in area
- Marine macroalgae such as *Ecklonia* and *Sargassum* species
- Estuarine and marine rocky reefs
- Coastal lakes and lagoons that are permanently open or subject to artificial opening via agreed management arrangements (e.g. managed in line with an entrance management plan)
- Aquatic habitat within 100 m of a marine park, an aquatic reserve or intertidal protected area
- Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna
- Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1
- Weir pools and dams up to full supply level where the weir or dam is across a natural waterway

TYPE 3 – Minimally sensitive key fish habitat may include:

- Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna
- Coastal and freshwater habitats not included in TYPES 1 or 2
- Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation

Table 5: Extract from Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (NSW Department of Primary Industries 2013) showing KFH class classification. Class of South Creek highlighted.

Table 2 - Classification of waterways for fish passage

Classification	Characteristics of waterway class
CLASS 1 Major key fish habitat	Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g. river or major creek), habitat of a threatened or protected fish species or 'critical habitat'.
CLASS 2 Moderate key fish habitat	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. TYPE 1 and 2 habitats present.
CLASS 3 Minimal key fish habitat	Named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or other CLASS 1-3 fish habitats.
CLASS 4 Unlikely key fish habitat	Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools post rain events (e.g. dry gullies or shallow floodplain depressions with no aquatic flora present).

Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (NSW Department of Primary Industries 2013) recommends that where possible a 100 m VRZ is the desired outcome. However, this is not regulated by the *Fisheries Management ACT* 1994 and therefore the 40 m VRZ as regulated by the *NSW Water Management Act* 2000 is the required outcome.

The proposed development will require stormwater treatment and at the time of assessment it was proposed stormwater infrastructure may be required to connect the development site to a discharge point on South Creek. Given this waterway is considered Key Fish Habitat and the construction of

stormwater infrastructure will likely disturb the creek bed and bank consent will be required from DPI Fisheries.

High Ecological Value and Water Dependent Ecosystems

The proposed development requires construction of stormwater infrastructure to capture, treat and discharge stormwater run-off from the site. MUSIC modelling undertaken by Costin Roe Consulting (2020) of pre and post development scenarios show pre-development run-off volume, above the critical flow, of 17.3 ML/year which is modelled to increase to 35.1 ML/year post development. A result which represents a doubling of annual run-off above the critical flow.

Costin Roe also modelled a Stream Erosion Index (SEI) of 2.03 post development for the site. This result is compliant with both SEI of 1 - 3.5 outlined by Penrith City Council's (PCC) Water Sensitive Urban Design (WSUD) Policy (PCC 2013) and SEI of 3.5 - 5 outlined for Western Sydney Growth Centres.

Therefore, the stormwater treatment strategy developed by Costin Roe Consulting (2020) meets the policy requirements for Penrith City Council and Western Sydney Growth Centres.

The reach of South Creek adjacent to the proposed development has been mapped as a high value ecosystem (HEV) (DPIE 2019) (Figure 3) and has therefore been prioritised by DPIE for protection. However, no targets for protection have been issued by DPIE and in their absence the compliant SEI of 2.03 should be considered as an acceptable level of risk.

Riparian vegetation and creek channel

The condition of riparian vegetation and creek channel in the reach of South Creek within the subject land was assessed as poor to fair. Site 1 was assessed as being in poor condition and Sites 2-5 were assessed as being in fair condition.

These results reflect the degraded nature of the riparian vegetation in this reach of South Creek and as was the case for Site 1 was influenced by the significant erosion of the western bank, which is not contained in the subject land, caused by the failure of the historical weir/crossing. However, this structure is likely providing protection to the upstream reach of South Creek by forming a deep pool which controls flow, provides fish habitat and mitigates against bed and bank erosion in periods of high flow.

Results of this assessment reflect the typical signs of degradation common to waterways with catchments undergoing urbanisation which include restricted vegetated riparian buffers, reduced habitat complexity, loss of native vegetation, weed invasion, litter and accelerated erosion. These

factors are common symptoms of what has been coined the 'urban stream syndrome' (Walsh et al 2005) and represent the ubiquitous degradation of waterways the world over.

Field validation by Ecoplanning (2018) showed remnant vegetation contained within the riparian zone of the subject land to be PCT 835 - Forest Red Gum – Rough -barked Apple grassy woodland on alluvial flats in a disturbed and shrubby condition. The majority of this vegetation lies outside the development footprint and will as a result be minimally disturbed during the construction phase if adequate mitigation is put in place (see recommendations).

It is likely the riparian zone found within the subject land will benefit as a result of the proposed development as this area is outside of the development footprint and encompasses the flood zone of South Creek (Ecoplanning 2018). With future appropriate management the condition of this area should be enhanced to provide benefits to terrestrial biodiversity and enhance fish habitat (see recommendations).

Conclusion and Recommendations

This assessment of aquatic and groundwater dependent ecosystems, key fish habitat and riparian vegetation and creek channel condition concludes that GDE's are present within the South Creek corridor and adjacent riparian zone. However this area is outside the development footprint and therefore it is unlikely future development will significantly impact upon these if appropriate measures to protect this area are implemented.

Review of NSW topographic maps and calculation of Strahler Stream Order shows South Creek is classed as a 5th Order stream. The proposed development is considered as a Controlled Activity under the *NSW Water Management Act (WMA*) 2000 which regulates the width of vegetated riparian zones on waterfront land and, therefore, a 40 m vegetated riparian zone (VRZ) measured from top of bank is required for South Creek. Liaison with and consent by NSW Office of Water will be required if stormwater infrastructure impacts the VRZ and disturbance of this area is considered a Controlled Activity under *NSW Water Management Act*.

Desktop and field survey showed South Creek is considered as Type 1 – highly sensitive fish habitat, Class 2 – moderate key fish habitat due to the habitat attributes observed within the creeks and the intermittent flow regime. However due to ongoing drought conditions across the Sydney Basin, the flow condition at the time of assessment should be considered stochastic and under "normal" rainfall conditions this reach of South Creek has permanent flow and therefore it is appropriate to consider this reach as Type 1 – highly sensitive fish habitat, Class 1 – major key fish Key fish habitat. As a result,

liaison with and consent by DPI Fisheries will be required if stormwater infrastructure impacts the bed and bank of South Creek as per *NSW Fisheries Management Act 1994.*

The current proposed stormwater treatment strategy combines bio-retention, propriety treatment devices and eventual discharge to South Creek. Stormwater modelling shows the Stream Erosion Index is within limits acceptable by both Penrith City Council and Growth Centre stormwater management policies.

The condition of the riparian vegetation and creek channel along this reach of South Creek is considered to range between poor and fair. Historical and current land use practices at the subject land and within the upper have resulted in significant degradation to the waterway and surrounding vegetation community. However with appropriate management of the riparian zone and adjacent floodplain the condition of this area will be enhanced.

Given the results of this assessment it is unlikely the proposed development will directly impact on riparian, aquatic and/or groundwater dependent ecosystems as they are outside the major development footprint, thus satisfying the *State Environmental Planning Policy (Western Sydney Employment Area) 2009*. To ensure potential impacts to these systems are avoided in the future the following recommendations are considered.

1. Establish appropriate Vegetated Riparian Zones (VRZ). To protect GDE's, KFH and riparian vegetation it is recommended appropriate VRZ's are established along South Creek corridor. Under the Strahler system of stream ordering South Creek is classed as a 5th Order stream and therefore to comply with requirements of the NSW *Water Management Act* (2000) a 40 m VRZ from top of bank is required to be maintained along South Creek. Laison with NSW Office of Water may be required if implementation of the averaging rule is proposed. Liason with NSW Office of Water will also be required if stormwater infrastructure is proposed to be constructed within the VRZ as this will be considered a controlled activity as per the *NSW Management Act* (2000) and disturbance of the creek bed and bank will require consent from DPI Fisheries as per *NSW Fisheries Management Act* (1994).

2. Develop a Vegetation Managemant Plan (VMP). In the event stormwater infrastructure encroaches into the VRZ it is likely the proposed development will require a VMP as a condition of consent from NSW Office of Water. It is recommended this be developed and details an appropriate management strategy to protect and enhance the riparian and floodplain vegetation comunities within the subject land. Guidance on the development of a VMP can be found in 'Controlled activities on Waterfront Land – Guidelines for Vegetation Management Plans on Waterfront Land' (NSW Office of Water 2012b). The VMP should also consider implementation of native aquatic and emergent

vegetation and snags to enhance aquatic habitats as recommended by 'Policy and Guidelines for Fish Habitat Conservation and Management' (NSWDPI 2013).

3. Develop a Construction Environmental Management Plan (CEMP). To avoid potential indirect offsite impacts to both aquatic and riparian ecosystems during the construction phase of the proposed development, an appropriate erosion and sedimentation control plan should be in place following best practice protocols such as Landcom (2004). It is recommended that this is included in a site-specific CEMP, prior to any construction works taking place.

Figure 10: Required VRZ as per NSW Water Management Act (2000) and recommended Key Fish Habitat VRZ as per NSW DPI (2013). Note buffers on this map are measured from the centre of the creek channel as top of bank was not surveyed as part of this study. Therefore, it is likely the official VRZ as measured from top of bank will extend further into the study area.

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Appendix 1 – Riparian Vegetation and Creek Channel Summary Reports

South Creek

or catchment area

Site 1

Type **Regular** Date **30/04/2018** Time **10:59:31 am** Assessor **Ben**

Site Condition and Score: **poor -2.1**

stream order: **5+**

notes

The site is in poor condition, with a score of -2.1 overall. The bed type is natural bed clay - Nvc. The bank type is natural vegetation - Nveg. Assessment point approx 50 upstream of SW pipeline. Weir/ old crossing obstructing creek and fish passage. Bank slump.

landuse

Within the 50 metre assessment radius, left bank land use is 20% bushland, 80% pasture, approximately. Right bank land use is 100% pasture, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 80% pasture grassland, 20% derived native shrubland, approximately. Right bank vegetation structure is 10% forest/woodland, 60% pasture grassland, 30% weed/exotic, approximately. This is reflected in the vegetation structure subtotal.

upstream

downstream

extraction	absent	
excavation	absent	
litter	high >20	
sewer/stormwater	absent	
odour	normal/none	
turbidity	medium	
Land Use	Subtotal	2.2
Site Features	Total	2.2
channel shape	dam/divert/pipe	
pool riffle sequence	absent	
meanders	unconfined yes	
large woody debris	high >10	
woody debris size	> 3 metres length	
overhanging vegetation	low <30%	
natural bed detritus	present	
natural gravel bed	absent	
natural rock in-stream	absent	
native macrophyte	present	
mapped Key Fish Habitat	yes	Class 2 / Type 1
KFH riparian buffer zone	100 metres	
Aquatic Habitat	Total	1
benches	present unconstricted	
islands	absent	
channel bars	absent	
Deposition	Total	1
bedrock/clay exposure	absent	
undercutting	minor <10% bank	
bank slumps	severe >30% bank	
knick point	unsupported	
bank erosion	gully/rill	
Erosion	Total	-10
total riparian corridor WMAct	80	
riparian buffer width left	over 40m	
riparian buffer width right	over 40m	
Riparian Vegetation	Subtotal	20
Vegetation Structure	Subtotal	3.7
weed density left bank	severe over 70%	
weed density right bank	severe over 70%	
Weeds	Subtotal	-20
Vegetation	Total	3.7

South Creek

or catchment area

Site 2

Type **Regular** Date **30/04/2018** Time **11:28 am** Assessor **Ben**

Site Condition and Score

fair
12.5

stream order

5+

notes

The site is in fair condition, with a score of 12.45 overall. The bed type is natural bed clay - Nvc. The bank type is natural vegetation - Nveg. Observed: Carp and Goldfish.

landuse

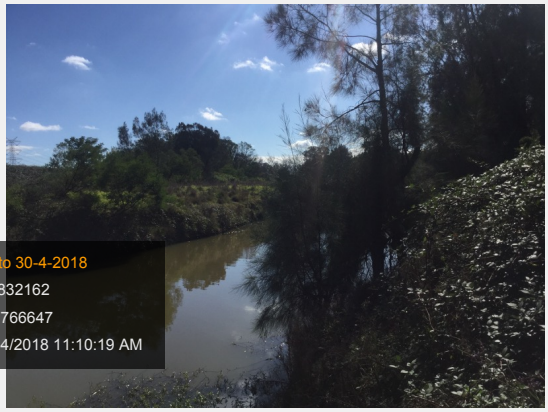
Within the 50 metre assessment radius, left bank land use is 5% bushland, 95% pasture, approximately. Right bank land use is 30% bushland, 70% pasture, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 10% forest/woodland, 90% pasture grassland, approximately. Right bank vegetation structure is 10% forest/woodland, 20% derived native shrubland, 70% pasture grassland, approximately. This is reflected in the vegetation structure subtotal.

upstream

downstream



extraction	absent	
excavation	absent	
litter	low 1-5	
sewer/stormwater	absent	
odour	normal/none	
turbidity	medium	
Land Use	Subtotal	2.85
Site Features	Total	2.85
channel shape	simple	
pool riffle sequence	absent	
meanders	unconfined no	
large woody debris	high >10	
woody debris size	> 3 metres length	
overhanging vegetation	low <30%	
natural bed detritus	not visible	
natural gravel bed	absent	
natural rock in-stream	absent	
native macrophyte	present	
mapped Key Fish Habitat	yes	Class 1 / Type 1
KFH riparian buffer zone	100 metres	
Aquatic Habitat	Total	1
benches	absent	
islands	absent	
channel bars	absent	
Deposition	Total	0
bedrock/clay exposure	absent	
undercutting	minor <10% bank	
bank slumps	absent	
knick point	absent	
bank erosion	gully/rill	
Erosion	Total	-4
total riparian corridor WMAct	80	
riparian buffer width left	over 40m	
riparian buffer width right	over 40m	
Riparian Vegetation	Subtotal	20
Vegetation Structure	Subtotal	4.6
weed density left bank	moderate 40-70%	
weed density right bank	moderate 40-70%	
Weeds	Subtotal	-12
Vegetation	Total	12.6

South Creek

or catchment area

Site 3

Type **Regular** Date **30/04/2018** Time **11:30 am** Assessor **Ben**

Site Condition and Score

fair
24.1

stream order

5+

notes

The site is in fair condition, with a score of 24.1 overall. The bed type is natural bed clay - Nvc. The bank type is natural vegetation - Nveg. Old informal crossing.

landuse

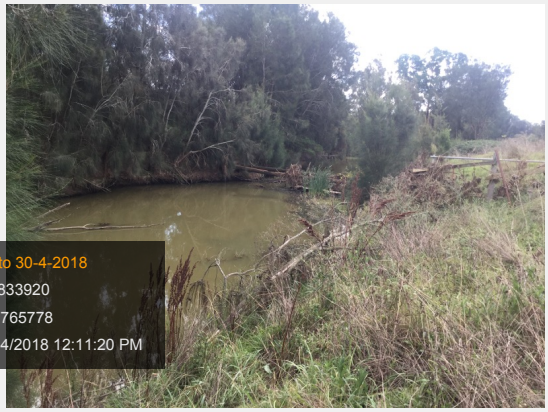
Within the 50 metre assessment radius, left bank land use is 60% bushland, 40% pasture, approximately. Right bank land use is 10% bushland, 90% pasture, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 40% forest/woodland, 40% pasture grassland, 10% weed/exotic, 10% derived native shrubland, approximately. Right bank vegetation structure is 10% derived native shrubland, 70% pasture grassland, 20% weed/exotic, approximately. This is reflected in the vegetation structure subtotal.

upstream

downstream



extraction	absent	
excavation	absent	
litter	low 1-5	
sewer/stormwater	absent	
odour	normal/none	
turbidity	medium	
Land Use	Subtotal	6.7
Site Features	Total	6.7
channel shape	simple	
pool riffle sequence	absent	
meanders	unconfined yes	
large woody debris	moderate 4-10	
woody debris size	> 3 metres length	
overhanging vegetation	low <30%	
natural bed detritus	absent	
natural gravel bed	absent	
natural rock in-stream	absent	
native macrophyte	present	
mapped Key Fish Habitat	yes	Class 1 / Type 1
KFH riparian buffer zone	100 metres	
Aquatic Habitat	Total	6
benches	absent	
islands	absent	
channel bars	absent	
Deposition	Total	0
bedrock/clay exposure	absent	
undercutting	moderate 10-30%	
bank slumps	minor <10% bank	
knick point	absent	
bank erosion	absent	
Erosion	Total	-3
total riparian corridor WMAct	80	
riparian buffer width left	over 40m	
riparian buffer width right	over 40m	
Riparian Vegetation	Subtotal	20
Vegetation Structure	Subtotal	6.4
weed density left bank	moderate 40-70%	
weed density right bank	moderate 40-70%	
Weeds	Subtotal	-12
Vegetation	Total	14.4

South Creek

or catchment area

Site 4

Type **Regular** Date **30/04/2018** Time **11:59 am** Assessor **Ben**

Site Condition and Score

fair
10.7

stream order

5+

notes

The site is in fair condition, with a score of 10.7 overall. The bed type is natural bed clay - Nvc. The bank type is natural vegetation - Nveg. Carp observed.

landuse

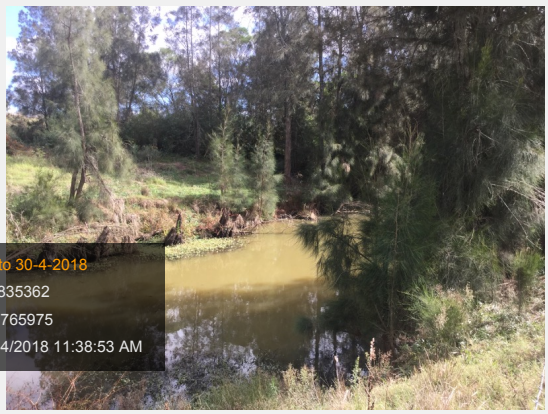
Within the 50 metre assessment radius, left bank land use is 50% bushland, 50% pasture, approximately. Right bank land use is 30% bushland, 70% pasture, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 20% forest/woodland, 50% pasture grassland, 10% derived native shrubland, 20% weed/exotic, approximately. Right bank vegetation structure is 10% forest/woodland, 20% derived native shrubland, 60% pasture grassland, 10% weed/exotic, approximately. This is reflected in the vegetation structure subtotal.

upstream

downstream



extraction	absent	
excavation	absent	
litter	low 1-5	
sewer/stormwater	present	
odour	normal/none	
turbidity	medium	
Land Use	Subtotal	1.8
Site Features	Total	1.8
channel shape	simple	
pool riffle sequence	absent	
meanders	confined yes	
large woody debris	low 1-3	
woody debris size	> 300 mm dia and 3 m	
overhanging vegetation	low <30%	
natural bed detritus	absent	
natural gravel bed	not visible	
natural rock in-stream	not visible	
native macrophyte	not visible	
mapped Key Fish Habitat	yes	Class 2 / Type 1
KFH riparian buffer zone	100 metres	
Aquatic Habitat	Total	2
benches	minor restriction	
islands	present	
channel bars	minor restriction	
Deposition	Total	-1
bedrock/clay exposure	absent	
undercutting	moderate 10-30%	
bank slumps	minor <10% bank	
knick point	absent	
bank erosion	gully/rill	
Erosion	Total	-6
total riparian corridor WMAct	80	
riparian buffer width left	over 40m	
riparian buffer width right	over 40m	
Riparian Vegetation	Subtotal	20
Vegetation Structure	Subtotal	5.9
weed density left bank	moderate 40-70%	
weed density right bank	moderate 40-70%	
Weeds	Subtotal	-12
Vegetation	Total	13.9

South Creek

or catchment area

Site 5

Type **Regular** Date **30/04/2018** Time **12:34 pm** Assessor **Ben**

Site Condition and Score

fair
15.0

stream order

5+

notes

The site is in fair condition, with a score of 15 overall. The bed type is natural bed clay - Nvc. The bank type is natural vegetation - Nveg.

landuse

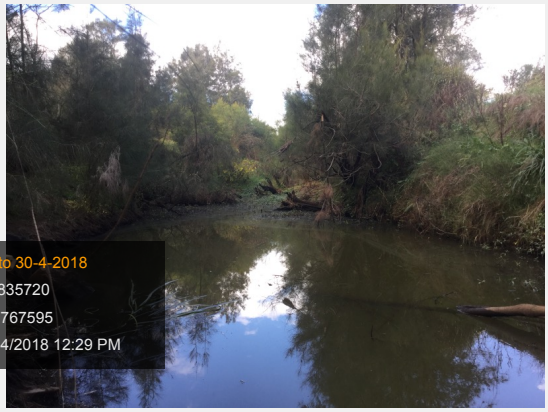
Within the 50 metre assessment radius, left bank land use is 10% bushland, 90% pasture, approximately. Right bank land use is 20% bushland, 80% pasture, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 10% derived native shrubland, 90% pasture grassland, approximately. Right bank vegetation structure is 10% forest/ woodland, 10% derived native shrubland, 80% pasture grassland, approximately. This is reflected in the vegetation structure subtotal.

upstream

downstream



extraction	absent	
excavation	absent	
litter	med 6-20	
sewer/stormwater	absent	
odour	normal/none	
turbidity	high	
Land Use	Subtotal	.3
Site Features	Total	.3
channel shape	complex	
pool riffle sequence	absent	
meanders	confined yes	
large woody debris	moderate 4-10	
woody debris size	> 3 metres length	
overhanging vegetation	low <30%	
natural bed detritus	absent	
natural gravel bed	absent	
natural rock in-stream	natural > 500 mm	
native macrophyte	present	
mapped Key Fish Habitat	yes	Class 2 / Type 1
KFH riparian buffer zone	100 metres	
Aquatic Habitat	Total	5
benches	minor restriction	
islands	absent	
channel bars	absent	
Deposition	Total	-1
bedrock/clay exposure	from incision	
undercutting	minor <10% bank	
bank slumps	minor <10% bank	
knick point	unsupported	
bank erosion	absent	
Erosion	Total	-7
total riparian corridor WMAct	80	
riparian buffer width left	over 40m	
riparian buffer width right	over 40m	
Riparian Vegetation	Subtotal	20
Vegetation Structure	Subtotal	3.7
weed density left bank	light up to 40%	
weed density right bank	light up to 40%	
Weeds	Subtotal	-6
Vegetation	Total	17.7